Technical Innovation and X Efficiency in the Chinese Banking Industry: Estimations Based on Shadow Profit Function

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Abstract -- X efficiency here means inefficiency, and X represents all of the factors leading to lower efficiency. At present, from input and output aspects, foreign academic circles decompose X efficiency into two components: technical inefficiency and allocative inefficiency. For the research methods, some scholars have demonstrated that the profit-function method has more advantages than the traditional stochastic cost method, data envelopment analysis and distribution-free approach. About X efficiency of banking industry, researches of Chinese scholars have two obvious deficiencies: i) neither considering technical inefficiency nor considering allocative inefficiency of the banking industry, ii) profit function method is rarely used in studying, and simplified bank of inputs and outputs. One of the unanimous conclusions by Chinese scholars is that state-owned banks are more inefficient than joint-stock banks. In view of this, under the hypothesis of multiple inputs and outputs and through the trans-log shadow profit function, this paper estimates the X efficiency of China's banking industry. In order to get more accurate examinations of X efficiency here, besides both technical and allocative inefficiency, the paper simultaneously considers all the factors which can influence X efficiency, such as ownerships of banks, monetary policies, technology innovations, the regulation of central bank and banking self-help-pricing power. We found that all these factors influence X efficiency in China, so simply asserting that the state-owned banks are more inefficient than joint-stock banks is not accurate.

Keywords - X efficiency, technical inefficiency, allocative inefficiency, shadow profit

I. INTRODUCTION

X-efficiency, first advocated by Leiben-Stein(1966), was in fact a low-efficient or inefficient state, X representing all factors that contribute to the X-efficiency. According to the explanations, "the firm theory also advocated some assumptions as any other theories. One of the assumptions is that firms are efficient inside…..these assumptions make it possible for economic theories to neglect the operations and efficiency inside firms and focus on the market efficiency outside firms. Because of these assumptions, there is a sort of inefficiency called X-efficient by Leiben Stein." That is to say, under given inputs of factors, if the changes of inputs of factors can increase outputs of some products, and do not decrease the outputs of any other products simultaneously, it means that X-inefficiency exists inside the firm.

At early times, research methods about X efficiency mainly included Stochastic Cost Frontier which was applied in studies made by Kumbhakar (1991),Timme and Yang(1991) and Kaparakis et al.(1994). Another research method is Data Envelopment Analysis which incorporates with programming technology and assumes that there are no random impacts. It was also implemented in researches made by Kopp and Diewert (1982), Aly et al.(1990), Ferrier and Lovell (1990, Ferrier et al.(1991） and English et al.(1993).

Berger et al.(1993) questioned the two research methods and thought the basic assumptions based on these two methods were that: if a firm could not maximize its output with given inputs, it would be considered to have X-efficiency. Through demonstrating the output scale being lower than the production possibility frontier, Researchers usually concluded the firm had X-efficiency inside. As a matter of fact, Companies that could not reach the maximum production can also result from unreasonable inputs. Therefore, Berger et al.(1993)raised the concepts of Technological Inefficiency(TI) and AI and gave the latter a definition: since input decisions will influence the relative shadow price, firm always faces extra constraints from the supervisor. Moreover, after price adjustment, the relative shadow price will always be different from relative actual price. They added intercept terms describing the characteristics of firm into input equations, and used the terms to express the deviation of each input from its ideal level. Such a definition made AI and TI to independent each other. And in the research, Berger et al.(1993) has applied a distribution-free approach to the non-logarithmic normalized profit function. The most prominent advantage lies in its ability to decompose both AI and TI into input and output components, which make the nature of X efficiency even clearer.

After that, the conceptions of AI and TI were accepted by the entire western academy. However, many scholars questioned about distribution-free method. For example, instead of accepting distribution-free method, Kumbhakar(1996) advocated the analyzing profit function approach. He regarded the analyzing profit function approach being better than distribution-free approach, basing on follow two reasons. First, although Distribution-free approach can decompose TI and AI, the premise must be that their covariance is 0 which means they have no influence on each other. And it may be inconsistent with the actual situation. Second, as profit being the ultimate goal of companies, the approach is naturally predominant through analyzing profit function. Early researches which utilized analyzing profit function approach included Toda (1976), Yotopoulos(1971), Atkinson and Halvorsen(1980,1984),etc. Basing on these researches, Atkinson and Cornwell (1994a, 1994b) normalized single output profit function and simultaneously introduced both TI and AI into the function under a profit maximization framework

Recently, Huang (2010) developed the analyzing profit function approach mainly in two aspects: first, translating single output profit function into multi-output profit function, second, substituting actual price and actual profit with shadow price and shadow profit. He thought, shadow price contains information about the factors' efficiency, so it is more appropriate for measuring X efficiency. The methods which distinguish between TI and AI in studying X efficiency is undoubtedly reasonable. However, data of time series are frequently used by scholars in empirical study about X efficiency. A premise is underlying in such researches, that is: during sample period, companies do not make any technological innovations .If the period is relatively short; such negligence will cause little deviance. But for a long sample period, it will lead to distortion of result.

Since 2000, many Chinese scholars have studied about X efficiency in China's bank industry. The consensuses of these studies include that there exists X efficiency in China's banking system, mainly presenting in inconsistent changes between scale efficiency in bank industry and the levels of efficiency per year, such as Jianhua Zhang(2003), that efficiency of joint-stock banks is higher than those of state-owned banks, such as Kailian Liu and Haiyan Luo (1990), Kun Chang and Shouqiao Jia(2006), Lingling Liu and Xixin Li (2006), Zhixin Liu and Liuchen (2006), Guotai Chi et al. (2005), Zhunan and other researches(2004),as well as study made by Yaojie et al. (2004). Some scholars even conducted research about difference of bank efficiency due to regional diversity, such as study made by Jianhua Zhang (2003) in which he pointed out banks with the lowest efficiency in China are commercial banks in urban area. Also, Zhixin Liu and Chen Liu (2004) indicated in their research that those who have gone public among joint-stock commercial banks are ones with higher efficiency.

However other scholars regarded that there is no apparent distinction between state-owned banks and joint-stock banks. For example, basing on testing efficiency in China's commercial banks, Lujun Zheng and Tingqiu Cao(2005) drew a conclusion that there was no apparent difference among state-owned banks. Similar researches include Zhaohua Xie and Junshan Duan (2005) as well as Huaiyong Zhao and Yue Wang (1999), etc.. Still some Chinese scholar put their focal point of research on factors that influence X efficiency of banking system in China. For examples, Chuanzhen Xu and Shutian Qi (2007) indicated that changes in economic environment and the supervision policies of central bank were the most familiar factors of X efficiency of Chinese bank industry, and the most powerful factor is the level of bank's the management level, such as share of non-performing loans, profitability and ability to control cost. Differences in asset liability structure also boast uncertain influences.

II. BASIC THOUGHTS AND RESEARCH METHODS OF THIS ARTICLE

From the above discussion, we can learn that scholars in China rarely take TI and AI into consideration when estimating X efficiency, not to mention the influence of technological innovation. Therefore, despite their findings that efficiency in state-owned banks of China is lower than that of joint-stock ones, they cannot say if it is technological efficiency or capital AI of the state-owned banks lower than that of shareholding ones.

In light of this, this article will, under the premise of TI, make further study about the X efficiency of China's bank industry to explore whether the low efficiency of state-owned banks is attributed to TI or AI. If the answer is AI, then problems lie in the capital investment of state-owned banks, otherwise, in their low service efficiency of funds.

Western research methods cannot be copied to study X efficiency in China's bank industry due to the two tremendous differences in management: First and foremost, prices of financial product in western countries (interest rates) are determined by the market, while those in China are defined by central bank. As price is a significant factor that influence the profit, analyzing X efficiency of China's bank industry must take into consideration of whether commercial banks have the right to set price. Second, commercial banks in China must strictly implement currency policies launched by central banks, which makes it not exactly a market behavior. When austere currency policy was carried out by central bank, commercial banks have to cut down on their issuing of loans, resulting to inevitable influences on their profit. Thus, characteristics of market behaviors in commercial banks of China must be taken into account when analyzing X efficiency of China's bank industry.

Other than TI, this article also takes influences of asset quality and equity capital (EC) into account and considers them as fixed investment. Asset quality of banks will be represented by their rate of non-performing loans (NP). As banks with high NP rates usually result from overdue risky loans, which may lead to higher profit rates, but also can contribute to higher rates of loss. Therefore, banks with higher NP rates have easier access to higher profit, but inevitably waste more resources on credit rate. To reduce the risks of bankruptcy, risk-aversing banks may keep a relatively higher stock option-to-deposit ratio. Stock option provides not only cushion for losses in investment portfolio, but also altered currency used as deposit and loans with loans of funds. Risk-neutral banks, on the other hand, may have a relatively lower stock option-to-deposit ratio. Hence, we can learn that compared with risk-aversing banks, those banks with neutral risk will make its output in a way of AI, with its profit being exaggerated due to its exclusion of stock right cost. A conclusion can be drawn that together with option capital, NP loans in examples can manipulate the difference of appetite for risk. And the basic thoughts of research are as follow:

(1)THEORETIC RESEARCHES. Through using the influences of shadow prices and shadow profits on AI, TI and technological innovation, this article will reference the ideas coming from Huang (2010) to provide an appropriate measuring model. The separation TI from AI must conducted under the precondition that covariance of AI and TI is not 0 (TI and AI is connected to each other).Hence, methods transcendental function is adopted to deal with the function of shadow profit. This is because of the two prominent advantages of transcendental functions: Firstly, it can fit data well and performs quite extraordinary especially when processing data with disequilibrium and heterogeneity. Secondly, it can reflect interaction between explanatory and explained variables.

(2)COMPARATIVE RESEARCHES. Sample period chosen by this article must include periods of tight policies and expansionary monetary policies. Through comparing the empirical results, we can know how monetary policies influence X efficiency. Besides, samples chosen by this article must include state-owned, joint-stock banks and shadow banks1. Comparisons the empirical results among these three sorts of banks, we can know how banking systems, supervisions of central bank and the banks' pricing power influence the X efficiency.

III. THEORETICAL MODEL

We assume that the Banks have m sources of capital, expressed by vector $X=(x_1,x_2,...,x_m)'$, and produce n sorts of financial products, expressed by vector $Y=(y_1,y_2,...,y_n)'$. Obviously, vectors X and Y are non-negative. The production-possible sets T of all possible inputs and outputs of bank are:

$$T=\{(\widetilde{Y}/B,X)\,|\,\widetilde{Y}/B \text{ can be produced by } X\} \tag{1}$$

Where $B\in(0,1]$ is the technical inefficiency measure, which denotes technical efficiency of banks if B closes to 1. If the weak regularity condition holds, according to Baumol et al.(1982),there must be a continuous production transformation function which increases with X and decreases with $\widetilde{Y}$. We can express the function as:

$$y_n/B=F(Y/B,X);\ Y=(y_1,y_2,...,y_{n-1})' \tag{2}$$

Then the short-term standard shadow profit function of bank is:

$$\Pi^*(P^*,W^*)=\underset{Y,X}{SUP}\{BF(Y/B,X)+P^*Y-W^*X\,|\,Y,X\in R_+^{n-1}*R_+^m\} \tag{3}$$

Π^* is shadow profit, $P^*=(p_1^*/p_n^*,...,p_{n-1}^*/p_n^*)$ is the vector of shadow prices of outputs , $W^*=(w_1^*/p_n^*,...,w_m^*/p_n^*)$ the vector of shadow prices of inputs. p_n^* is the shadow price of output y_n. We assume that all banks make decisions basing on shadow prices. When the marginal rate of technical substitution between any two inputs or the marginal rate of transformation between any two outputs is not equal to the ratio of corresponding input or output prices, the AI appears. The former can be referred to as input AI, and the latter as output AI. Multiplying (3) on both sides with B−1, we obtain:

$$\hat{\Pi}^*(P^*,\hat{W}^*)=\underset{Y/B,X}{SUP}\{F(Y/B,X)+P^*Y/B-\hat{W}^*X\,|\,Y,X\in R_+^{n-1}*R_+^m\} \tag{4}$$

$\hat{W}^*=(w_1^*/p_n^*B,...,w_m^*/p_n^*B)$ is the vector of the efficiency-adjusted shadow input prices. We can obtain follow outputs supply and inputs demand functions through Legendre transformation:

$$\partial\hat{\Pi}^*/\partial P_i^*=Y_i(P^*,\hat{W}^*)/B,\ i=1,2,...,n-1 \tag{5}$$

$$\partial\hat{\Pi}^*/\partial W_j^*=-X_j(P^*,\hat{W}^*),\ j=1,2,...,m \tag{6}$$

Technical inefficiency raises the shadow prices of inputs through B^{-1}. Since input demand function is non-increasing in prices of inputs, X_j in function (5) is decreasing. However, the impacts on supply function are ambiguous. So we can only argue that banks with technical inefficiency cannot increase outputs so as to realize its efficiency-

1 Usually, the shadow banks have two meanings. One means a structure of the organization and another means the operated businesses by some organizations which can be banks or not. Here the shadow banks Refers to the latter, such as Wealth Management Products, Interbank Business, and Bill financing business. http://www.360doc.com/content/15/0309/09/18603808_453712201.shtml.

adjusted shadow profit. We express the actual profit function similar to function (3):

$$\Pi = BF[Y(P^*,\hat{W}^*)/B, X(P^*,\hat{W}^*)] + P^*Y(P^*,\hat{W}^*) - WX(P^*,\hat{W}^*) \quad (7)$$

Π is the actual profit, and $P=(p_1/p_n,...,p_{n-1}/p_n)$ is the vector of actual prices of outputs, $W=(w_1/p_n,...,w_m/p_n)$ the actual prices of inputs p_n are the actual price of output y_n. All banks make decisions basing on shadow prices, so vectors X and Y must still be the vectors of shadow prices in function (7). The function (7) can be reformulated as:

$$\hat{\Pi} = \Pi/B = \hat{\Pi}^* + \sum_{i=1}^{n-1}(P_i - P_i^*)\frac{\hat{S}_i^*\hat{\Pi}^*}{P_i^*} + \sum_{j=1}^{m}(\hat{W}_j - \hat{W}_j^*)\frac{\hat{S}_i^*\hat{\Pi}^*}{P_i^*} = \hat{\Pi}^* G(P^*,\hat{W}^*) \quad (8)$$

$\hat{W} = W/B$; $P_i^* = \lambda_i P_i$; $W_j^* = \theta_j W_j$; $j=1,...,m$

$\hat{S}_j^*(P^*,\hat{W}^*) = (Y_i P_i^*)/(B\hat{\Pi}^*(P^*,\hat{W}^*))\frac{Y_i}{B}$,

$i=1,...,n-1$,

$$G(P^*,\hat{W}^*) = 1 + \sum_{i=1}^{n-1}(\lambda_i^{-1}-1)\hat{S}_i^* + \sum_{j=1}^{m}(\theta_j^{-1}-1)\hat{S}_j^*$$

λ_i and θ_j are unknown positive parameters. According function (8), the more λ_i and θ_j close to 1, the more the actual profit closes to shadow profit. $\hat{S}_i^*$ and $\hat{S}_j^*$ are the shadow profit ratios of the i^{th} output and j^{th} input respectively. $G(P^*,\hat{W}^*)$ is the difference between actual and shadow profits. Taking natural logarithms of both sides of (8), we can obtain:

$$\ln\Pi = \ln\hat{\Pi}^*(P^*,\hat{W}^*) + \ln G(P^*,\hat{W}^*) + \ln B \quad (9)$$

We can express the relations of actual and shadow profits by $\hat{S}_i$ and $\hat{S}_j$ as:

$$\hat{S}_i = (PY_i/B)/\hat{\Pi} = \hat{S}_i^*(\lambda_i, G)^{-1} \quad (10)$$

$$\hat{S}_j = -X_j\hat{W}/\hat{\Pi} = \hat{S}_j^*(\theta_i, G)^{-1}$$

(11)

$i=1,...,n-1$, $j=1,...,m$. We assume the shadow profit is translog with fixed inputs and outputs, then:

$$\ln\hat{\Pi}^* = a_0 + \sum_{i=1}^{n-1}a_1\ln P_i^* + \frac{1}{2}\sum_{i=1}^{n-1}\sum_{k=1}^{n-1}a_{ik}\ln P_i^*\ln P_k^* + + \sum_{j=1}^{m}b_j\ln\hat{W}_j^* + \frac{1}{2}\sum_{j=1}^{m}\sum_{r=1}^{m}b_{jr}\ln\hat{W}_j^*\ln\hat{W}_r^* + \sum_{i=1}^{n-1}\sum_{j=1}^{m}\alpha_{ij}\ln P_i^*\ln\hat{W}_j^* + \sum_{k=1}^{q}c_k\ln Z_k + \frac{1}{2}\sum_{k=1}^{q}\sum_{j=1}^{q}c_{kj}\ln Z_k\ln Z_j + \sum_{i=1}^{n-1}\sum_{k=1}^{q}\beta_{ik}\ln P_i^*\ln\hat{W}\ln Z_k + \sum_{j=1}^{m}\sum_{k=1}^{q}\phi_{jk}\ln\hat{W}_j^*\ln Z_k \quad (12)$$

In the case of symmetry, viz., $a_{ik}=a_{ki}$ ($\forall i,k$); $b_{jr}=b_{rj}$ ($\forall j,r$); $c_{jk}=a_{kj}$ ($\forall j,k$), then:

$$\hat{S}_i^* = \frac{\partial\ln\hat{\Pi}^*}{\partial\ln P_i^*} = a_i + \sum_{k=1}^{n-1}a_{ik}\ln P_k^* + \sum_{j=1}^{m}a_{ij}\ln\hat{W}_k^* + \sum_{k=1}^{q}\beta_{ik}\ln Z_k \quad (13)$$

$$\hat{S}_j^* = \frac{\partial\ln\hat{\Pi}^*}{\partial\ln\hat{W}_i^*} = b_j + \sum_{k=1}^{m}b_{ir}\ln\hat{W}_k^* + \sum_{i=1}^{n-1}a_{ij}\ln P_k^* + \sum_{k=1}^{q}\phi_{jk}\ln Z_k \quad (14)$$

$$G(P^*,\hat{W}^*) = 1 + \sum_{i=1}^{n-1}(\lambda_i^{-1}-1)(a_i + \sum_{k=1}^{n-1}a_{ik}\ln P_k^* \sum_{j=1}^{m}(\theta_j^{-1}-1)(b_j + \sum_{r=1}^{m}b_{jr}\ln\hat{W}_r^* + \sum_{i=1}^{n-1}\alpha_{ij}\ln P_i^* + \sum_{k=1}^{q}\phi_{jk}\ln Z_k) + \sum_{j=1}^{m}a_{ij}\ln\hat{W}_j^* + \sum_{k=1}^{q}\beta_{ik}\ln Z_k) \quad (15)$$

$i=1,...,n-1$; $j=1,...,m$. Substituting functions (13) and (11) into (6) respectively, we can obtain:

$$\ln\Pi(P^*,\hat{W}^*) = \ln\hat{\Pi}^*(P^*,\hat{W}^*) + \ln G(P^*,\hat{W}^*) + \ln B = \ln\Pi^*(P^*,W^*) + I(P^*,W^*,B) = \ln\Pi^*(P^*,W^*) + I(P^*,W^*,B) + \ln[G(P^*,W^*) + H(B,\tau)] \quad (16)$$

$$\hat{S}_i = (S_i^* - \ln B\sum_{j=1}^{m}\alpha_{ij})/\{\lambda_i[G(P^*,W^*) + H(B,\tau)]\} \quad (17)$$

$$\hat{S}_j = (S_j^* - \ln B\sum_{r=1}^{m} b_{jr})/(\frac{S_j^* - \ln B\sum_{r=1}^{m} b_{jr}}{\theta_i[G(P^*,W^*)+H(B,\tau)]}) \tag{18}$$

$$I(P^*,W^*,B) = \ln B[1-\sum_{j=1}^{m} b_j - \sum_{j=1}^{m}\sum_{r=1}^{m} b_{rj}\ln W_j^* - \frac{1}{2}\ln B\sum_{j=1}^{m}\sum_{r=1}^{m} b_{jr}$$

$$-\sum_{i=1}^{n-1}\sum_{j=1}^{m}\alpha_{ij}\ln P_i^* - \sum_{j=1}^{m}\sum_{k=1}^{q}\phi_{jk}\ln Z_k]$$

$$G(P^*,W^*) = 1+\sum_{i=1}^{n-1}(\lambda_i^{-1}-1)S_i^* + \sum_{j=1}^{m}(\theta_j^{-1}-1)S_j^*$$

$$S_i^* = a_i + \sum_{k=1}^{n-1} a_{ik}\ln P_k^* + \sum_{j=1}^{m}\alpha_{ij}\ln W_k^* + \sum_{k=1}^{q}\beta_{ik}\ln Z_k \;;$$

$$S_j^* = b_j + \sum_{r=1}^{m} b_{jr}\ln W_k^* + \sum_{i=1}^{n-1}\alpha_{ij}\ln P_k^* + \sum_{k=1}^{q}\phi_{ik}\ln Z_k \;;$$

$$H(B,\tau) = -\ln B[\sum_{i=1}^{n-1}(\lambda_i^{-1}-1)\sum_{j=1}^{m}\alpha_{ij} + \sum_{i=1}^{n-1}(\theta_i^{-1}-1)\sum_{j=1}^{m} b_{jr}]$$

$\tau = (\lambda_1,...,\lambda_{n-1},\theta_1,...,\theta_m)'$ .Function (16) shows that $\ln\Pi^*(P^*,W^*)$ and $G(P^*,W^*)$ only have all AIs and the second term contains both technical and AIs. If $\sum_{r=1}^{m} b_{jr} = \sum_{j=1}^{m}\alpha_{ij} \neq 0$ holds, we can separate these inefficiency parameters.

IV. EMPIRICAL METHODS OF MEASURES

A. Empirical Methods of Technical and AI

Equations (14) and (16) include both data and the unknown parameters. To test the unknown parameters, we assume that these equations have a random distribution of zero mean and fixed variance among all banks. In order to improve the tested inefficiencies, we estimate the profit function and profit ratio system at the same time. Profit function contains a complex error term which consists of two parts: pure random disturbance and a non-positive error term. The non-positive error term is regarded as the negative effects which denote the respondents of technical and AIs to bank's profit. The system always contains $m+n-1$ equations to be tested, which means that the singular variance and covariance will never appear.

In order to accurately estimate all the parameters, in particular B , λ_i and θ_j , we need some econometric models which can accurately describe the behaviors of X inefficiency of different banks and different periods. We assume that the technical parameters B and θ_j are different among different banks, but don't vary with time. This assumption only means that there are no differences among ratios of shadow price to the actual price, and that don't means all the shadow prices remain constant. Term $\lambda_i < 1$ ($\lambda_i > 1$) implies under- (over-) production of output i , and $\theta_j < 1$ ($\theta_j > 1$) reflects that the firm mistakenly desires to employ more (less) of input j relative to the nth output.

Through the nonlinear iterative seemingly unrelated regression (NISUR) technique, we estimate equation (16) by (18) after adding classical error terms to each of the equations. We label the above specifications on TI and AI as Model 1. Model 1 assumes that firm-specific TI and input-specific AI, in addition to the two fixed net puts NP and EC as well as the time trend. We can confirm the TI and AI by testing the parameters.

We first assume that $B=1$ hold which means there is no inefficiency among all banks and testing expectant profit $\ln\Pi$ under this assumption. Then we assume that B takes a normal value and testing again the expectant profit $\ln\Pi$ under this assumption. The difference between the two expectant profits is the profit loss resulting from TI. Similarly, under two assumptions of $\tau=1$ and τ taking normal value, we can estimate the profit loss of AI.

$$\Pi_{TI}^1(\tau) = \ln\pi(P^*,\hat{W}^*)|_{B=1} - \ln\pi(P^*,\hat{W}^*)$$
$$= \ln\pi(P^*,\overline{W}^*) - \ln\pi(P^*,\hat{W}^*) \tag{19}$$

$$\Pi_{AI}^1(B) = \ln\pi(P^*,\hat{W}^*)|_{\tau=1} - \ln\pi(P^*,\hat{W}^*)$$
$$= \ln\pi(P,\hat{W}) - \ln\pi(P^*,\hat{W}^*) \tag{20}$$

$$\Pi_{TI}^2 = \ln\pi(P,\hat{W})|_{B=1} - \ln\pi(P,\hat{W})$$
$$= \ln\pi(P,W) - \ln\pi(P,\hat{W}) \tag{21}$$

$$\Pi_{AI}^2 = \ln\pi(P^*,W^*)|_{\tau=1} - \ln\pi(P^*,W^*)$$
$$= \ln\pi(P,W) - \ln\pi(P^*,W^*) \tag{22}$$

Deviously, equation $\Pi_{TI}^1(\tau)$ (Π_{TI}^2) is profit loss resulting from TI and $\Pi_{AI}^1(B)$ (Π_{AI}^2) is the one resulting from AI. Since Π_{TI}^2 (Π_{AI}^2) is Independent on AI (TI), and $\Pi_{TI}^1(\tau)$ ($\Pi_{AI}^1(B)$ is not, so it is impossible for $\Pi_{TI}^1(\tau) = \Pi_{TI}^2$ as well as $\Pi_{AI}^1(B) = \Pi_{AI}^2$. It means that TI and AI are always can be estimated.

B. The Empirical Methods of Technical Innovations

Most previous studies on technical innovations in banking fall into the framework of a general cost function.

Under the assumption that the firms are always on their efficient frontier, the investigators usually evaluate technical innovations on the efficient cost frontier without considering X efficiency. Neglecting X efficiency is very likely to result in a biased measure of technical innovations. In fact, a time trend (t) can easily be included into equation (12) by treating it as a fixed net put (or example $t = \ln Z_q$). Equation (16) may then be equivalently expressed as:

$$\ln \Pi(P^*, \hat{W}^*, t) = \ln \Pi^*(P^*, W^*, t) + \ln[G(P^*, W^*, t) + H(b, \tau)] + I(P^*, W^*, B, t) \tag{23}$$

Technical innovation is can be defined as the rate of change in profit (or cost) over time holding all else factors constant. In particular, if technical inefficiency B is assumed to be time-invariant and firm-specific, then:

$$\Pi_t = \frac{\partial \ln \Pi}{\partial t} = \frac{\partial \ln \Pi^*(P^*, W^*, t)}{\partial t} + \frac{\partial \ln[G(P^*, W^*, t) + H(B, \tau)}{\partial t} + \frac{\partial I(P^*, W^*, B, t)}{\partial t}$$
$$= (c_q + c_{qq} t + \sum_{k=1}^{q-1} c_{kq} \ln Z_k + \sum_{i=1}^{n-1} \beta_{iq} \ln P_i \sum_{j=1}^{m} \phi_{jq} \ln W_j)$$
$$- \ln B \sum_{j=1}^{m} \phi_{jq} + \{ \frac{(\sum_{i=1}^{n-1} (\lambda_i^{-1} - 1)\beta_{iq} + \sum_{j=1}^{m} (\theta_j^{-1} - 1)\phi_{jq})}{G(P^*, W^*, t) + H(B, \tau)}$$
$$+ \sum_{i=1}^{n-1} \beta_{iq} \ln \lambda_i + \sum_{j=1}^{m} \phi_{jq} \ln \theta_j \} \tag{24}$$

The equation indicates that technical innovation consists of three components. $\ln B \sum_{j=1}^{m} \phi_{jq}$ is the contribution of TI, while $\sum_{i=1}^{n-1} \beta_{iq} \ln \lambda_i$ and $\sum_{j=1}^{m} \phi_{jq} \ln \theta_j$ are contributions of TI and AI respectively. Since B and τ appear in equation (24), omitting any one or both of them would result in a biased measure of technical change unless $B = \tau$ =1. Another possibility that technical change is independent of X-inefficiency occurs when technical change is neutral, which leads to $\beta_{iq} = \phi_{jq} = 0$ ($\forall i, j$).

$$\Pi_t = c_q + c_{qq} t + \sum_{k=1}^{q-1} c_{kq} \ln Z_k \tag{25}$$

However, technical innovation in equation (7) is still inappropriate as it would be computed using inconsistent parameter estimates c_q, c_{qq} and c_{kq} ($k = 1, ..., q-1$). Such parameter inconsistency is attributed to the exclusion of X-inefficiency from the model.

V. THE DEFINITIONS OF THE VARIABLES AND DATA

The variables as well as the corresponding data are defined as follow:

Tow outputs variables of bank: investment of bank Y_1 and loan Y_2. Where Y_1 is denoted by the government bonds and other securities hold by the selected bank during the sample period, and Y_2 the long-term and short-term loans issued by selected bank during the sample period. The actual prices of outputs are approximated by the yield rate of securities and the loan interest rate charged by bank respectively.

Tow inputs variables of bank: monetary input X_1 and labor force input X_2. Where X_1 is denoted by all kinds of deposits and all borrowed money by the selected bank in sample period, and X_2 the number of employees by the selected bank during sample period. The inputs prices are approximated by interest rate on deposit or borrowing rate and the wage of employees.

Two constant inputs variables of bank: rate of non-performing loan NP and the rate of equity capital. Where NP is approximated by rate of the outstanding loan overdue 90 days in overall loans, and EC the rate of equity capital in total capital used by bank in operation during sample period.

In views of the particularities of businesses of Chinese Policy Banks and the spatial limitations of businesses of Chinese local commercial banks, the paper select 16 national commercial banks, which include 4 state-owned commercial banks and 12 joint-stock banks. For convenience, the paper codes orderly the 16 banks with 1-16, and correspond: The Industrial and Commercial bank of China, China construction bank, The Bank of China, Agricultural Bank of China, Bank of communications, Shanghai Pudong Development Bank, Shenzhen Development bank, Industrial Bank, Huaxia Bbank, China Merchants Bank, Guangdong Development Bank, China Minsheng Bank, China Citic Bank, China Everbright Bank, Hengfeng Bank, ZheShang Bank. In addition, because of the complexities of businesses and availability of data of shadow banks, the paper only considers the regulation-missed businesses, which are operated by the banks supervised by the central bank but some of their businesses are not supervised, such as Wealth Management Products, Interbank Business, Bill financing business and Entrusted Loans. We regard Wealth Management Products, Interbank Business, Bill financing business as Y_1 and Entrusted Loans as Y_2 of shadow banks.

The selected sample period is from the first quarter of 2001 to the fourth quarter of 2014, which include a tight-money policy period (form the second quarter of 2010 to the third quarter of 2013) and an expansionary monetary policy period (from the first quarter to the fourth quarter of 2014). The used data come from China Statistical Yearbook 2015 and China's Financial Yearbook 2015.

VI. THE EMPIRICAL RESULTS

A. Parameters Estimations

The results of parameters estimations of model 1and model 2 are showed in table 1.The standard deviations are constant after adjusting the heteroscedasticities. The paper only shows the standard deviations without any adjustments.

TABLE 1 RESULTS OF PARAMETERS ESTIMATIONS

Variables	Model 1	Model2	Variables	Model 1	Model2
Constant	-3.231(2.033)	-1.813(1.746)	$\ln P_2 * \ln FK$	-0.151(0.139)	-0.117(0.128)
$\ln P_2$	0.411(1.027)	-0.177(0.869)	$\ln w_1 * \ln NP$	-0.069b(0.031)	-0.085c(0.051)
$\ln P_2 * \ln P_2$	-1.328a(0.402)	-1.505a(0.316)	$\ln w_1 * \ln FK$	-0.045(0.060)	-0.088(0.081)
$\ln w_1$	0.510(0.481)	0.907c(0.497)	$\ln w_2 * \ln NP$	-0.082c(0.041)	-0.039(0.028)
$\ln w_2$	0.534(0.857)	0.832(0.571)	$\ln w_2 * \ln FK$	0.141(0.097)	0.129c(0.070)
$\ln w_1 * \ln w_1$	-0.331a(0.079)	-0.443a(0.089)	π_2	4.306a(1.330)	3.102a(0.807)
$\ln w_1 * \ln w_2$	-0.311a(0.085)	-0.241a(0.078)	θ_1	1.599a(0.498)	1.591a(0.371)
$\ln w_2 * \ln w_2$	-0.839a(0.187)	-0.872a(0.114)	θ_2	5.002a(1.302)	3.303a(0.702)
$\ln P_2 * \ln w_1$	-0.503a(0.156)	0.630a(0.151)	t	-0.050(0.172)	-0.007(0.006)
$\ln P_2 * \ln w_2$	1.026a(0.249)	1.012a(0.159)	t^2	-0.008(0.006)	0.002a(0.000)
$\ln NP$	-0.302(0.310)	-0.284(0.219)	$\ln P_2 * t$	-0.113a(0.040)	--
$\ln FK$	2.513a(0.071)	1.983a(0.506)	$\ln w_1 * t$	0.047a(0.017)	--
$\ln NP * \ln NP$	-0.051b(0.022)	-0.048c(0.027)	$\ln w_2 * t$	0.091a(0.030)	--
$\ln NP * \ln FK$	0.091c(0.052)	0.085b(0.042)	$\ln NP * t$	0.014(0.011)	--
$\ln FK * \ln FK$	-0.317a(0.096)	-0.281a(0.091)	$\ln FK * t$	-0.015(0.020)	--
$\ln P_2 * \ln NP$	0.170b(0.063)	0.166a(0.060)	Log likehood	-2319.15	-2320.42

Notes: a: significant at 1% level, b: significant at 5%level, c: significant at 10% level. Numbers in parentheses are standard errors.

The test for the null hypothesis that all seven coefficients of the terms involving variables NP and EC are jointly zero is decisively rejected by the Wald test at even the 1% level of significance. These two variables appear to be relevant in the study of X-efficiency, particularly through a profit function. A model ignoring them may result in bias inferences. The TI parameter B can be defined as follow:

$$\ln B_{it} = K_{0i} + K_{1i}t + K_{2i}t^2 \tag{25}$$

Where K_{0i} , K_{1i} and K_{2i} are parameters describing the Characteristics of corresponding banks. The equation allows TI changes according to a simple way among different banks and over time. Moreover, under the condition that $K_{1i} = K_{2i} = 0$ holds, the equation simplify to model 1. In addition to, the null hypothesis to achieve TI can be validated through testing $K_{0i} = K_{1i} = K_{2i} = 0$ （$\forall i$）. So we reduce the number of parameters through follow equation:

$$\ln B_{it} = K_{0i} + K_1 t + K_2 t^2 \tag{26}$$

Where K_1 and K_2 are constant among different banks and over time, and we label the equation model 2. Under the condition that the estimation value of K_2 is positive, it can be confirmed that the average technical efficiency is constant over time. As for AI parameter $\tau = (\lambda_2, \theta_1, \theta_2)'$, we assume that τ is different among different banks but constant over time. The AI can be defined as follow:

$$\tau_{it} = K_{0ji} + K_1 t + K_2 t^2, \quad j = 1,2,3 \qquad (27)$$

Intercept term K_{0ji} varies among banks, while K_1 and K_2 are constant among banks and over time. Although the values of parameters estimations are different, model 1 and model 2 are similar somewhat. That the estimation values of λ_2 in both models are significantly bigger than 1 indicates that output of loans is overproduced. To increase revenue and profit, given the input mix, firms should reduce the production of loans and increase the production of investments. Because $\hat{\theta}_1 / \hat{\theta}_2$ is smaller than 1, we can conclude that the input of borrowed money is over-utilized as opposed to labor. In order to decrease cost, the banks should hire more labor and reduce the use of borrowed money. The reduced use of borrowed money means that the banks should increase equity capital and decrease loan meanwhile. It will improve capital adequacy ratio and reduce the possibility of bankruptcy of the bank.

Based on above models, the results of parameter estimations of relative TI are showed in table2. All the parameters have positive signs as expected before. The results of AI are showed in table 3.

Results of TI indicate that: (1) the technical efficiency of state-owned banks are congruously be superior to that of joint-stock banks;(2) compared with the all sample period, the technical efficiency decrease significantly no matter sample period of expansionary monetary policy or of tight monetary policies.

TABLE 2-1 RESULTS OF PARAMETERS ESTIMATION OF TI: ALL SAMPLE PERIOD

Banks	1	2	3	4	5	6	7	8
Model1	0.843	0.843	0.851	0.890	0.815	0.821	0.809	0.764
Model2	0.811	0.852	0.847	0.901	0.911	0.923	0.887	0.806
BNAKS	9	10	11	12	13	14	15	16
Model1	0.806	0.731	0.769	0.734	0.805	0.735	0.773	0.724
Model2	0.873	0.838	0.843	0.796	0.832	0.800	0.815	0.788

TABLE 2-2 RESULTS OF PARAMETERS ESTIMATION OF TI: PERIOD OF TIGHT MONETARY POLICY

Banks	1	2	3	4	5	6	7	8
Model1	0.727	0.731	0.724	0.760	0.715	0.738	0.719	0.664
Model2	0.752	0.749	0.767	0.772	0.759	0.791	0.745	0.681
BNAKS	9	10	11	12	13	14	15	16
Model1	0.686	0.683	0.719	0.704	0.771	0.755	0.793	0.811
Model2	0.699	0.701	0.735	0.726	0.804	0.783	0.818	0.820

TABLE 2-3 RESULTS OF PARAMETERS ESTIMATION OF TI: PERIOD OF EXPANSIONARY MONETARY POLICY

Banks	1	2	3	4	5	6	7	8
Model1	0.913	0.892	0.904	0.892	0.835	0.870	0.879	0.864
Model2	0.918	0.893	0.911	0.900	0.849	0.821	0.891	0.871
BNAKS	9	10	11	12	13	14	15	16
Model1	0.893	0.871	0.889	0.864	0.915	0.865	0.903	0.871
Model2	0.912	0.893	0.895	0.886	0.922	0.875	0.908	0.883

TABLE 3-1 RESULTS OF PARAMETERS ESTIMATION OF AI： ALL SAMPLE PERIOD

Banks	1	2	3	4	5	6	7	8
Model1	0.713	0.687	0.694	0.678	0.757	0.778	0.749	0.764
Model2	0.722	0.701	0.713	0.695	0.793	0.801	0.795	0.781
BNAKS	9	10	11	12	13	14	15	16
Model1	0.767	0.771	0.789	0.804	0.815	0.805	0.813	0.821
Model2	0.801	0.791	0.795	0.816	0.820	0.818	0.828	0.835

TABLE 3-2 RESULTS OF PARAMETERS ESTIMATION OF AI: PERIOD OF TIGHT MONETARY POLICY

Banks	1	2	3	4	5	6	7	8
Model1	0.627	0.601	0.614	0.607	0.675	0.683	0.674	0.702
Model2	0.631	0.612	0.628	0.625	0.710	0.709	0.711	0.72
BNAKS	9	10	11	12	13	14	15	16
Model1	0.657	0.678	0.705	0.726	0.728	0.719	0.709	0.755
Model2	0.687	0.700	0.735	0.763	0.772	0.746	0.732	0.791

TABLE 3-3 RESULTS OF PARAMETERS ESTIMATION OF AI: PERIOD OF EXPANSIONARY MONETARY POLICY

Banks	1	2	3	4	5	6	7	8
Model1	0.733	0.705	0.711	0.697	0.773	0.801	0.770	0.794
Model2	0.742	0.721	0.732	0.712	0812	0.814	0.808	0.814
BNAKS	9	10	11	12	13	14	15	16
Model1	0.790	0.802	0.811	0.818	0.830	0.817	0.821	0.830
Model2	0.821	0.816	0.824	0.835	0.841	0.825	0.832	0.847

Results of AI indicate that:(1) the AI of state-owned banks are congruously be inferior to that of joint-stock banks;(2) the AI of all banks in sample period don't change significantly during period of expansionary monetary policy, but decrease significantly during the period of tight monetary policies.

B. Profit Loss Resulted from X-efficiency

Through equations (1)-(4), parameter values estimated by model 1 measure the influences of inefficiency on the selected banks. When facing the same prices of inputs and outputs, the achieved profits by inefficient banks are much less than that of the efficient ones. Because it is possible for the inefficient banks to produce less with the same inputs, or input more with the same outputs, or both. The estimated results are showed in table 4. In the table, results showed in column (1) are the profits of banks under the conditions of both IT and AI existing meanwhile, and column (2) under conditions of only TI existing, column (3) under conditions of only AI, column (4) under conditions of no TI and AI. So the differences of (2)-(1) and (4)-(3) are the profits loss resulted from TI. Correspondingly, the differences of (3)-(1) and (4)-(2) are the profits loss resulted from AI.

The results indicate that in the all sample period the profits loss of stated owned banks resulted from X-efficiency are greater than that of joint-stock banks, which are consist with all other research conclusions. The profit loss resulted from shadow banks are least. However, when TI and AI are considered, the profits loss of stated-owned banks resulted from AI are much greater than that of all other banks resulted from AI, while the profits loss of stated-owned resulted from AI approximate to that of joint-stock banks resulted from AI. Profits loss of shadow banks resulted both from AI and TI are least. We can conclude that compared with the joint-stock banks, the X-efficiency of stated-owned banks mainly shows AI, while compared with the shadow banks, the stated-owned banks and joint-stock banks have significant TI and AI.

TABLE 4-1 PROFIT LOSS RESULTED FROM *X*- EFFICIENCY：ALL SAMPLE PERIOD

Bank Type	（1） B and τ take normal values	(2) B takes normal value and $\tau=1$	(3) $B=1$ τ takes normal value	(4) $B=\tau=1$
Stated-owed banks	12.789	12.912	12.985	13.090
joint-stock banks	10.908	11.033	11.059	11.171
Shadow banks	8.560	8.655	8.650	8.747

	Profit loss resulting from X-efficiency (4)-(1)	*Profit loss resulting from TI*		*Profit loss resulting from AI*	
		$\Pi^1_{AI}(B)$ =(2)-(1)	$\Pi^2_{AI}(B)$ =(4)-(3)	$\Pi^1_{TI}(B)$ =(3)-(1)	$\Pi^2_{TI}(B)$ =(4)-(2)
Stated-owed banks	0.301	0.123	0.105	0.178	0.196
joint-stock banks	0.263	0.125	0.112	0.138	0.151
Shadow banks	0.187	0.103	0.097	0.054	0.09

TABLE 4-2 PROFIT LOSS RESULTED FROM *X*- EFFICIENCY: PERIOD OF TIGHT MONETARY POLICY

Bank Type	（1） B and τ take normal values	(2) B takes normal value and $\tau=1$	(3) $B=1$ τ takes normal value	(4) $B=\tau=1$
Stated-owed banks	10.933	11.068	11.188	11.315
joint-stock banks	9.995	10.135	10.196	10.326
Shadow banks	9.233	9.322	9.324	9.409

	Profit loss resulting from X-efficiency (4)-(1)	*Profit loss resulting from TI*		*Profit loss resulting from AI*	
		$\Pi^1_{AI}(B)$ =(2)-(1)	$\Pi^2_{AI}(B)$ =(4)-(3)	$\Pi^1_{TI}(B)$ =(3)-(1)	$\Pi^2_{TI}(B)$ =(4)-(2)
Stated-owed banks	0.382	0.135	0.127	0.247	0.255
joint-stock banks	0.331	0.140	0.130	0.191	0.201
Shadow banks	0.176	0.089	0.085	0.087	0.091

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TABLE 4-3 PROFIT LOSS RESULTED FROM *X*- EFFICIENCY: PERIOD OF EXPANSIONARY MONETARY POLICY

(1) B and τ take normal values	(2) B takes normal value and τ =1	(3) B =1 τ takes normal value	(4) $B=\tau$ =1
14.794	14.935	14.866	15.007
14.710	14.859	14.759	14.908
8.013	8.137	8.090	8.214

Profit loss resulting from X-efficiency (4)-(1)	*Profit loss resulting from TI*		*Profit loss resulting from AI*	
	$\Pi_{AI}^{1}(B)$ =(2)-(1)	$\Pi_{AI}^{2}(B)$ =(4)-(3)	$\Pi_{TI}^{1}(B)$ =(3)-(1)	$\Pi_{TI}^{2}(B)$ =(4)-(2)
0.213	0.141	0.139	0.072	0.074
0.198	0.149	0.150	0.049	0.048
0.201	0.124	0.118	0.077	0.083

TABLE 5 TECHNICAL INNOVATION MEASURE

Bank Type	(1) B and τ take normal values	(2) B takes normal value and τ =1	(3) B =1 τ takes normal value	(4) $B=\tau$ =1
Stated-owed banks	0.0537^{b}(0.029)	0.0318(0.031)	0.0227(0.037)	0.0231(0.031)
joint-stock banks	0.0542^{a}(0.024)	0.0401(0.039)	0.0215(0.038)	0.0239(0.040)
Shadow banks	0.0775^{a}(0.025)	0.0705^{b}(0.041)	0.0511^{b}(0.037)	0.0303(0.035)

Notes: a: significant at 1% level, b: significant at 5%level, c: significant at 10% level. Numbers in parentheses are standard errors.

The results indicate that compared with all sample period the profit loss of stated-owned and joint-stock banks resulted from X-efficiency both increase, while the growth of stated-owned banks are greater significantly, that profit loss of the shadow banks decrease. After further researches of AI and TI, we find that compared with all sample period the TI don't generate universally profit loss of stated-owned and joint-stock banks during the sample period of tight monetary policies and the profit loss resulted from AI decease much. The profit losses of shadow banks resulted from AI does not increase further, while that resulted from TI decreases. It can conclude that the profit losses of stated-owned and joint-stock banks during the sample period of tight monetary policies mainly result from AI.

The results indicate that compared with all sample period the profit losses of stated-owned and joint-stock banks resulted from X-efficiency decrease universally during sample period of expansionary monetary policies, while that of shadow banks increases. Further analyses of TI and AI, we find that the profit losses of the stated-owned and joint-stock banks resulted from TI don't decrease significantly during the sample period of expansionary monetary policies, while these resulted from AI decrease apparently. The profit losses of shadow banks resulted from AI don't change significantly, while that resulted from TI increases.

C. Technical Innovation Influence

Estimations of technical innovation are showed in table 5. Column (1) shows the influence of technical innovation on X-efficiency under the conditions of both IT and AI existing meanwhile, and column (2) under conditions of only TI existing, column (3) under conditions of only AI, column (4) under conditions of no TI and AI.

Results showed in column (1) indicate that with considering TI and AI meanwhile, the results of all sorts of banks are significant at 5% or 1% level. There is no significant difference between technical innovations of stated-owned and joint-stock banks, while the technical innovation of shadow banks is significantly greater. Results showed in column (4) indicate that none of results of all sorts of banks are significant even at 10% level without considering X-efficiency. Results showed in column (2) and (3) indicate that with considering TI and AI respectively, none of the estimated results of technical innovations of stated-owned and joint-stock banks are significant even at 10% level, while the result of shadow banks is significant at 5% level.

In a word, only under extreme condition, i.e. = =1, there is no technical innovation in shadow banks, while, the stated-owned and joint-stock banks will have apparent technical innovation only under X-efficiency.

VII. CONCLUSIONS AND EXPLANTIONS

(1)There certainly exists X-inefficiency in China's bank industry and the X-inefficiency of state-owned banks is indeed higher than that of the joint-stock banks, which is consistent with the conclusions drawn by many China's scholars. However, researches on TI and AI show that TI of state-owned banks is better than that of joint-stock banks while AI is not as good as the latter. Compared with joint-stock banks, X-Efficiency in state-owned banks mainly comes from AI. Besides, X-efficiency in China's bank industry will be greatly improved during the period of expansionary monetary policy, while deteriorated during period of tight monetary policy.

There are two possible reasons for above conclusions. One is that TI is measured by profits of selected banks. The tight monetary policy during sample period in China is mainly implemented by increasing legal reserve ratio. So the declines of loanable funds of commercial banks resulted from reserve requirements rises will inevitably decrease the profits of banks, and deteriorate the performances TI. While in period of expansionary monetary policy, the loanable funds will be increased, and the profits of banks and the performances of TI will be improved meanwhile.

Another possible reason is that interest rates in Chinese financial market are set by central bank which makes it impossible for commercial banks to compensate their profit losses through raising interest rate during the period of tight monetary policy. If the Chinese commercial banks have the right to set interest rates in markets, it is possible for tight monetary policy to have no impacts on TI, because of the flexible interest rates. The increases of loan of commercial banks during the period of expansionary monetary policy will incur the increases of demands for loans and decrease the legal reserves and excess reserves, which will improve the performances of AI. While the decreases of loans of commercial banks during the period of tight monetary policy will incur the decrease the demands for loans and increase the legal reserves and excess reserves, which will deteriorate the performances of AI.

(2) As far as the profit losses resulted from X-efficiency, the biggest are these of stated-owned banks and the smallest are these of shadow banks. When both AI and AI are considered, profit losses of state-owned banks resulted from AI apparently greater that these of other banks, while the profit losses of state-owned banks resulted from TI are approximate to these of the joint-stock banks. The profit losses of shadow banks resulted both from TI and AI are the smallest. Moreover, compared with the all sample period, the profit losses of both state-owned and joint-stock banks resulted from X-efficiency during the period of tight monetary policy increase somewhat, while these of shadow banks don't increase but decrease somewhat. The profit losses of both state-owned and joint-stock banks resulted from X-efficiency during the period of expansionary monetary policy decrease, while these of shadow banks increase.

Here are the possible two reasons. First, the reasons for why the profit losses of state-owned banks resulted from X-efficiency are the biggest while these of shadow banks the smallest lie in the facts that the state-owned and joint-stock banks must implement the monetary policies carried out by the People's Bank of China, such as rising legal reserve ratio, while the shadow banks does not necessarily do. So the AI of shadow banks apparently is more superior to that of the state-owned and joint-stock banks. In addition to, the shadow banks can flexibly set the interest rates in the financial market, so the interest rates carried out by shadow banks are apparently greater than these carried out by the state-owned and joint-stock banks which will result in better efficiency of shadow banks. Decreases of loans of the state-owned and joint-stock banks during the period of tight monetary policy will further increase the demand for loans of shadow banks, which will increase the profit of shadow banks. So compared with all sample period the profit losses of the state-owned and joint-stock banks during the period of tight monetary policy increase, while the profit losses of shadow banks decrease.

(3) Researches show that technological innovation in shadow banks is clearly better than those joint-stock banks in China. Under the current financial system, state-owned banks and joint-stock banks boast only limited innovation ability as they don’t have ability to make market decisions by themselves. On the contrary, shadow banks are out of the supervision of central banks, thus they have more potential in innovation.

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