LOAN PRICING IN INTEREST RATE LIBERALIZATION IN CHINA

by

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Table of Contents

List of Figures

Abstract

In order to find how the process of interest rate liberalization influences the pricing strategy of dominant lenders in China's loan market and their mark-up power, I establish a pricing model to examine the effect of level of discretion in an oligopoly loan market on the incumbent lenders' entry-deterrence pricing strategy. In my theoretical models, I find two critical propositions: first, with perfect information, the mark-up power of the interest rate in the primary market decreases as the level of discretion in price-setting increases. This effect is mitigated, however, by moral hazard. Second, with the existence of adverse selection, an increase in the level of discretion indicates that the incumbent lenders can have more room to set the pool-pricing interest rate in the primary market. Moreover, I provide empirical evidence for decreasing mark-up pricing in China's loan market as loan rate liberalization completes, consistent with the prediction of my model.

List of Abbreviations Used

ARDL	Autoregressive Distributed Lag
BOC	Bank of China
CBD	China Development Bank
CCB	China Construction Bank
ECM	Error Correction Model
FED	Federal Reserve
FOMC	Federal Open Market Committee
FFR	Federal Fund Rate
GTS	Grim Trigger Strategy
ICBC	Industrial and Commercial Bank of China
LPR	Loan Prime Rate
MLF	Mid-term Lending Facility
NIFC	National Interbank Funding Center
NPL	Non-performing Loan
OLS	Ordinary Least Squares
PBOC	People's Bank of China
VAR	Vector Autoregression
VECM	Vector Error Correction Model

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Chapter 1 Introduction

The Chinese government adopted a gradual and cautious process to achieve the goal of interest rate liberalization since the People's Bank of China (PBOC) decided to set benchmark ceiling and floor for both deposit benchmark rate and loan benchmark rate in 1993. The PBOC gradually widened the gap between the interest rate ceilings and floors until the loan rate ceilings were completely removed in July 2013, suggesting the completion of partial interest rate liberalization. In August 2019, the PBOC announced the loan prime rate (LPR) to replace the loan benchmark rate, marking the completion of liberalization of the loan rates. Unlike its predecessor (the loan benchmark rate) which is set by the PBOC, LPR is the arithmetic average of the quotations, after removing the highest and lowest quotes, from 18 commercial banks as the representatives in the LPR quotation groups. As the prime rate in the United States is primarily influenced by the Federal Fund Rate (Friedman & Shachmurove, 2015), the LPR is linked to the Medium-term Lending Facility (MLF), which is the price of funds that PBOC lends to banks based on the demand for central bank liquidity (Zhou & Yao, 2019).

Starting a new era of post loan rate liberalization, the introduction of LPR is an important milestone on the road of interest rate liberalization in China. This intrigues my research interest to find how the increasing level of discretion in the market influences the pricing strategy of dominant lenders and their mark-up power in China's loan market. Li and Liu (2019) examine the passthrough of changes in the policy rate to bank loan rates in China for the pre-liberalization (January 1995 to July 2013) and partial-

liberalization (August 2013 to December 2017) periods. They find empirical evidence that the mark-up power of ICBC (one of the big five lenders) is lower in the period of partial liberalization than before. They attribute the decreasing mark-up power of dominant lenders to more competitiveness among Chinese commercial banks due to the ongoing reforms of China's banking system. However, their explanation ignores the structure of China's loan market. The higher level of discretion in the process of interest rate liberalization will cause more competitiveness among commercial banks in the fringe loan market but not in China's dominant oligopoly market. I argue that the decrease in the mark-up power is not a signal of the lower market power of dominant lenders but a change of their pricing strategy with the increasing level of discretion in the loan market to protect their information advantage over potential entrants. My loan pricing model can fully explain this argument.

Following prior theoretical research (Gan & Riddough, 2008; Stiglitz & Weiss, 1981), I establish a pricing model in two versions to examine the effect of level of discretion in an oligopoly loan market on the incumbent lenders' entry-deterrence pricing strategy, including a baseline version (the pricing model through the channel of information advantage) and an extended version (pricing model in the game of imperfect information with primary borrowers). I find two important propositions in my models: First, with perfect information in a primary market, the mark-up power of the interest rate in the primary market decreases as the level of discretion in price-setting increases; This effect is mitigated, however, by moral hazard. Second, with the existence of adverse selection, an increase in the level of discretion indicates that the incumbent lenders can have more room to set the pool-pricing interest rate for the primary market. My empirical

analysis supports the first important proposition, through which I provide empirical evidence of decreasing mark-up pricing in China's loan market as the process of loan rate liberalization completes.

The values of my research are mainly derived from my unique loan pricing model. Unlike Stiglitz & Weiss (1981) and Gan & Riddough (2008) also establish their pricing models in either a perfectly competitive market or a monopoly market, I apply some of their ideas and develop the pricing models in an oligopoly loan market, which gains more external validity from more realistic assumptions and applications. Moreover, in my pricing models, I find some unique and valuable propositions related to the pricing behaviours and structural characteristics of the dominant-firms oligopoly market.

The reminder of the thesis is structured as follows. Chapter 2 covers the institutional background of China's loan market and financial reform on the interest rate liberalization. Chapter 3 summarizes some important loan pricing strategies. The Chapter 4 fully describes my two versions of the loan pricing model with information advantage and asymmetric information. The last two chapters discuss the statistical method and empirical results regarding the effect of interest rate liberalization on the mark-up pricing in China's loan market.

Chapter 2 Institutional Background

2.1 Structure of the Loan Market in China

The structure of China's loan market is a typical dominant-firm oligopoly market despite over 3,000 lenders in the market, among which 136 banks are in the top 1000 world banks. Five big lenders (the first layer of China's bank system or the primary-dominant lenders) have been dominating China's loan market for decades, including one policy bank [China Development Bank (CBD)] and four commercial banks [Industrial and Commercial Bank of China (ICBC), Agricultural Bank of China (ABC), Bank of China (BOC), and China Construction Bank (CCB)]. These commercial banks are also the top 4 banks in the world in terms of the size of assets. Moreover, there are 12 large national joint-stock commercial banks (the second layer of China's bank system or the secondary-dominant lenders) gradually holding an increasing market share in the recent decade. According to the *Report of China's Banking Industry in 2019* (KPMG, 2019), the total amount of all commercial loans at the end of 2018 was 136.30 trillion Chinese yuan or about 27.04 trillion Canadian dollars, among which 64.71 trillion Chinese yuan (47.5% of market share) were lent by the big five lenders (ICBC: 11.3%, CCB: 10.1%, BOC: 8.7%, ABC: 8.7%, and CBD: 8.6%) and 99.62 trillion Chinese yuan (73.0%) were lent by the top 17 lenders (the primary and secondary dominant lenders). 47.5% of loan market is quite evenly shared by the big five banks, the 12 larger national joint-stock commercial banks jointly own 25.5% of the loan market, and other 27% of loan market is crowded of over 3,000 small lenders.

The top 17 lenders' (primary and secondary dominant lenders) unshakeable market dominance is derived from their political advantages, low operational costs, and massive economies of scale. Firstly, unlike most dominant lenders in western loan markets, the largest shareholder for each of the big five banks (the primary dominant lenders) in China is from only one company, the Central Huijin Investment Co., Ltd., which is owned by the government of People's Republic of China (64.0% in BOC, 57.1% in CCB, 40.3% in ABC, 34.7% in ICBC and 34.7% in CDB by the end of 2018) (China Investment Corporation, 2019). Taking public and social responsibility, these state-owned commercial and policy banks often provide medium to long-term financial support and facilities that can serve the Chinese government's long-term economic and social development strategies, such as infrastructure construction projects and agricultural development poverty reduction, and so on. As a result, the central bank (People's Bank of China) must consider the critical role of the big five lenders in both the money and goods markets when setting a new policy rate (Li & Liu, 2019). Secondly, the top 17 lenders in China's loan market usually are the ones who have advanced centralized operation, efficient cost management, and abundant innovations from research and development to achieve lower operational costs than their competitors (KPMG, 2019). Thirdly, compared to small lenders, the top 17 lenders have had a great amount of solid and stable customer bases for decades so that the top 17 lenders have not only more significant economies of scales but they also have a greater information advantage regarding the credit quality of millions of borrowers than their small competitors and potential entrants. Combining together, political advantages, low operational costs, and massive economies of scale

create substantial entry barriers between the large market that the top 17 lenders dominate and the small market crowd of thousands of other lenders.

During China's ongoing financial reform, the Chinese government has succeeded in enhancing the competitiveness of its banking industry by building five layers of commercial banks (Li & Liu, 2019): the first layer includes five big state-owned commercial banks (including four commercial banks out of the big five lenders); the second layer consists of 12 national joint-stock commercial banks operating under the logic of market economy; the third layer involves 134 of city commercial banks from cities' credit union; the fourth layer is composed of thousands rural commercial banks and rural financial institutions from rural credit unions which absorb private capital to solve illegal lending issues; and the fifth layer consists foreign banks and policy banks. Admittedly, the Chinese government has issued series of policies to stimulate competitiveness in the banking system and financial markets since the global financial crisis in 2008, facilitating the growth of small banks and the emergence of new entrants. For example, on August 17th in 2019, the LPR was changed from the weighted average based on the size of loans to the arithmetic average of the quotations from 18 representative banks, which dramatically improved the pricing power of the banks from the third layer (city commercial banks), the fourth layer (rural commercial banks), and the fifth layer (foreign banks and other financial institutions). However, I argue that the entry-inducing policies can lower the barriers to entry in the third and fourth layers but not the entry costs of entering into the market that the top 17 lenders dominate. Moreover, as the process of interest rate liberalization completes step by step and as the loan market in China has a higher and higher level of discretion in pricing, the dominant

lenders (top 17 lenders) can gain more and more market power from the high entry costs between the dominant market and fringe market. Eventually, the loan market in China will be separated into two markets: a large oligopoly market that is evenly shared by a limited number of big lenders and a small but perfectly competitive fringe market.

2.2 Liberalization of Deposit and Lending Rates in China

The channel of monetary policy transmission through the interest rate in China is quite different from that in most western countries. In the United States, for example, the Federal Reserve (FED) conducts monetary policy by the target federal funds rate (the key policy rate set by the Federal Open Market Committee (FOMC)), which is the interest rate at which depository institutions lend reserve balances to other depository institutions overnight on an uncollateralized basis (FED, n.d.). Changes in the federal funds rate indirectly influence the short-term interest rates and the overall availability and cost of credit in the economy of the United States (FED, n.d.). In China, however, both the deposit and loan rates were more directly controlled by the Chinese government and the lenders in China's loan market have less autonomy in pricing the interest rate based on market conditions. The people's bank of China (PBOC) conducts monetary policy by setting the deposit benchmark rate and the loan benchmark rate, which can be considered as the prime rate set by the government in the deposit market and loan market, respectively. Since Chinese people have a habit of long-term saving, the deposit benchmark rate is a more efficient channel to conduct monetary policy than the loan

benchmark rate in China. Therefore, the one-year deposit benchmark rate serves as the policy rate in China (Li & Liu, 2019).

As Li & Liu (2019) note, the Chinese government adopted a gradual and cautious process to achieve the goal of interest rate liberalization. The interest rate liberalization started in 1993 when the PBOC decided to set benchmark ceilings and floors for both deposit and loan benchmark rates to make the interest rate more flexible with the market. Since then, the PBOC gradually widened the gap between the interest rate ceilings and floors before they were completely removed. The liberalization of deposit rates made great progress even though it has not been fully completed yet. The deposit rate floor was removed in 2004. The ceiling of the deposit rate gradually increased from 100% of the benchmark rate to 130% from June 2012 to May 2015. In October 2015, the PBOC decided to remove the ceiling of the deposit rate, implying the completion of the first stage of deposit rate liberalization. It took about 25 years for the Chinese government to complete the liberalization of the loan benchmark rate. In the beginning, lenders could set their loan rates between 90% and 130% (110%) of the loan benchmark rate for large borrowers (small and medium borrowers). In 2004, the PBOC removed the ceiling of the loan rate. In 2012 the floor of the loan rate was lowered further down to 70% of the benchmark rate and one year later was fully removed. In 2019, the PBOC announced the loan prime rate (LPR) to replace the loan benchmark rate, suggesting the completion of liberalization of the loan rates.

Replacing the loan benchmark rate, the LPR is the most preferential lending rate offered by a commercial bank to its prime clients and other loan rates in a loan market are offered based on the LPR by adding or subtracting basis points. In the mortgage loan

market, the LPR is the lowest loan rate to the highest-quality borrowers, acting as the loan rate floor. Published by the National Interbank Funding Center (NIFC), the LPR is the arithmetic average of the quotations, after removing the highest and lowest quotes, from 18 commercial banks as the representatives in the LPR quotation groups. These 18 commercial banks, including the big five state-owned commercial banks, urban commercial banks, rural commercial banks, foreign-invested banks and private banks, are the ones with significant influence in the loan market, strong loan pricing powers, and better service effect (ICBC, n.d.). As the prime rate in the United States is primarily influenced by the Federal Fund Rate (Friedman & Shachmurove, 2015), the LPR is mainly influenced by the Medium-term Lending Facility (MLF), which is the price of funds that PBOC lends to banks. Therefore, MLF became the policy rate in China after 2019.

Chapter 3 Literature Review

The LPR marks the completion of loan rate liberalization, which is an important milestone on the road of interest rate liberalization in China. As the liberalization of loan interest rate completes, how the increasing level of discretion in the market influences the pricing strategy of dominant lenders in China's loan market, and their mark-up power becomes my research focus. Li and Liu (2019) examine the passthrough of changes in the policy rate to bank loan rates in China for the pre-liberalization (January 1995 to July 2013) and partial-liberalization (August 2013 to December 2017) periods by using the autoregressive distributed lag (ARDL) bound test and an error correction model (ECM). They find that interest rate liberalization has a positive effect on monetary policy transmission. Their empirical evidence shows that the mark-up power of ICBC (one of big five lenders) is lower, and interest rate passthrough has become more complete in the partial-liberalization period (2013-2017). Li and Liu (2019) attribute the decreasing mark-up power of dominant lenders to more competitiveness among Chinese commercial banks due to the ongoing reforms of China's banking system. However, Li and Liu's explanation for the decrease in the mark-up power of dominant lenders during the process of interest rate liberalization ignores the structure of China's loan market. Firstly, as discussed in the section on institutional background, the higher level of discretion in the process of interest rate liberalization will cause more competitiveness among commercial banks in the fringe loan market (almost perfect competition) but not in the dominant oligopoly market in China. Secondly, the dominant lenders can gain more market power

from the high entry barriers between the dominant market and fringe market after interest rate liberalization. During the partial-liberalization period (2013-2018), the market share of the dominant lenders (the top 17 lenders) in China's loan market increased from 70.1% to 73.0%; in addition, the profit of dominant lenders increased by 0.3 trillion yuan while the profit of fringe lenders approximately kept the same (KPMG, 2019; KPMG, 2015). Therefore, I can say that the decrease in the mark-up power is not a signal of the lower market power of dominant lenders but a change of their pricing strategy with the increasing level of discretion in the loan market. As a result, I review some important theoretical and empirical research regarding the loan pricing strategy. Some of the prior research (Gan & Riddough, 2008; Stiglitz & Weiss, 1981) provide us with fundamental ideas to establish two pricing models to answer my research question.

3.1 The Value of Information in the Loan Pricing Strategy

3.1.1 Pricing Strategy with Adverse Selection/Moral Hazard

Lenders are making loans based on the interest rate they receive on the loan and the riskiness of the loan. With the assumption of perfect information in the loan market, the monopolist lender will set the interest rate based on the riskiness of the loan (Gan & Riddiough, 2008); the interest rate in a perfectly competitive market will be jointly determined by supply and demand of loans and by the risk premium of loans (BoC, n.d.). In reality, however, there is information asymmetry between lenders and borrowers regarding the riskiness of loans. Compared to lenders, borrowers have better knowledge of the underlying riskiness of the project they seek to finance. This asymmetric

information about the riskiness will cause two problems for lenders: adverse selection and moral hazard.

Adverse selection exists in a loan market when riskier borrowers are willing to participate in the loan market and are more likely to demand credit and use their loans. Assuming the informational asymmetry in a perfectly competitive loan market, Stiglitz and Weiss (1981) theoretically prove the existence of adverse selection: for a given loan interest rate, only the borrowers, whose riskiness is higher than a critical value, are willing to borrow. Supporting Stiglitz and Weiss's theoretical findings, Crawford et al. (2018) provide empirical evidence of adverse selection in the form of a positive correlation between the unobserved determinants of demand for credit and default. From an equilibrium model with credit rationing in a perfectly competitive market, Stiglitz and Weiss (1981) find that an increase in the loan interest rate exacerbates adverse selection, inducing a decrease in the credit quality of the pool of borrowers. Therefore, the loan interest rate is acting as a “screening device” for distinguishing between good and bad risks (Stiglitz & Weiss, 1981). Following Stiglitz and Weiss, Crawford et al. (2018) also find that when adverse selection increases, prices rise because a riskier pool of borrowers implies more defaults.

In a perfect loan market, there exists an equilibrium interest, referred by Stiglitz and Weiss (1981) as the "bank-optimal" rate, beyond which lenders think the underlying riskiness is much higher than the average loan at the bank-optimal rate so that the expected return is lower. As a result, lenders should charge the borrowers with the "bank-optimal" rate in a loan market rather than the interest rate associated with the economic equilibrium in the loan market, even though this pricing strategy could cause "credit

rationing." Alternatively, lenders could separate borrowers in terms of their riskiness and conduct a risk-based pricing strategy to mitigate the negative effect of adverse selection (Adams et al., 2009). In this case, several separating equilibriums will exist with heterogeneous customers in the loan market (Adams et al., 2009). In fact, lenders have increasingly been using risk-based pricing of interest rates in loan markets since the mid-1990s (Edelberg, 2006). More interestingly, in a loan market with high concentration, the adverse selection can lead to higher prices, less lending, and more defaults, but these negative market outcomes of adverse selection can be mitigated by the lender's market power (Crawford et al., 2018).

Moral hazard occurs in a loan market when high repayment requirements on loans (interest rate) reduce borrowers' incentive to exert effort, thus increasing the default probability of the loans (Holmstrom & Tirole, 1997; as cited by Crawford et al., 2018). In other words, the positive relationship between the loan interest rate and default rate implies the existence of a moral hazard. When estimating a structural model of firms' demand for credit, loan use, and default with a model of bank pricing in Italy's loan market, Crawford et al. (2018) provide empirical evidence of moral hazard effect by finding a causal effect of interest rates on borrowers' default. Moreover, Adams et al. (2009) also find moral hazard in the subprime auto-loan market in the United States, where the default rate increases significantly with loan size. Furthermore, Arping (2017) establishes a theoretical model with a borrower moral hazard where the bank's non-performing loan (NPL) ratios are endogenously related to their loan interest rate. According to Arping's (2017) model, less competition in a relatively uncompetitive loan market leads to lower loan rates and safer loans.

3.1.2 Pricing Strategy with Information Advantage

As I discussed before, the information asymmetry between borrowers and lenders could cause some adverse market outcomes. On the other hand, the information asymmetry between lenders regarding the information of borrowers' risks could make the lenders who have information advantage gain more mark-up power than the lender who does not. By monitoring borrowers' loan repayment behaviour, a lender can gain more private information about the exact riskiness of his customers, which lets the lender have an information advantage over other incumbent lenders and potential competitive entrants.

Focusing on the pricing strategy with information advantage over the incumbent competitors, Rajan (1992) examines competition between an informed "inside" bank which knows whether his current customers will default or not and a uniformed "outside" bank which only knows that the customers of the "inside" bank will repay loans with probability q. Rajan (1992) finds that the inside bank's information advantage over outside banks equips the inside bank with limited monopoly power over the borrower. In other words, a borrower will be pegged as a lemon by outside banks if he seeks to find a better offer than his current loan. As a result, the borrower is "held up" by his inside bank so that the inside bank can charge him a risk-adjusted monopoly rate. Santos and Winton (2018) provide empirical evidence that this informational hold-up effect is significant. Moreover, Rajan (1992) finds that an increase in q lowers the default risk that the outside bank will take, so the probability of the outside bank making a bid to offer a loan increases, which lowers the average risk-adjusted rate that the inside bank can charge. Following Rajan, Santos and Winton (2018) support Rajan's theoretical proposition that

hold-up power increases with borrower risk by comparing the pricing of loans for bank-dependent borrowers with access to public debt markets. Due to the attraction of being the inside lenders, lenders may conduct a dynamic pricing game to grow their customer base. Allen and Li (2020) develop a framework for investigating dynamic competition in markets, where the price is negotiated between a borrower and several lenders repeatedly. Focusing on the Canadian mortgage market, they provide empirical evidence of an "invest-then-harvest" pricing strategy: lenders offer relatively low loan rates to attract new customers and then charge a risk-adjusted interest rate which is higher than what may be offered by outside lenders at renewal (Allen & Li, 2020).

Gan and Riddiough (2008), on the other hand, focus on the pricing strategy with information advantage over the potential competitive entrants. They develop a theoretical model that shows how information advantage over the potential entrants affects the incumbent's pricing strategies with entry-deterrence incentives. Facing the threat of entry, the incumbent lender with information advantage has strong incentives to protect its information advantage and market share from potential entrants (Gan & Riddough, 2008). In their model, Gan and Riddiough (2008) examine the endogenous relationship between market structure and loan pricing strategy, where the incumbent monopoly lender employs a "proprietary screening technology" to deter entry. Taking advantage of the credit quality information, which is unobservable to potential competitive entrants, the incumbent monopoly lender charges prime market borrowers (the higher-credit quality borrowers) a uniform rate higher than the risk-based monopoly rate with the purpose of concealing the credit quality information. The incumbent monopoly always prefers the entry-deterrence pricing strategy as long as the monopoly ensures that the

lower bound of pool pricing region will signal zero post-entry profits to potential entrants.

Chapter 4 Model

In order to find how the process of interest rate liberalization influences the pricing strategy of dominant lenders in China's loan market and their mark-up power, I establish a pricing model in two versions to examine the effect of level of discretion in an oligopoly loan market on the incumbent lenders' entry-deterrence pricing strategy based on prior theoretical research (Gan & Riddough, 2008; Stiglitz & Weiss, 1981). First of all, I establish a baseline version of the pricing model through the channel of information advantage, where the incumbent oligopoly lenders charge their primary borrowers (a group of borrowers whose credit quality is higher than the cut-off level) a pool-pricing interest rate (a uniform rate that is higher than the risk-based monopoly rate) to conceal the credit quality information in the primary market and deter entry. Then considering that the imperfect information (asymmetric information) could cause moral hazard and adverse selection in the primary loan market, I build up an extended version of the pricing model in the game of imperfect information with primary borrowers. Based on the empirical evidence of the positive relationship between the level of discretion and the market concentration of the loan market (Cerqueiro et al., 2011), I find two important propositions in my models. First, with perfect information in a primary market, the mark-up power of the interest rate in the primary market decreases as the level of discretion in price-setting increases. This effect is mitigated, however, by moral hazard. Second, with the existence of adverse selection, an increase in the level of discretion indicates that the

incumbent lenders can have more room to set the pool-pricing interest rate for the primary market.

4.1 Pricing Model through the Channel of Information Advantage

The model of pricing strategy of incumbent lenders through the channel of information advantage is developed based on Gan and Riddiough's (2008) research. In their model, Gan and Riddiough (2008) examine the endogenous relationship between market structure and loan pricing strategy, where the incumbent monopoly lender employs a "proprietary screening technology" to deter entry. Taking advantage of the credit quality information, which is unobservable to potential competitive entrants, the incumbent monopoly lender charges prime market borrowers a uniform rate higher than the risk-based monopoly rate with the purpose of concealing the credit quality information to signal zero post-entry profits to entrants. When I apply Gan and Riddough's model to the Chinese loan market, I must add three critical adjustments. Firstly, unlike the assumption of an incumbent monopolist in Gan and Riddough's model, I assume an oligopoly market with N lenders issuing homogeneous loans at the beginning. Secondly, I add a parameter δ, which denotes the lenders' discount factor and is bounded by $(0, 1)$. Thirdly, I add a parameter $\tau \in (0, 1)$, which represents the level of discretion in the loan rate-setting process (variance of unexplained dispersion of loan rates). Following Cerqueiro et al. (2011), the parameter τ is associated with large deviations in loan rates. During the period of interest rate liberalization in China, the parameter τ increases as commercial banks gain more considerable authority to set their

deposit rate and loan rate based on borrowers' credit quality and pricing strategy. With these three adjustments, the model predicts a lower entry-deterrence interest rate (the uniform interest rate charged for primary market borrowers) and lower loan "mark-up relation" (Monti, 1972; Klein, 1971; as cited in Gan & Riddough, 2008) when the process of interest rate liberalization has become more completed in China.

4.1.1 Profit-Maximizing Loan Pricing in Oligopoly Market

Here I examine the lenders' profit-maximizing strategy without any entry threat in an oligopoly market where N identical lenders issue homogeneous loans to their target borrowers. Assume that each lender, after the initial loan screening, perfectly observes each consumer's credit quality $\theta \in (0, 1)$, which is usually measured by *1 –PD*, where *PD* is the probability of default. Assume lenders collude to fix the interest rate at the monopoly rate, and this collusion can be sustained forever (see equation (6)). This assumption is realistic in China's banking industry because the Central Huijin Investment Co., Ltd., owned by the government of PRC, is the largest shareholder of each of big five lenders in China (64.0% in BOC, 57.1% in CCB, 40.3% in ABC, 34.7% in ICBC and 34.7% in CDB). By sticking to the cooperative pricing strategy in the Bertrand Model of Price Competition (here price is the loan rate), all lenders maximize expected profits in each period by charging an optimal loan rate for each borrower, as follows:

$$\underset{r}{Max}\ \pi(\theta,\ r) = \underset{r}{Max}\ (\theta r - \kappa^{C})\, D(r) \qquad (1)$$

where π is the total profit of all lenders who collude together as a monopolist, $\theta = 1 - PD \in (0, 1)$ is the credit quality of the loan with $f(\theta)$ as the probability density

function for credit quality θ, r is the loan rate and θr is the loan's expected return, κ^C is the per-unit cost of financial capital, and $D(r)$ is loan demand.

Based on the first-order condition (FOC), the optimal loan rate is:

$$r^m(\theta) = \frac{\kappa^C}{\theta}\left(\frac{\varepsilon}{\varepsilon - 1}\right) \tag{2}$$

where $\varepsilon = -(dD/D)/(dr/r)$ is the price elasticity of the demand (assuming $\varepsilon > 1$, which is supported by empirical evidence (DeFusco & Paciorek, 2017)). It is clear to see that the mark-up (α) of the expected optimal interest rate ($\theta r^m(\theta)$) is $\varepsilon/(\varepsilon - 1)$.

The total expected profit of all lenders in each period is

$$\pi^m = \int_0^1 \pi^m(\theta) f\,(\theta) d\theta = \int_0^1 (\theta r^m(\theta) - \kappa^C) D\big(r^m(\theta)\big) f\,(\theta) d\theta$$

$$= \int_0^1 \frac{\kappa^C D(r^m(\theta))}{\varepsilon - 1} f\,(\theta) d\theta \tag{3}$$

By sticking to the cooperative pricing strategy in the Bertrand model of price competition, each lender *i*'s profit would be π^m/N during all subsequent periods. Therefore, its discounted stream of profits is ($\delta \in (0, 1)$ denotes lenders' discount factor):

$$\frac{\pi^m}{N} + \delta\frac{\pi^m}{N} + \delta^2\frac{\pi^m}{N} + \cdots = \frac{1}{1-\delta}\frac{\pi^m}{N} \tag{4}$$

Alternatively, lender *i* could deviate from the cooperative pricing strategy by setting the loan interest rate marginally lower than its rival to capture all markets. However, such a deviation is detected by its rival, which leads all lenders to follow the Grim Trigger Strategy (GTS) by setting the interest rate equal to the minimum average cost after that. As a result, the discounted stream of profits that lender *i* obtains from deviating is:

$$\pi^m + \delta 0 + \delta^2 0 + \cdots = \pi^m \tag{5}$$

The assumption of long-term collusion in the oligopoly market implies that:

$$\frac{1}{1-\delta}\frac{\pi^m}{N} > \pi^m \Rightarrow \delta > 1 - \frac{1}{N} \tag{6}$$

In 2018, the big five lenders in China's loan market owned 48% of market share, and the top 17 lenders jointly accounted for 73% of market share (KPMG, 2019). Therefore, I could conservatively think that *N* is 17, which is the number of primary and secondary dominant lenders in China's loan market. In order to meet the condition of long-term collusion, either the discount factor δ must be larger than 0.94 ($0.94 = 1 - 1/17$) or the intertemporal discount rate ($1 - \delta$) must be less than 6%. The discount rate for Chinese lenders can be measured by the Medium-term Lending Facility (MLF, which is the price of loans that PBOC lends to commercial banks) or roughly by the deposit rate (the price paid by banks to deposit account holders). Both the MLF and the deposit rate in China have never reached 5% since the process of interest rate liberalization in China started in 1998. As a result, the assumption of long-term collusion in the oligopoly market strongly fits in the Chinese loan market.

4.1.2 Equilibrium with Endogenous Learning and Entry

Similar to Gan & Riddiough (2008), I assume the incumbent lenders have an information advantage over their potential competitive entrant in the loan market. That is the incumbent lenders precisely know each borrower's credit quality θ, while the potential entrant can not observe the full information of θ at $T = 0$. Instead, the potential entrant can interpret θ based on the loan rate *r*, which is the common knowledge. On the basis of the information they observe or interpret, the potential entrant must determine whether to

enter or not at $T = 1$. κ^E is the fixed cost of entry for entrants, constant for all θ but related to the level of discretion in the loan rate-setting process τ. Cerqueiro et al. (2011) propose a heteroscedastic linear regression model to analyze the determinants of the unexplained dispersion of loan rates. Seeing "rules" and "discretion" as the extremes of a continuum along which any loan-pricing model can be classified regarding its level of standardization, Cerqueiro et al. (2011) find that the weight of "discretion" increases with the level of concentration in the banking market. Based on Cerqueiro et al.'s research, I reasonably assume that the level of discretion in the loan rate τ (variance of unexplained dispersion of loan rates) in my model is positively related to the cost of entry κ^E (high cost of entry is positively related to the high level of market concentration), so $\partial\kappa^E/\partial\tau = \kappa'(\tau) > 0$.

Facing the threat of entry at $T = 0$, the incumbent lenders modify their pricing strategy with the purpose of deterring an entry at $T = 0$. If the incumbent lenders do not conduct an entry-deterrence pricing strategy but insist on charging each borrower with a risk-based monopoly rate, the potential entrant will interpret each borrower's credit quality from the rate he gets. Given a borrower with the credit quality of θ, the discounted stream of post-entry expected profits for a new entrant is:

$$\frac{\pi^m}{N+1} - \kappa^E + \delta\frac{\pi^m}{N+1} + \delta^2\frac{\pi^m}{N+1} + \cdots = \frac{1}{1-\delta}\frac{\pi^m}{N+1} - \kappa^E \qquad (7)$$

Moreover, there are some constraints regarding the characteristics of potential entrants. If the discounted stream of post-entry profits for a new entrant is positive regardless of the credit quality of borrowers, there would be nothing the incumbent lenders could do to stop him entering. If the discounted stream of post-entry profits for a

new entrant is negative even though all their borrowers have the highest credit quality ($\theta = 1$), there would be no threat of entry. Therefore, the restrictions on the entrants are as follow:

$$\frac{1}{1-\delta}\frac{\pi^m}{N+1} - \kappa^E < 0 \tag{8}$$

$$\frac{1}{1-\delta}\frac{\pi^m(\theta=1)}{N+1} - \kappa^E > 0 \tag{9}$$

Based on these two restrictions, combined with the monotonicity of $\pi^m(\theta)$ and the continuity of θ, there must exist θ_0 such that:

$$\frac{1}{(1-\delta)(N+1)}\int_{\theta_0}^{1}\frac{\kappa^C D(r^m(\theta))}{\varepsilon-1} f(\theta)d\theta - \kappa^E = 0 \tag{10}$$

Assume that the potential entrants who are deterred at the first period have no intention to enter again. From the incumbent lenders' perspective, the incremental total expected profit from an entry-deterrence pricing strategy to an entry-inducing pricing strategy ($\omega(\theta)$) is:

$$\begin{aligned}\omega(\theta) &= \left[\frac{\pi^D(\theta)}{N} + \delta\frac{\pi^m}{N} + \delta^2\frac{\pi^m}{N} + \cdots\right] - \left[\frac{\pi^m}{N} + \delta\frac{\pi^m}{N+1} + \delta^2\frac{\pi^m}{N+1} + \cdots\right] \\ &= \underbrace{\left[\frac{\pi^D(\theta)}{N} + \frac{\delta}{1-\delta}\frac{\pi^m}{N}\right]}_{\text{Entry-deterrence profit}} - \underbrace{\left[\frac{\pi^m}{N} + \frac{\delta}{1-\delta}\frac{\pi^m}{N+1}\right]}_{\text{Entry-inducing profit}}\end{aligned} \tag{11}$$

where $\pi^D(\theta) < \pi^m$ is the resulting first-period profit of all incumbent lenders when an entry is deterred. The condition for $\omega(\theta) > 0$ is

$$\omega(\theta) > 0 \Rightarrow \pi^D(\theta) > \left[1 - \frac{\delta}{(1-\delta)(N+1)}\right]\pi^m \tag{12}$$

Because the assumption of long-term collusion implies $\delta > 1 - 1/N$, the right-hand side of the condition is less than zero. Therefore, the condition (12) holds if

$\pi^D(\theta) > 0$. In other words, the entry-deterrence pricing strategy is preferred by the incumbent lenders as long as the incumbent lenders can make positive entry-deterrence profit at $T = 0$.

According to Gan & Riddiough (2008), with the purpose of deterring entry, the incumbent lenders would charge a uniform rate $r^{LP} = r^m(\theta^{LP})$ higher than $r^m(\theta)$ to all borrowers in the pool-pricing region $\theta \in (\theta^{LP}, 1)$, concealing the credit quality information to signal zero post-entry profits to the potential competitive entrants (obviously, θ^{LP} must be lower than θ_0 (defined in equation (10)) to deter entry). As a result, the entry-deterrence profit for an incumbent lender is:

$$\pi^D(\theta^{LP}) = \int_0^{\theta^{LP}} \pi^m(\theta) f(\theta)\, d\theta + \int_{\theta^{LP}}^1 (\theta r^m(\theta^{LP}) - \kappa^C) D\big(r^m(\theta^{LP})\big) f(\theta)\, d\theta \quad (13)$$

By the monotonicity of $\pi^D(\theta^{LP})$ and continuity of θ, there must exist $\theta^{\underline{LP}}$ such that $\pi^D(\theta^{\underline{LP}}) = 0$. As a result, the condition (12) holds for $\theta^{LP} \in (\theta^{\underline{LP}}, 1)$.

With the incumbent lenders conducting the entry-deterrence pricing strategy, the entrant cannot exactly infer θ of each borrower from the primary market but learns that $\theta \in (\theta^{LP}, 1)$. Therefore, using Bayes' rule, the entrant's posterior density function is

$$f\big(\theta \big| r = r^{LP}\ for\ \theta \in (\theta^{LP}, 1)\big) = \begin{cases} \dfrac{f(\theta)}{1 - F(\theta^{LP})}, & if\ \theta \in (\theta^{LP}, 1) \\ 0 & otherwise \end{cases} \quad (14)$$

In this case, if a new entrant decides to enter the market with high credit quality ($\theta \in (\theta^{LP}, 1)$), the entrant would set a risk-based monopoly rate without knowing the full credit information for each borrower at the first period. After the first period, the credit information for each borrower can be fully informed. Consequently, the potential discounted stream of post-entry profits for a new entrant is

$$\pi^E(\theta^{LP}) = \underbrace{\frac{1}{N+1}\int_{\theta^{LP}}^{1}\frac{\kappa^C D\left(r^m(\theta)\right)}{\varepsilon-1}\frac{f(\theta)}{1-F(\theta^{LP})}d\theta - \kappa^E}_{\text{The profit at } T=1}$$

$$+ \underbrace{\frac{\delta}{(1-\delta)(N+1)}\int_{\theta^{LP}}^{1}\frac{\kappa^C D\left(r^m(\theta)\right)}{\varepsilon-1}f(\theta)d\theta}_{\text{The discounted stream of post-entry profit for } T\geq 1}$$

$$= \frac{1}{N+1}\int_{\theta^{LP}}^{1}\frac{\kappa^C D\left(r^m(\theta)\right)}{\varepsilon-1}\frac{f(\theta)}{1-F(\theta^{LP})}d\theta - \kappa^E$$

$$+ \left[-\frac{1}{N+1}\int_{\theta^{LP}}^{1}\frac{\kappa^C D\left(r^m(\theta)\right)}{\varepsilon-1}f(\theta)d\theta + \frac{1}{(1-\delta)(N+1)}\int_{\theta^{LP}}^{1}\frac{\kappa^C D\left(r^m(\theta)\right)}{\varepsilon-1}f(\theta)d\theta\right]$$

$$= \underbrace{\left[\frac{1}{N+1}\int_{\theta^{LP}}^{1}\frac{\kappa^C D\left(r^m(\theta)\right)}{\varepsilon-1}\frac{F(\theta^{LP})}{1-F(\theta^{LP})}f(\theta)\,d\theta\right]}_{>0}$$

$$+ \underbrace{\left[\frac{1}{(1-\delta)(N+1)}\int_{\theta^{LP}}^{1}\frac{\kappa^C D(r^m(\theta))}{\varepsilon-1}f(\theta)d\theta - \kappa^E\right]}_{<\frac{1}{(1-\delta)(N+1)}\int_{\theta_0}^{1}\frac{\kappa^C D(r^m(\theta))}{\varepsilon-1}f(\theta)d\theta - \kappa^E \equiv 0 \text{ because } \theta^{LP}<\theta_0} \quad (15)$$

Like Gan & Riddiough's (2008) proof, there exists a cut-off credit quality $\theta^{\overline{LP}}$ such that $\pi^E\left(\theta^{\overline{LP}}\right) = 0$. The perfect Bayesian equilibrium exists in the entry-deterrence pricing strategy for the incumbent lenders on the interest rate:

$$r^D(\theta) = \begin{cases} r^m(\theta) = \dfrac{\kappa^C}{\theta}\left(\dfrac{\varepsilon}{\varepsilon-1}\right), & if\ \theta \in (0,\ \theta^{\overline{LP}}] \\ r^{\overline{LP}} = r^m\left(\theta^{\overline{LP}}\right), & if\theta \in \left(\theta^{\overline{LP}}, 1\right) \end{cases} \quad (16)$$

Proposition 1.

An increase in the cost of entry κ^E will result in an increase in the cut-off credit quality $\theta^{\overline{LP}}$ that separate all borrowers into the primary market ($\theta \in \left(\theta^{\overline{LP}}, 1\right)$) and subprime market ($\theta \in (0,\ \theta^{\overline{LP}}]$) and decrease in the pool-pricing interest rate for the

primary market, $r^{\overline{LP}}$. Therefore, $r^{\overline{LP}}$ decreases as the level of discretion in the loan market increases.

$$\frac{\partial\, \theta^{\overline{LP}}}{\partial \kappa^E} > 0, \qquad \frac{\partial r^{\overline{LP}}}{\partial \kappa^E} < 0, \qquad \frac{\partial r^{\overline{LP}}}{\partial \tau} < 0 \tag{17}$$

Proof: This follows immediately upon $\pi^E\left(\theta^{\overline{LP}}\right) = 0$, $\partial \pi^E(\theta^{LP})/\partial \theta^{LP} > 0$, and $\partial \kappa^E/\partial \tau > 0$.

Define the mark-up for expected entry-deterrence pool-pricing interest rate, α^D as

$$\alpha^D = \frac{\theta r^{\overline{LP}}}{\kappa^C} \; for\; \theta \in \left(\theta^{\overline{LP}}, 1\right) \tag{18}$$

Proposition 2.

An increase in the level of discretion in the loan market will lead the mark-up power of the incumbent lenders in the primary market to decrease.

$$\frac{\partial \alpha^D}{\partial \tau} = \frac{\theta}{\kappa^C}\frac{\partial r^{\overline{LP}}}{\partial \tau} < 0 \tag{19}$$

This proposition predicts that as the process of interest rate liberalization completes in China, the mark-up power of the incumbent lenders will decrease.

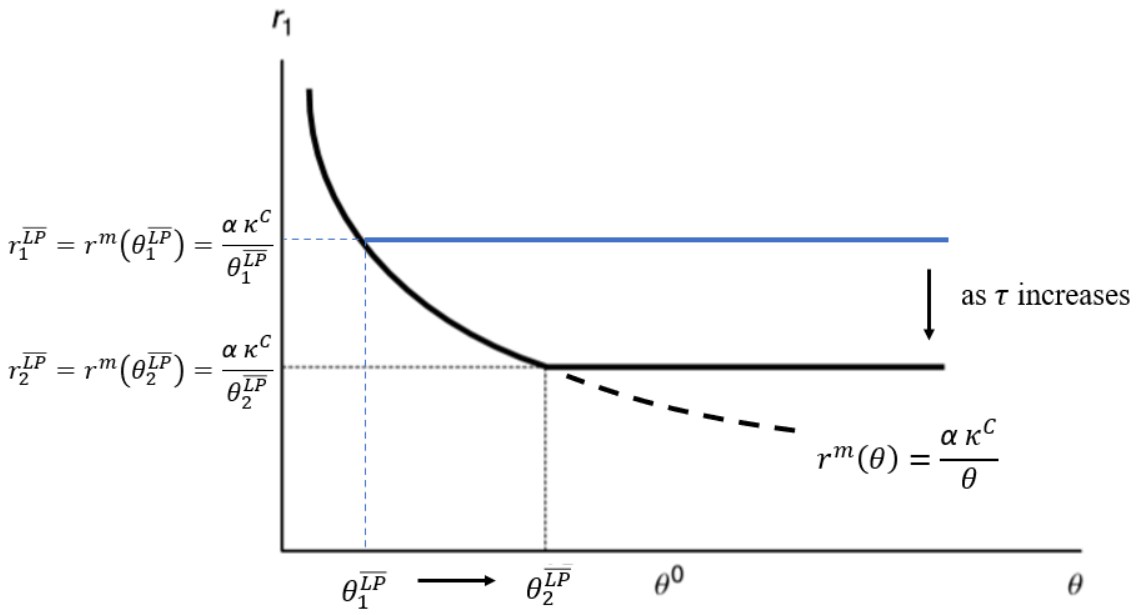

Figure 4.1 The pricing model through the channel of information advantage (with an increase in the level of discretion in the loan market)

4.2 Pricing Model in the Game of Imperfect Information with Primary Borrowers

Three limitations of the model of pricing strategy of incumbent lenders through the channel of information advantage are:

- Assume perfect information between incumbent lenders and borrowers.
- Assume borrowers are price-takers, who will always accept the lowest interest rate given to them.
- Assume the probability density function for credit quality θ, $f(\theta)$ is exogenous.

These assumptions are strong enough to mitigate the external validity of the propositions from the pricing model through the channel of information advantage.

Firstly, as discussed in the section of the literature review, it is unrealistic that the information regarding credit quality θ, can be fully observed by all lenders. In reality, there usually exits some private information to each borrower about the underlying riskiness of the project he seeks to finance. Secondly, borrowers cannot always accept the available offers in the market, especially when borrowers find that the expected returns associated with the loans can not cover the interest rate they are supposed to pay. Thirdly, the arguments against the first two aforementioned assumptions will cause the emergence of "adverse selection" (Stiglitz & Weiss, 1981) and "moral hazard" (Rothschild & Stiglitz, 1978). Because adverse selection and moral hazard lead both of the probability density function and the individual default probability for borrowers' credit quality to be associated with repayment requirements on loans, the $f(\theta)$ and θ are no longer exogenous in the model. Consequently, I must take into account the role of asymmetric information in the loan market.

Complementing my baseline pricing model through the channel of information advantage, I focus on the effect of asymmetric information on pricing strategy in the prime loan market and develop an extended pricing model in the game of imperfect information with primary borrowers. There are two reasons for choosing the primary loan market: First, when the incumbent lenders use the pool-pricing interest rate for the primary market, $r^{\overline{LP}}$ to deter entry, the primary market ($\theta \in \left(\theta^{\overline{LP}}, 1\right)$) with one uniform rate for all primary borrowers creates good conditions for adverse selection and moral hazard. Second, the $r^{\overline{LP}}$ is the lowest interest rate at which the incumbent lenders can provide in the whole market. This means that $r^{\overline{LP}}$ is more sensitive as the policy rate changes. Therefore, $r^{\overline{LP}}$ serves as a benchmark loan rate or primary rate. The model of

pricing strategy in the game of imperfect information with primary borrowers is developed based on some idea of Stiglitz and Weiss's (1981) research. In their model, Stiglitz and Weiss (1981) theoretically illustrate how credit rationing could be an equilibrium feature of the loan market with the existence of adverse selection. Acting as a "screening device" that filters out the risky borrowers from the interest rate they are willing to pay, the interest rate increases with the exacerbation of adverse selection, inducing a decrease in the average credit quality (an increase in the average riskiness) of the pool of borrowers. My model proves the existence of a moral hazard and adverse selection with the assumption of asymmetric information (or imperfect information) in the primary loan market, which is separated by incumbents' entry-deterrence pricing strategy. Furthermore, I examine the effect of moral hazard and adverse selection on the incumbent lenders' mark-up power and their discretion-room to set a pool-pricing interest rate for the primary market. Note that because the pricing model in the game of imperfect information with primary borrowers is a supplementary model for the pricing model through the channel of information, these two models share the same notations unless I mention the difference specifically.

4.2.1 The Effect of Moral Hazard on the Loan Pricing Strategy

At first, I examine the existence of moral hazard in the primary loan market with imperfect information. I assume that there is a distinct probability distribution of return R for the project that different individual borrower seeks to finance. The most important assumption is that all lenders can not directly observe the probability distribution of return for each project but are able to distinguish projects with different mean returns. For simplicity, therefore, I assume the lenders are facing projects with the same mean return

in the primary loan market ($\theta \in (\theta^{\overline{LP}}, 1)$). I write the probability density function of returns R as $g(R, \sigma) \in (0, \infty)$ and the cumulative distribution $G(R, \sigma) \in (0, 1)$, where parameter σ represents the borrower's riskiness. Like Stiglitz and Weiss (1981), I assume that greater σ corresponds to greater risk in the sense of mean preserving spreads. According to the proposition of second-order stochastic dominance (SOSD), for $\sigma_1 > \sigma_2$ ($G(R, \sigma_1)$ is a mean preserving spread of $G(R, \sigma_2)$), if

$$\int_{-\infty}^{\infty} R g(R, \sigma_1) dR = \int_{-\infty}^{\infty} R g(R, \sigma_2) dR \tag{20}$$

then for any $y_1 \geq y_2$ and for any increasing and convex $u(\cdot)$

$$\int_{y_1}^{y_2} u(R, \sigma_1) dG(R, \sigma_1) \geq \int_{y_1}^{y_2} u(R, \sigma_2) dG(R, \sigma_2) \tag{21}$$

If the incumbent lenders charge a primary borrower $r^{\overline{LP}}$ for each dollar he is willing to borrow; then I say that the borrower will default on his loan if the return R plus the collateral C for each dollar of his loan are not enough to payback r^{LP}. That is a borrower will default if

$$R + C \leq r^{\overline{LP}} \leftrightarrow \underbrace{R - r^{\overline{LP}}}_{\text{profit from repayment}} \leq \underbrace{-C}_{\text{profit from default}} \tag{22}$$

Therefore, it is clear to see that each consumer's credit quality θ, which is measured by *1 – PD*, is:

$$\theta = 1 - PD = \int_{r^{\overline{LP}} - C}^{\infty} g(R, \sigma) dR = 1 - G(r^{\overline{LP}} - C, \sigma) \tag{23}$$

Obviously, each borrower's credit quality is not exogenous but related to the interest rate, r^{LP} that lenders offer to him. Simply differentiating the above equation, I get:

Proposition 3.

The credit quality of borrowers decreases as the interest rate increases.

$$\frac{\partial \theta}{\partial r^{\overline{LP}}} = -g\left(r^{\overline{LP}} - C, \sigma\right) < 0 \tag{24}$$

Proposition 3 proves the existence of "moral hazard." With the existence of a moral hazard, I can rewrite mark-up for expected entry-deterrence pool-pricing interest rate, α^D as

$$\alpha^D = \frac{\theta r^{\overline{LP}}}{\kappa^C} = \frac{[1 - G\left(r^{\overline{LP}} - C, \sigma\right)]r^{\overline{LP}}}{\kappa^C} \tag{25}$$

Proposition 4.

With perfect information in a primary market, the mark-up power (α^D) of the interest rate in the primary market decreases as the level of discretion in price-setting increases. This effect is mitigated, however, by moral hazard.

This follows immediately upon differentiating α^D with respect to τ:

$$\begin{aligned}
\frac{\partial \alpha^D}{\partial \tau} &= \frac{1 - G\left(r^{\overline{LP}} - C, \sigma\right) - g\left(r^{\overline{LP}} - C, \sigma\right)r^{\overline{LP}}}{\kappa^C} \frac{\partial r^{\overline{LP}}}{\partial \tau} \\
&= \frac{1 - G\left(r^{\overline{LP}} - C, \sigma\right)}{\kappa^C} \frac{\partial r^{\overline{LP}}}{\partial \tau} + \left[-g\left(r^{\overline{LP}} - C, \sigma\right) \frac{r^{\overline{LP}}}{\kappa^C} \frac{\partial r^{\overline{LP}}}{\partial \tau}\right] \\
&= \underbrace{\frac{\theta}{\kappa^C} \frac{\partial r^{\overline{LP}}}{\partial \tau}}_{\frac{\partial \alpha^D}{\partial \tau} | perfect\ information < 0} + \underbrace{\frac{\partial \theta}{\partial r^{\overline{LP}}} \frac{r^{\overline{LP}}}{\kappa^C} \frac{\partial r^{\overline{LP}}}{\partial \tau}}_{\text{effect of moral hazard} > 0}
\end{aligned} \tag{26}$$

4.2.2 The Effect of Adverse Selection on the Loan Pricing Strategy

Next, following Stiglitz and Weiss's (1981), I examine the role of adverse selection in the pricing-strategy for the primary loan market. Based on the above discussion, the net return to the borrower $\Pi(R,\ r^{\overline{LP}})$ can be written as

$$\Pi\left(R,\ r^{\overline{LP}}\right) = max\ (R - r^{\overline{LP}}, -C) \tag{27}$$

As a result, I can immediately observe that $\Pi\left(R,\ r^{\overline{LP}}\right)$ is a convex function for $R \in \left(-\infty, \infty\right)$:

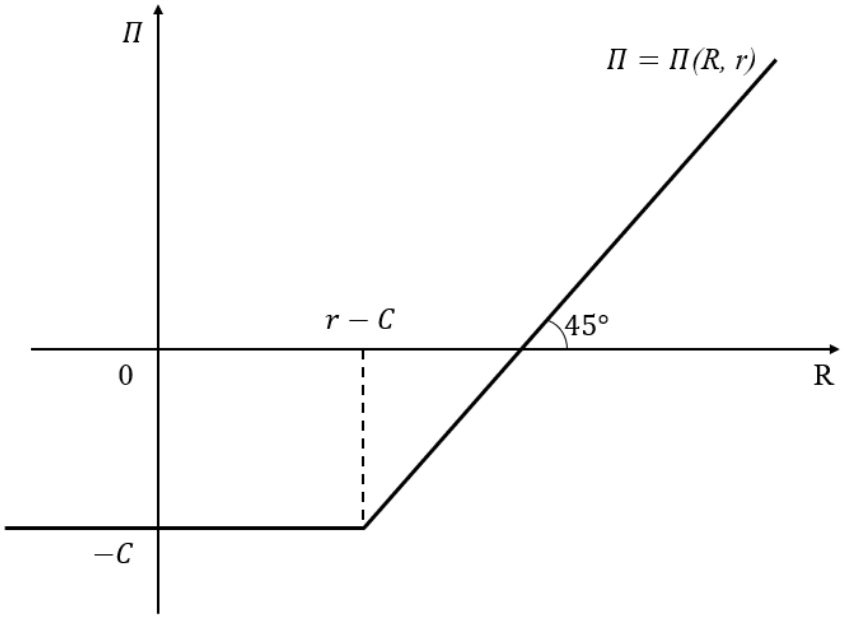

Figure 4.2 The borrowers' profits are a convex function of the return on the project

Define a critical value $\hat{\sigma}$ such that the expected profits $\overline{\Pi}(r, \hat{\sigma})$ of a borrower with a given interest rate is zero:

$$\overline{\Pi}(r, \hat{\sigma}) \equiv \int_{-\infty}^{\infty} \Pi\left(R,\ r^{\overline{LP}}\right) dG(R, \hat{\sigma}) \equiv \int_{-\infty}^{\infty} max\ (R - r^{\overline{LP}}, -C) dG(R, \hat{\sigma}) \tag{28}$$

Proposition 5.

For a given interest rate $r^{\overline{LP}}$, borrowers borrow if and only if $\sigma > \hat{\sigma}$ and $\theta < \hat{\theta}$.

Proof: Given an interest rate $r^{\overline{LP}}$, borrowers borrow if and only if the expected profits $\overline{\Pi}(r, \sigma)$ is larger than zero:

$$\overline{\Pi}(r, \sigma) \geq 0 \equiv \overline{\Pi}(r, \hat{\sigma}) \tag{29}$$

By the convexity of $\Pi\left(R,\ r^{\overline{LP}}\right)$ and the proposition of SOSD (even though $\Pi\left(R,\ r^{\overline{LP}}\right)$ is not strictly convex, the following proof is still valid because $-\infty < r - C < \infty$),

$$\int_{-\infty}^{\infty} \Pi\left(R,\ r^{\overline{LP}}\right) dG(R, \sigma) \geq \int_{-\infty}^{\infty} \Pi\left(R,\ r^{\overline{LP}}\right) dG(R, \hat{\sigma})$$

if and only if

$$\sigma > \hat{\sigma}\ (G(R, \sigma_1) \text{ is a mean preserving spread of } G(R, \sigma_2))$$

$$\Rightarrow 1 - G(r^{\overline{LP}} - C, \sigma) < 1 - G(r^{\overline{LP}} - C, \hat{\sigma}) \Rightarrow \theta < \hat{\theta} \tag{30}$$

Proposition 5 proves the existence of adverse selection, which results in the interest rate acting as a screening device to separate good and bad risks among the primary loan market. Consequently, the adverse selection shrinks the primary loan market from the borrowers with the credit quality of $\theta \in \left(\theta^{\overline{LP}}, 1\right)$ to $\theta \in \left(\theta^{\overline{LP}}, \hat{\theta}\right)$.

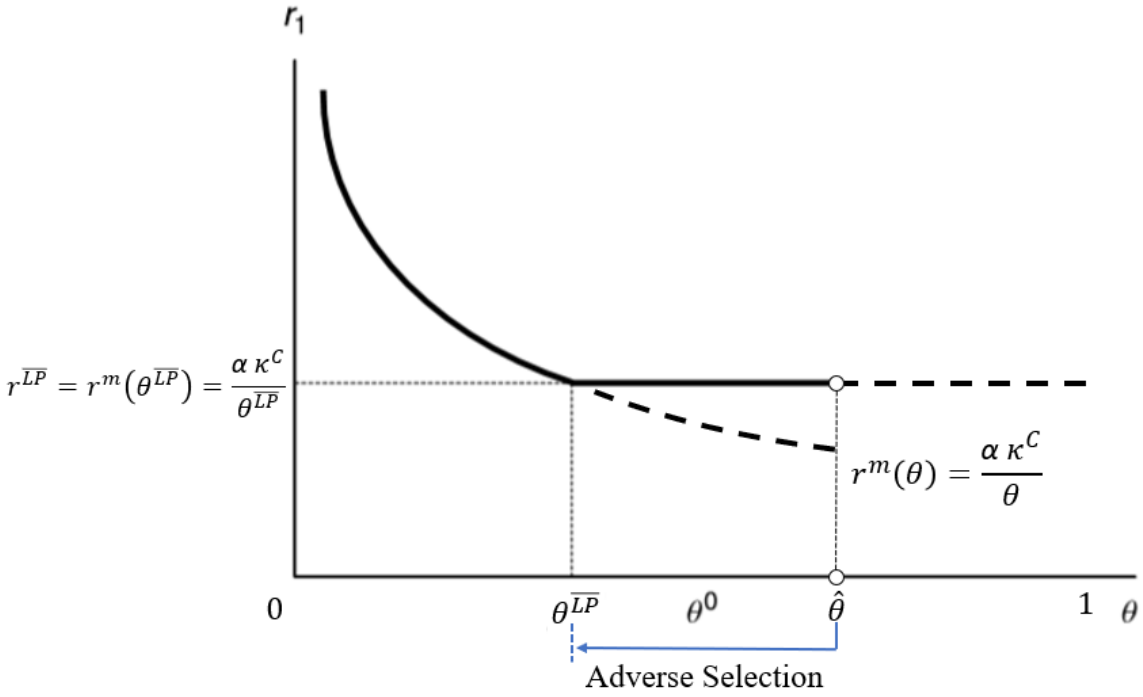

Figure 4.3 The existence of adverse selection in the loan market with incumbent lenders conducting entry-deterrence pricing strategy

With the existence of adverse selection, the first-period profit of all incumbent lenders when an entry is deterred, π^D is:

$$\pi^D = \int_0^{\theta^{\overline{LP}}} \pi^m(\theta) f(\theta)\, d\theta + \int_{\theta^{\overline{LP}}}^{\hat{\theta}} \left(\theta r^m\left(\theta^{\overline{LP}}\right) - \kappa^C\right) D\left(r^m\left(\theta^{\overline{LP}}\right)\right) f(\theta)\, d\theta \quad (31)$$

As discussed in the pricing model through the channel of information advantage, the incumbent lenders are willing to conduct an entry-deterrence pricing strategy as long as $\pi^D > 0$. As $\theta^{\overline{LP}}$ decreases or $r^{\overline{LP}} = r^m\left(\theta^{\overline{LP}}\right)$ increases, π^D decreases until $\pi^D = 0$. Define the lowest value of pool-pricing interest rate as $\theta^{\underline{LP}}$ such that

$$\pi^D(\theta^{\underline{LP}}) = \int_0^{\theta^{\underline{LP}}} \pi^m(\theta) f(\theta)\, d\theta + \int_{\theta^{\underline{LP}}}^{\hat{\theta}} (\theta r^m(\theta^{\underline{LP}}) - \kappa^C) D\left(r^m(\theta^{\underline{LP}})\right) f(\theta)\, d\theta = 0 \quad (32)$$

Therefore, the range of $\theta^{\overline{LP}}$ with the change of exogenous variables in the model is ($\theta^{\underline{LP}}$, $\hat{\theta}$) while the range of the pool-pricing interest rate $r^{\overline{LP}}$ for the primary market is ($r^m(\hat{\theta})$, $r^m(\theta^{\underline{LP}})$), where the incumbent lenders always prefer the entry-deterrence pricing strategy. With perfect information in a primary market, the incumbent lenders can set the pool-pricing interest rate $r^{\overline{LP}}$ for the primary market within a fixed range of ((($r^m(1)$, $r^m(\theta^{\underline{LP}})$). With the existence of adverse selection, the range of $r^{\overline{LP}} \in$ ($r^m(\hat{\theta})$, $r^m(\theta^{\underline{LP}})$) becomes flexible.

Proposition 6.

With the existence of adverse selection, an increase in the level of discretion indicates that the incumbent lenders can have more room to set the pool-pricing interest rate $r^{\overline{LP}}$ for the primary market.

$$as\ \tau\ increases \xrightarrow{r^{\overline{LP}}\downarrow \Rightarrow \hat{\sigma}\uparrow \Rightarrow \hat{\theta}\uparrow \Rightarrow \theta^{\underline{LP}}\downarrow} \left(r^m(\hat{\theta}),\ r^m(\theta^{\underline{LP}})\right)\ expands \qquad (33)$$

This follows immediately by using the aforementioned propositions.

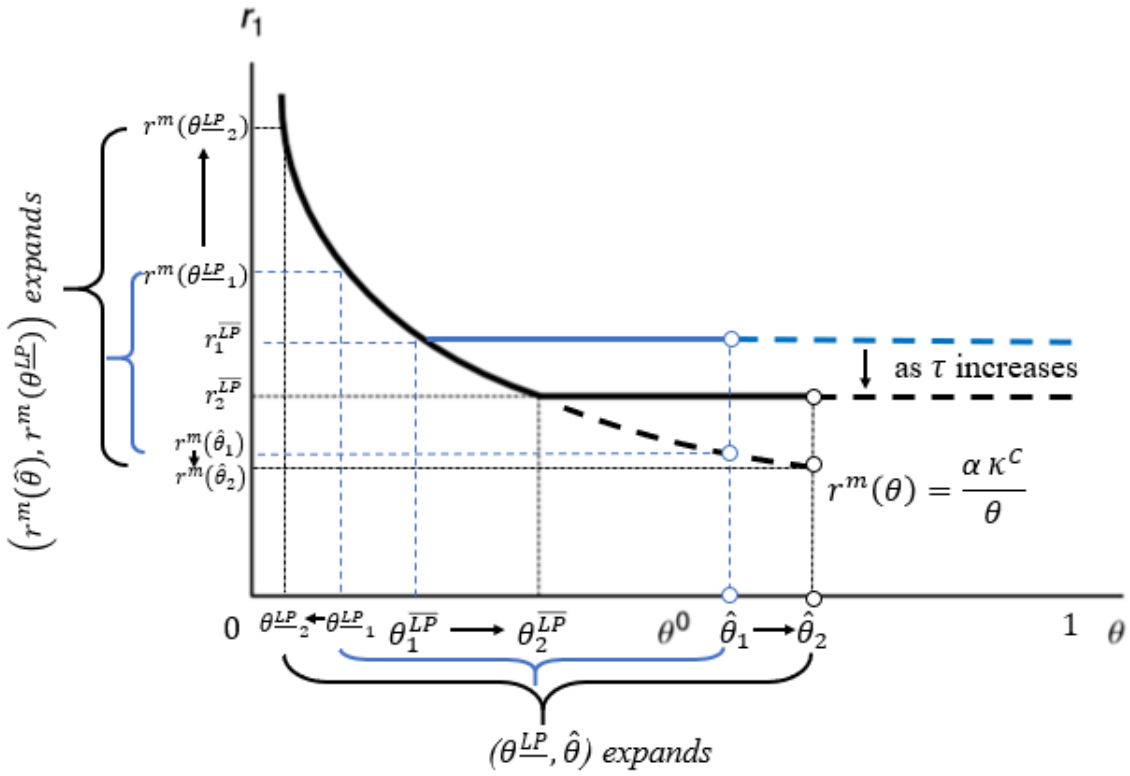

Figure 4.4 The effect of adverse selection in the loan market with incumbent lenders conducting entry-deterrence pricing strategy

Chapter 5 Statistical Methodology

One important prediction of my theoretical models is that as the process of interest rate liberalization completes in China, the mark-up power of the incumbent lenders will decrease (see Proposition 2). As I discussed in Chapter 4, the decrease in the mark-up power is not a signal of the lower market power of dominant lenders but a change of their pricing strategy with the increasing level of discretion in the loan market to protect their information advantage over potential entrants. Therefore, the next job of my research is to find empirical evidence of decreasing mark-up with the progress of interest rate liberalization from the real-world data to support my theoretical propositions. Since many researchers confirm the fitness of the OLS model (Zhu, et al., 2009; Li & Liu, 2019) in the relevant research field, I also conduct a linear regression on short-run relationship between loan interest rate and cost per loan with period dummies to test the effect of interest rate liberalization on the mark-up pricing in China's loan market.

5.1 The Regression on Short-run Relationship with Period Dummies

$$y_t = \alpha_1 D_1 + \alpha_2 D_2 + \alpha_3 D_3 + \beta_1 D_1 x_t + \beta_2 D_2 x_t + \beta_3 D_3 x_t + \gamma_1 x_{t-1} + \varepsilon_t \quad (34)$$

$$H_0: \alpha_1 = \alpha_2 = \alpha_3$$

vs

$$H_a: \alpha_1 > \alpha_2 \,\&\, \alpha_2 > \alpha_3$$

where D_1 equals 1 when it is pre-loan rate liberalization and 0 otherwise; D_2 equals 1 when it is partial loan rate liberalization and 0 otherwise; D_3 equals 1 when it is post-loan rate liberalization and 0 otherwise. Note that in order to avoid the perfect multicollinearity, I drop the constant (1) and x_t from the regression model.

Because my research focuses on the mark-up pricing in the loan market in China, y_t is the historical loan rate offered by a big lender and x_t should be the cost per loan. Since it is difficult to observe the cost per loan, the researcher usually chooses the policy rate or deposit rate as the alternatives. For example, Friedman and Shachmurove (2015) use the Federal Funds Rate (FFR) as the cost of per loan x_t due to the fact that FFR acts as the policy rate in the United States. Zhu et al. (2009) choose a 3-month certificate of deposit (CD) rates to study the prime rate behavior in the movement of market interest rates. Therefore, I use one-year deposit benchmark rate, which is also the policy rate in China, as the alternative to the cost per loan.

Following Li and Liu (2019), α_1, α_2, and α_3 represent the level of mark-ups during the period of pre-loan rate liberalization, partial loan rate liberalization, and post loan rate liberalization, respectively. According to the Proposition 2 from my pricing model through the channel of information advantage, the mark-up is supposed to be decreasing as the progress of interest rate liberalization: $\alpha_3 < \alpha_2 < \alpha_1$.

Chapter 6 Data and Empirical Results

6.1 Data

I collect the monthly time series of the one-year deposit benchmark interest rate (*rd*) from the official website of the PBOC. As I discussed in the section of institutional background, deposit benchmark interest rate is the main tool used by the PBOC to conduct monetary policy, so the one-year deposit benchmark interest rate is the policy rate in China. Moreover, I collect the monthly time series of a one-year loan rate (*rl*) from the official website of the Bank of China (BOC). Although my data sample has high similarities with Li and Liu's (2019) data, there are three differences between my data sample and theirs. Firstly, my sample period is from January 1993 (when PBOC decided to set benchmark ceiling and floor for both deposit and loan benchmark rates) to the latest data published to the public (August 2020). Secondly, unlike Li & Liu consider the removal of the loan rate floor in 2013 as the completion of loan rate liberalization, I regard the replacement of loan benchmark rate by LPR as the completion of loan rate liberalization. In this sense, I separate the sample into three periods (see Appendix A-C): pre-loan interest rate liberalization (Jan 1993 to June 2013), partial loan rate liberalization (July 2013 to July 2019), and post-loan interest rate liberalization (August 2019 to now). Thirdly, my sample data of the loan interest rate is from the historical loan rate offered by BOC, one of the big lenders in China's loan market.

6.1.1 Descriptive Statistics

Table 1 (see Appendix C) reports the summary statistics for time series of interest over sampling period, including *rd*, *rl*, *loan spread* ($loan\ spread = rl - rd$), *up* ($up = loan\ spread_t - loan\ spread_{t-1} | \ loan\ spread_t > loan\ spread_{t-1}$), and *down* ($down = loan\ spread_t - loan\ spread_{t-1} | \ loan\ spread_t < loan\ spread_{t-1}$). I notice that there is no increase in the loan spread (no observation of *up*) since the removal of loan rate floor in July 2013. Specifically, the loan spread decreased once during the period of partial loan rate liberalization and three times during the period of post-loan rate liberalization until January 2020 (since which the POBC decreases MLF to conduct expansionary monetary policies to stimulate the decreasing aggregate demand caused by COVID-19). Compared to the pre-loan rate liberalization, the deposit benchmark rate rd has less right-skewness or even left-skewness from July 2013 to January 2020, implying lower frequency of low-interest rates and less expansionary monetary policies after 2013. Therefore, I can say that the higher frequency of decreasing loan spread is not likely due to expansionary monetary policies but attributed to the process of interest rate liberalization. Because loan spread can roughly reflect the degree of mark-up power in the loan market, the above finding from descriptive statistics of data is consistent with the prediction of my theoretical models: as the process of interest rate liberalization complete in China, the mark-up power of the incumbent lenders will decrease (see Proposition 2). I re-confirm this consistency by observing a decreasing loan spread and a decreasing ratio of loan rate to the deposit rate during the period of post-loan rate liberalization.

6.2 Impact of Interest Rate Liberalization on Short-run Relationship

After confirming the appropriate specification of linear regression on the behaviour of loan rate and policy rate, I firstly conduct the OLS regression on the short-run relationship between a one-year loan rate and a one-year deposit benchmark rate with three-period dummies (see Appendix D). Statistically significant, the coefficients of the dummy of pre-loan rate liberalization (*D1*) and the dummy of partial loan rate liberalization (*D2*) are 4.16 and 2.72. These coefficients imply that before the loan rate liberalization, the average mark up is 4.16 while during the period of partial loan rate liberalization, the average mark up in the loan market decreases by 1.44 to 2.72 percentage points on average. Unfortunately, I can not find an efficient coefficient of the dummy of post-loan rate liberalization (*D3*) because of the limited number of observations (which is 12). In order to estimate the effect of interest rate liberalization on the average mark-up of loan pricing during post-interest rate liberalization, I combine the periods of partial and post interest rate liberalization together and find that the coefficient of the new period dummy (*D_2*) of the period after the removal of loan rate floor (July 2013) is further down to 2.58 (see Appendix D). Obviously, I can say that the difference between the coefficient of *D_2 and D2* implies an even lower average mark-up in the period of post-loan rate liberalization than any period before. Consequently, I provide empirical evidence of decreasing mark-up loan pricing as the process of loan interest rate liberalization completes.

According to Li & Liu (2019), the slope coefficients β_1, β_2, and β_3 capture the effect of short-run passthrough from the policy rate to the loan rate offered by the

dominant lenders during the period of pre-loan rate liberalization, partial loan rate liberalization, and post loan rate liberalization. I find that there is an increasing trend in the slope coefficient β with the progress of loan rate liberalization ($\beta_1 = 0.44$, $\beta_2 = 0.84$, and β_3=2.45), suggesting that the effectiveness of monetary policy transmission through the channel of interest rate improves as the loan rate liberalization completes in China.

Chapter 7 Conclusions

The introduction of LPR in 2019 is an important milestone on the road of interest rate liberalization in China, suggesting the completion of the loan rate liberalization. In order to find how the process of interest rate liberalization influences the pricing strategy of dominant lenders in China's loan market and their mark-up power, I establish two pricing models to examine the effect of level of discretion in an oligopoly loan market on the incumbent lenders' entry-deterrence pricing strategy on the basis of prior theoretical research. In my pricing model through the channel of information advantage and pricing model in the game with primary borrowers, I find two important propositions: First, with perfect information in a primary market, the mark-up power of the interest rate in the primary market decreases as the level of discretion in price-setting increases; This effect is mitigated, however, by moral hazard. Second, with the existence of adverse selection, an increase in the level of discretion indicates that the incumbent lenders can have more room to set the pool-pricing interest rate for the primary market. Furthermore, I also provide empirical evidence of decreasing mark-up loan pricing as the process of loan interest rate liberalization completes, which is consistent with prediction of my theoretical model.

However, I have to mention some drawbacks of my empirical part of the study: Firstly, since the benchmark rates and loan rates in China sometimes stay unchanged for several months, the efficient information of time series of interest rates is limited in my data. Secondly, there may exist endogeneity in the right-hand side variables in my OLS

regression model. Thirdly, there is one identification problem in my empirical results. My econometric methodology cannot explain whether the deceasing mark-up price is attributed to the higher competitiveness in China's loan market (Li & Liu's (2019) explanation) or the change of pricing strategy with the increasing level of discretion (my explanation). Further research could focus on finding other empirical evidence to test the external validity of the propositions from my theoretical models of loan pricing with information advantage and the existence of asymmetric information. To identify the role of imperfect information (moral hazard effect and adverse selection effect) from the total effect of interest rate liberalization on the loan pricing of the entry-deterrence strategy, more granular data (at firm level) are required in the future study.

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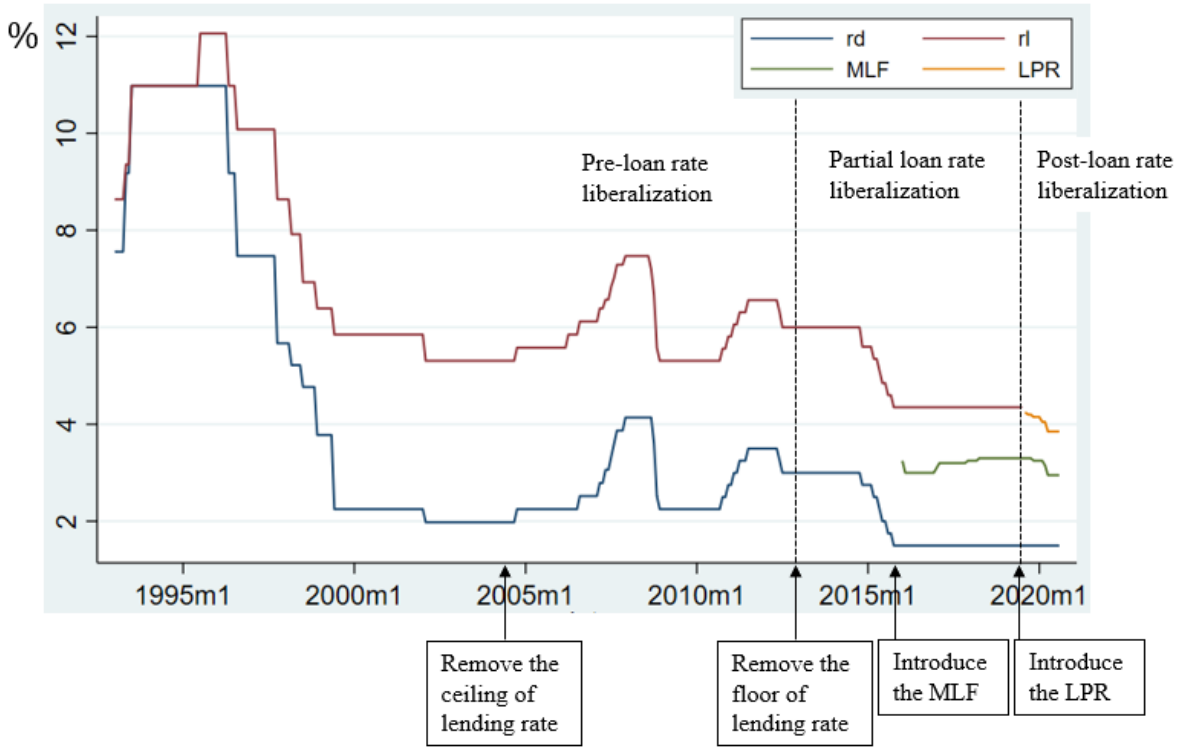
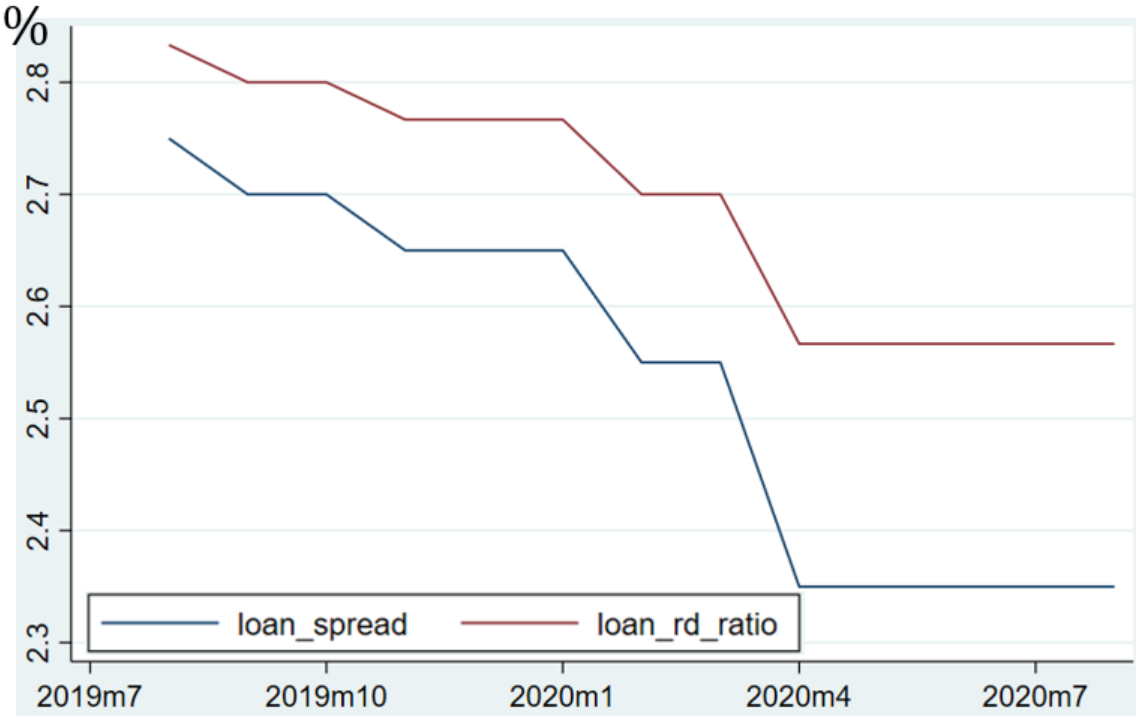
Appendix A

Time series of one-year loan rate (rl), one-year deposit rate (rd), Medium-term Lending Facility (MLF), and Loan Prime Rate (LPR) from Jan 1993 to Aug 2020



Appendix B

Time series of Interest loan spread (loan_spread) and the ratio of loan rate to deposit rate (loan_rd_ratio) in the post-loan rate liberalization



Appendix C

Table 1.

Descriptive Statistics

Pre-Interest Rate Liberalization: Jan. 1993 - Jun. 2013						
Variable	Obs	Mean	Std. Dev.	Min	Max	Skew.
rl	246	7.124	2.145	5.31	12.06	1.10
rd	246	4.405	3.134	1.98	10.98	1.25
loan_spread	246	2.719	1.106	0	3.6	-1.61
up	7	0.669	0.315	0.27	1.08	0.02
down	10	-0.276	0.262	-0.9	-0.06	-1.50
Partial Interest Rate Liberalization: July. 2013 - July. 2019						
Variable	Obs	Mean	Std. Dev.	Min	Max	Skew.
rl	73	4.838	0.703	4.35	6	0.88
rd	73	1.955	0.649	1.5	3	0.83
loan_spread	73	2.883	0.062	2.85	3	1.36
up	0					
down	1	-0.150	.	-0.15	-0.15	
Post-Interest Rate Liberalization: Aug. 2019 - Aug. 2020						
Variable	Obs	Mean	Std. Dev.	Min	Max	Skew.
rl	13	4.035	0.161	3.85	4.25	-0.16
rd	13	1.500	0.000	1.5	1.5	0
loan_spread	13	2.535	0.161	2.35	2.75	0.16
up	0					
down	5	-0.100	0.061	-0.2	-0.05	-0.91

Note. The *loan_spread* is the difference between loan rate (rl) and deposit benchmark rate (rd). *Up* (*Down*) is measured by the difference between a *loan_spread* and that of the previous month, which is larger (less) than zero.

Appendix D

The Regression on Short-run Relationship with Period Dummies

v1	v2	v3
	(1)	-2
	Three Period Dummies	Two Period Dummies
VARIABLES	rl	rl
D1	4.16***	4.16***
	[-0.039]	[-0.039]
D2	2.72***	
	[-0.131]	
o.D3	-	
D1rd	0.44***	0.43***
	[-0.075]	[-0.076]
D2rd	0.84***	
	[-0.099]	
D3rd	2.45***	
	[]-0.099]	
L.rd	0.24***	0.24***
	[-0.075]	[-0.076]
D_2		2.58***
		[-0.123]
D_2rd		0.89***
		[-0.098]
Observations	331	331
R-squared	1	1
Prob > F (D1=D2 (=D3))	0.000	0.000

Standard errors in brackets *** p<0.01, **p<0.05, * p<0.1