Title Paper

How do regulatory ability and banking market structure affect the explicit deposit insurance scheme adoption and banks' risk taking?

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Please be kindly noted:
Ningyu Qian will present the paper,
Ningyu Qian, Kezhong Zhang, Changjun Zheng will attend the meeting.
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Abstract: This study investigates how regulatory ability and banking market structure affect the explicit deposit insurance scheme (eDIS) adoption and banks' risk taking under the eDIS. A regulator-bank dynamic game model explains why the implicit deposit insurance scheme is not the optimal choice when the regulator's regulatory ability is high, and how the effects of banking market structure and regulatory ability on the bank's risk taking are interdependent when the eDIS is effective in preventing crises, although excessive competitive banking market structure makes the eDIS ineffective. Empirical analysis on 190 countries worldwide 1996-2011 confirms that higher regulatory ability increases the probability of the eDIS adoption and the results indicate regulatory ability and market structure have negative effects on banking risk and increased regulatory ability weakens the negative effect of banking market structure on banking risk during normal times under the eDIS. In addition, the banking with more competitive market structures are more prone to experience a crisis under the eDIS.

Keywords: Deposit insurance scheme, Regulatory ability, Banking market structure, Banks' risk taking behavior
EFM classification codes: 520, 740

1 Introduction

Many evidences show that the explicit deposit insurance scheme (eDIS) decreases banking stability and increases the probability of banking crisis (Anginer et al., 2014a; Barth et al., 2004; Demirgüç-Kunt and Detragiache, 2002; Lambert et al., 2016). Moreover, the 2008 financial crisis highlights the inadequacy of eDIS (Allen et al., 2011a). However, the global eDIS reform does not stop anyway. Recently, China, the second biggest economy in the world, introduced eDIS in 2015. So why do the government regulators still adopt the eDIS?

With the DIS (explicit or implicit)[1], government regulators hope to stabilize the banking industry. What complicates matters is that under the DIS, the risk incentive of banks is affected by information asymmetry and market power. The former affects the banks' costs of increases in risk (Arping, 2010), and the latter influences the banks' franchise value (Keeley, 1990). The design of the DIS must be the government regulators' optimal choice that strikes the balance between the subsidies to banks and the risk-taking of banks prudently (Chan et al., 1992; Freixas and Rochet, 1998). Hence, the debate concerning whether the eDIS should be introduced is impacted by the two factors, but how the mechanism works is absent from extant literature. Moreover, what appealing us is based on the mechanism investigation we can exploit how profit-maximizing banks respond to the factors underlying the eDIS adoption. It is important for us to understand the banks' risk-taking behavior under the eDIS. Therefore, the aim of this paper is to answer these

[1] The category is based on the definition of Demirgüç-kunt et al. (2015), and we will discuss their differences in Section 2.

questions.

Most of the academic researchers pay their attention to assess the effects of the existing DIS. They provide insight into the characteristics of the different DISs. Traditionally, the flat premium structure is the common pricing method of the eDIS, however, Merton (1977) proves that it will give banks excessive risk-taking incentives for it is an option held by the banks on their assets. Consequently, scholars put forward the risk-based premium structure and believe that the latter is better than the former, because the "actuarially fair" pricing could maximize bank's cost of increase in risk and then reduce bank's incentive to take excessive risk (Bloecher et al., 2003; Gómez-Fernández-Aguado et al., 2014). Unfortunately, Chan et al. (1992) argue that the fair priced and incentive-compatible eDIS is impossible in the presence of private information. Furthermore, Pennacchi (2006) find that even the eDIS has the actuarially fair premium structure, bank's excessive risk taking still exists, so many studies support the view that government's subsidies could lighten the moral hazard problem and have positive effects on bank's stability protection (Allen et al., 2017, 2015). Only when the government regulators introduce the systematic risk-based premium structure, the actuarially fair pricing could mitigate the distortion in banking due to the implementation of eDIS (Lee et al., 2015).

This paper builds on the above researches and build a stylized two stage game model. The regulator introduces a DIS, the explicit or implicit one at the first stage; the bank then makes a decision about its risk-taking behavior. To perfect the model of the represented bank's risk taking under the DIS, we incorporate the regulatory ability of the represented government regulator and the market structure of banking. Particularly, different from extent literature[2], the regulatory ability captures the information asymmetry between the regulator and the bank. In practice, although banks are asked to disclose more and more information about their risk-taking behavior by regulators, but it not necessarily means the increase of information transparency (Baumann and Nier, 2004). The expertise of regulators determines whether they could interpret the great volume of information meaningful, thereby influencing the degree of information asymmetry, which distorts banks' risk-taking incentive. Our new bank model allows us to investigate why the regulator should adopt the eDIS in the face of such risk-taking motives of the bank. It also allows us to answer whether the regulatory prescriptions from previous studies remain accurate when the two factors affect bank's risk-taking decisions under the eDIS.

We find that (i) the regulatory ability of the government regulator is the determinant factor of the DIS choice and there exists a threshold: if the government regulator's regulatory ability above the threshold, the iDIS is not his best choice. (ii) When the eDIS is effective in preventing crises, the effects of banking market structure and regulatory ability on the bank's risk taking are interdependent, (iii) although the excessive competitive banking market structure makes the eDIS ineffective in preventing crises. Finally, in the empirical part we construct a panel data set covering the total 190 member countries of IMF over the time range from 1996 to 2011. This provide the opportunity to test the theoretical predictions mentioned above. The results confirm that higher regulatory ability increases the probability of the eDIS adoption. The results also indicate that during normal times a negative effect of regulatory ability on bank risk, whereas the effect of market structure on bank risk is negative either, as predicted. Moreover, the results support the prediction that the increase of regulatory ability weakens the negative effect of

[2] Scholars document that the owner-creditor (Barth et al., 2006) and owner-manager (Dolde and Knopf, 2006; Saunders et al., 1990) agency conflict influences the risk effects of the eDIS, Forssbæck (2011) give a comprehensive review about the literature.

banking market structure on banking risk under the eDIS. In addition, under the eDIS, the banking with more competitive market structures are more prone to experience a crisis.

This paper contributes to the literature in three ways. First, it adds to the currently expending literature that aims to investigate the design and consequences of the DIS. Some of extant theoretical analysis build the DIS design model and then study the effect of bank recapitalization mechanism on social welfare (Morrison and White, 2011), the transmission of monetary policy (Andries and Billon, 2010) and bank's risk-taking behavior (Arping, 2010), whereas other literature investigates the effect of deposit insurance coverage on bank competition (Shy et al., 2016). Besides, Demirgüç-Kunt et al. (2008) make use of a comprehensive data set covering 180 countries over 1960-2003 to identify the determinants of the eDIS adoption and design. In this study, we extend this debate by identify the effective and ineffective region of the eDIS with the introduction of regulatory ability (x-axis) and banking market structure (y-axis).

Second, this study complements the literature, which exploit the role of the banking market structure in bank's risk-taking behavior. Some scholars believe that less competition in the deposit market makes sure that the banks may have monopolistic market power and earn rent. So the increase of opportunity cost decreases banks' incentive to take excessive risk and they form the competition-fragility view (Berger et al., 2009; Fu et al., 2015; Hellmann et al., 2000; Keeley, 1990; Leroy and Lucotte, 2017; Repullo, 2004). However, these studies ignore the competition in loan market and are challenged by scholars who hold the view of competition-stability (Allen et al., 2011b; Boyd and Nicolo, 2005; Kick and Prieto, 2015; Schaeck et al., 2009; Schaeck and Cihak, 2014; Weiß et al., 2014). Because when the banks have market power in deposit market they intend to increase borrowing cost, which may increase borrowers' incentive to choose more risky project. Finally, the strategy in turn increases banks' risk (Boyd and Nicolo, 2005). Furthermore, some scholars believe that the relation between competition and the risk of bank failure is non-linear (Jiménez et al., 2013; Martinez-Miera and Repullo, 2010). This study goes beyond these factors. We identify a new joint effect of regulatory ability and market structure on the banks' excessive risk taking during normal times, although excessive competitive market structure is the reason why the banks' take extreme risk and makes the eDIS ineffective in preventing crises.

Third, this paper also relates to the literature, which examine the effects of information disclosure on the bank's risk-taking behavior. Cordella and Yeyati (1998) find that when banks disclose the information about their own risk choice, they virtually give the commitment about risk taking to depositors and are subject to more social discipline. Investors will punish banks, which violate promises to take high risk. Therefore, banks will take lower risk in a higher transparent environment. This finding is consistent with the result of Boot and Schmeits (2000) and empirical evidence is obtained (Nier and Baumann, 2006). In contrast, Hyytinen and Takalo (2002) consider the effect of disclosure cost on bank's risk-taking behavior. They prove that the cost of increasing the information transparency will reduce bank's franchise value, so the increase in information transparency will increase the banks' incentive to take excess risk. In this study, we investigate the effect of regulatory ability on banks' risk-taking behavior and identify that the channel through which the information asymmetry between regulators and banks influences the banks' excessive risk taking.

The reminder of the paper is organized in the following way. In Section 2, we develop the theoretical model and solve it in Section 3. In Section 4, the data is presented and In Section 5 the empirical methods and results are presented. Finally, Section 6 concludes.

2 **The model**

We consider a two-stage game model involving the government regulator and the bank. The regulatory ability (λ) and the banking market structure (μ) are common knowledge. In the first stage, the government regulator designs the DIS (θ) in order to maximize the social welfare. In the second stage, the representative bank develops the risk-taking strategy by setting up the credit acceptance criteria (α), which determines the risk of the bank's loan portfolio, in order to maximize its profit under the DIS. The sequence of events shown in the Fig. 2.

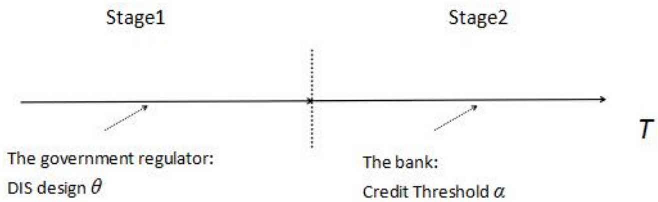

Fig.2 Sequence of events

2.1 The measurement of the bank's risk taking

We assume that the representative bank has no initial endowment and follow the classic assumption that the bank can obtain deposits provided in infinite supply elasticity at riskless interest $r \geq 1$ (Chan et al., 1992), in order to fulfill the demand for loan, and all the deposits get fully guaranteed[3] from the DIS. The bank has numerous potential borrowers, and each borrower needs a unit of loan to invest in the same one-period project which yields $R>r$ (Morrison and White, 2011). However, due to the differences in borrowers' operating ability, the quality of each borrower is different. For the sake of simplicity, we assume that the quality of potential borrowers is uniformly distributed on [0,1] and it is a common knowledge. More importantly, the bank is capable of screening the quality of the borrowers without cost (Shaffer, 1998). Thus, whether the bank accepts the borrowers' loan application depends on the establishment of credit acceptance criteria α of itself ($\alpha \sim U[0,1]$)and only the borrowers above the criteria can get loans. So α determines the loan and corresponding deposit size of the bank $D(\alpha)=1-\alpha$.

In addition, we assume that the probability distribution of bank's loan portfolio default is decided by the credit acceptance criteria: $p=p(D(\alpha))$, which is a common knowledge too. We impose the constraints on the probability distribution as follows:

Assumption 1： $\frac{dp}{dD}<0$, $\frac{dp}{d\alpha}=\frac{dp}{dD}\frac{dD}{d\alpha}>0$, $\frac{d^2p}{d\alpha^2}\leq 0$; especially, $p(\alpha=1)=1$, $p'(\alpha=1)=0$, $p'(\alpha=0)< p(\alpha=0)=p<1$.

2.2 Deposit insurance scheme（DIS）

In practice, the DIS has the risk-based premium structure and the flat premium structure (Demirgüç-kunt et al., 2015). So similar to Matutes and Vives (2000), we build the dynamic game model based on the two premium structures respectively in the paper. The main difference between the implicit DIS and explicit DIS is that the depositor compensation procedures of the

[3] The coverage limit exists in practice. However, a country considers cover problem when they make ceiling. For instance, the US covers 90 % and China covers 99.6%. Moreover, in minority rational family whose assets beyond ceiling, they scatter their capital in different banks and make deposits in each bank be less than ceiling and get their deposits fully protected.

latter are not formalized legally (Demirgüç-kunt et al., 2015). Under the iDIS, banks expect the government to bail out depositors in case of default. In fact, in some countries the government states that taxpayers bear depositors' loss (Klüh, 2005). However, most eDISs require banks to ex-ant finance the fund, which is the main source for the depositors' compensation when the bankruptcy occurs (Demirgüç-Kunt et al., 2005). To allow for the difference between the two kinds of schemes, we first follow Arping (2010) and model the risk-based premium structure of the DIS.

$$pI=(1-p)Dr\theta, \tag{1}$$

where I is the insurance premium, θ determines the extent to which the government requires the bank to finance the scheme. Therefore, θ=0 means that the government regulator enacts the iDIS and finance all debt of the bank in case of default by general taxation. In this paper, we are consistent with Diamond and Dybvig (1983) and assume that the government regulator could levy taxes without cost. On the contrary, when $\theta \in (0,1]$, the government regulator enacts eDIS, and share the debt with the bank in case of loan default. Especially, when θ=1, the DIS is actuarially fair priced. Similarly, we follow Matutes and Vives (2000) and model the flat premium structure of DIS.

$$I= Dr\theta, \tag{2}$$

therefore, when θ=0 the government regulator enacts the iDIS, however, when $\theta \in (0,1)$ the government regulator enacts the eDIS.

2.3 Regulatory ability and banking market structure[4]

We define government regulator's regulatory ability as the probability $\lambda \in (0,1)$ of the government regulator to observe actual risk profile of the bank (α), while the regulator could only infer the risk profile of the bank (α^u) from uninformative signal with probability $1-\lambda$[5]. Therefore, the information set of government regulator is $\{(\alpha,\alpha^u), (\lambda,1-\lambda)\}$. The definition emphasizes effectiveness of information as we discuss above.

Besides, we assume the loan market is not perfect competition, so banks have ability to price the loan rate r'. Following Chan et al. (1992) we assume a share, $\mu \in (0,1)$, of the surplus obtained from the project accrues to the bank[6], and not assume a particular banking market structure in our paper. Therefore, the loan rate r' is:

$$r' = \mu R + (1-\mu)\frac{r}{p} \cdot \tag{3}$$

Therefore, we can see that the bank could charge higher loan rate and earn more monopoly rents, when the competition is less.

2.4 Social welfare

Since the goal of the government regulator is the pursuit of the maximization of the social welfare, and for the sake of simplicity, we assume that the social welfare is the expected profits of the loans. Therefore, the government regulator's utility function is W.

$$W=pDR-Dr-L, \qquad \alpha \in [0,1] \tag{4}$$

[4] We the follows the assumption that accuracy of the banks' operating information and banking market structure are exogenous (Arping, 2010; Chan et al., 1992; Schultz, 2004).

[5] The regulatory ability of government regulator is derived from the knowledge and ability of government employees. The regulators with high ability could formulate and implement sound regulatory policies and build an effective regulatory system. Thus, the cost of regulatory ability is not considered in this paper (Chan and Mak, 1985).

[6] Besanko and Thakor (1987) prove the correlation between the allocation of investment project's profits and imperfect competition.

Especially, we assume that L is the deadweight cost. When α=1, the bank does not lend any borrower and this leads to the negative social welfare -L. In addition, when α=0, even the worst borrowers could get access to loan, so the bank's asset investment would maximize the probability of the bank default and we assume the crisis occurs this time. Therefore, the social welfare is damaged as well. In order to simplify the analysis, we assume that the social welfare is still -L. So

Assumption 2: $p(\alpha=0)R - r=0$, $W(\alpha=0)=-L$.

Furthermore, we study the properties of the social welfare function.

Lemma 1: The welfare-maximizing credit acceptance criteria is $\alpha^f \in (0,1)$, and $[p(\alpha^f)'D(\alpha^f) - p(\alpha^f)]R+r=0$.

Proof. See the Appendix 1.

3 Solving the model

Based on the definitions, assumptions and analysis, in this part, we try to solve the dynamic model developed in section 2.

3.1 Ineffective and effective regions of the DIS

Since the government regulator might receive the uninformative signal with probability $1-\lambda$ if the regulatory ability is λ. We follow the method of Arping (2010) and assume that the inferred credit acceptance criteria of the bank is the equilibrium α^*. When the DIS has the risk-based premium structure, the premium charged by government regulator is $I^*= \frac{(1-p^*)D^*r\theta}{p^*}$ and then the bank's profit is: $\pi^*=\mu(pDR - Dr)+(1-p)Dr - \frac{(1-p^*)D^*r}{p^*}(1-A)$, where $A=1-\theta$. Therefore, the expected profit of the bank in the second stage is: $\pi^c=\lambda\pi+(1-\lambda)\pi^*$ and we can get:

$$\pi^c=\mu(pDR - Dr)+(1-p)Dr+\lambda(A-1)(1-p)Dr-(1-\lambda)\frac{(1-p^*)D^*r}{p^*}(1-A)p \tag{5}$$

Similarly, when the DIS has the flat premium structure, the premium is $I=Dr\theta$, $\theta\in[0,1)$, then

$$\pi^c=\mu pDR+(1-\mu)Dr-pDr-pr\theta[\lambda D+(1-\lambda)D^*] \tag{6}$$

Following backward induction, we want to find the optimal credit acceptance criteria α^*. Therefore, we need to study the concavity and convexity of π^c first, in order to determine the solution method of this optimization problem. When the DIS has the risk-based premium structure

$$\frac{\partial \pi^c}{\partial \alpha}=\mu\frac{\partial W}{\partial \alpha} - Ar(p'D+1-p)-(1-\lambda)(1-A)r[p'D+(1-p)+\frac{(1-p^*)D^*}{p^*}p'] \tag{7}$$

$$\frac{\partial^2 \pi^c}{\partial \alpha^2}=[\mu R-(1-\lambda\theta)r](p''D-2p')-(1-\lambda)\theta r\frac{(1-p^*)D^*}{p^*}p'' \tag{8}$$

Similarly, when the DIS has the flat premium structure

$$\frac{\partial \pi^c}{\partial \alpha}=\frac{\partial W}{\partial \alpha}\mu - r - p'Dr - p'r\theta[\lambda D+(1-\lambda)D^*]+pr(1+\theta\lambda) \tag{9}$$

$$\frac{\partial^2 \pi^c}{\partial \alpha^2}=[\mu R-r(1+\theta\lambda)](p''D-2p')-p''r\theta(1-\lambda)D^* \tag{10}$$

Therefore, we have

Definition 1: The ineffective regions of the DIS are (I) and (II). The effective region of the DIS is (III). See Fig. 3, where $A=1-\theta, B=1+\theta$, $M=(1-A)\frac{p''}{p''-2p'}\frac{1-p^*}{p^*}$, $N=(B-1)\frac{D^*p''}{p''-2p'}$.

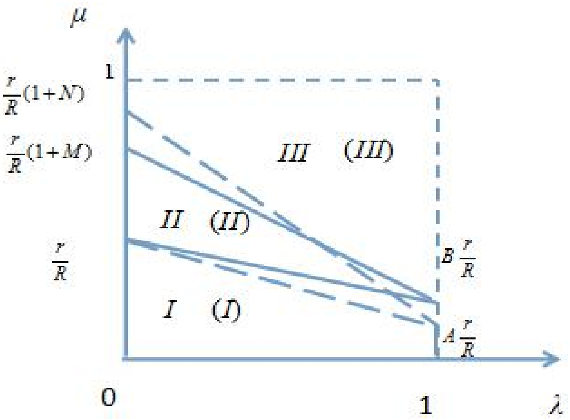

Fig.3 The effective and ineffective regions under the DIS

Remark: According to (8)

(I) When $\mu R-(1-\lambda\theta)r\leq 0$, π^c is a concave function.

(II) When $\mu R-(1-\lambda\theta)r>0$ and $[\mu R-(1-\lambda\theta)r](p''D-2p')-(1-\lambda)\theta r\frac{(1-p^*)D^*}{p^*}p''\geq 0$, then $\frac{\partial^2\pi^c}{\partial\alpha^2}\geq 0$, so π^c is a concave function. Because of in the regions (I) and (II) max $\pi^c=\max[\pi^c(\alpha=0), \pi^c(\alpha=1)]$, therefore, the DIS cannot help the government regulator avoid extreme risk taking of the bank.

(III) When $\mu R-(1-\lambda\theta)r>0$, and $[\mu R-(1-\lambda\theta)r](p''D-2p')-(1-\lambda)(1-A)r\frac{(1-p^*)D^*}{p^*}p''<0$, then $\frac{\partial^2\pi^c}{\partial\alpha^2}<0$, so π^c is a convex function; So the equilibrium a^* satisfies $\varphi^*(\alpha^*,A)=0$, then $\alpha^*=\alpha^*(A)$. Therefore, the DIS can effectively affect the risk taking of the bank. To sum up, we define the region (I) and (II) as the ineffective region of the DIS, and the region (III) is the effective region of the DIS.

Similarly, according to (10), we can get the ineffective region of the DIS (I), (II) and the effective region of the DIS (III):

(I) When $\mu R-(1+\theta\lambda)r\leq 0$, The profit function is a convex function;

(II) When $\mu R-(1+\theta\lambda)r>0$, and $(p''D-2p')[R\mu-r(1+\theta\lambda)]-p''r\theta(1-\lambda)D^*\geq 0$, the profit function is a convex function;

(III) When $\mu R-(1+\theta\lambda)r>0$, and $(p''D-2p')[R\mu-r(1+\theta\lambda)]-p''r\theta(1-\lambda)D^*<0$, the profit function is a concave function.

3.2 The endogenous evolution mechanism of the DIS

However, if we want to get the equilibrium effective and ineffective regions under the DIS, the key is to study the optimal DIS design. Therefore, in this section we first analyze endogenous evolution mechanism of the DIS with both the risk-based premium structure and flat premium structure.

(1) When the DIS has the risk-based premium structure, if

$$\psi_r^*=[\mu R-(1-\lambda+\lambda A)r](p^{*''}D^*-2p^{*'})-(1-\lambda)(1-A)r\frac{(1-p^*)D^*}{p^*}p''<0,$$

the bank's profit function is concave in credit acceptance criteria α. Therefore, the bank’s optimal credit acceptance criteria will satisfy the first order condition for profit maximization:

$$\varphi_r{*}=\mu\frac{\partial W^*}{\partial \alpha^*}-Ar(p^{*\prime}D^*-1+p^*)-(1-\lambda)(1-A)r[p^{*\prime}D^*+(1-p^*)+\frac{(1-p^*)D^*}{p^*}p^{*\prime}]=0.$$

Therefore, if the government regulator wants to choose the optimal DIS design in the first stage, the government regulator should maximize the social welfare and subject to both the incentive compatibility condition $\varphi_r{*}=0$ and the boundary condition $\psi_r{*}<0$. The programming problem can be expressed as follows.

$$\max_{\alpha^*,\ \theta} W^*=p^*D^*R-D^*r \tag{11}$$

$$s.t.\begin{cases}\varphi_r{*}=0,\\ \psi_r{*}<0,\\ \theta\in[0,1].\end{cases}$$

(2) When the DIS has the flat premium structure,

$$\varphi_f{*}=\mu\frac{\partial w^*}{\partial \alpha^*}-r-p^{*\prime}D^*r(1+\theta)+p^*r(1+\theta\lambda)=0,$$

$$\psi_f{*}=(p^{*\prime\prime}D^*-2p^{*\prime})[R\mu-r(1+\theta\lambda)]-p^{*\prime\prime}r\theta(1-\lambda)D^*<0.$$

Similarly, the government regulator's optimal DIS design problem can be expressed as follows

$$\max_{\alpha^*,\ \theta} W^*=p^*D^*R-D^*r \tag{12}$$

$$s.t.\begin{cases}\varphi_f{*}=0,\\ \psi_f{*}<0,\\ \theta\in[0,1).\end{cases}$$

Therefore, we can find the following

Proposition 1:

The government regulator's regulatory ability has a threshold λ_r'. In the effective region of the DIS (III), if $\lambda\in(\lambda_r',1)$ the iDIS (θ=0) is not the government regulator's optimal choice.

Proof. See the Appendix 1.

Proposition 1 tells us that the level of the government regulator's regulatory ability determines the choice of the DIS design. Intuitively, when the regulatory ability is low, the information asymmetry is high. Then the implementation of eDIS gives the bank more incentive to take excessive risk. Because it increases the operating costs of the bank, while it cannot effectively stop banks from shifting risk. Therefore, the iDIS is a preferred choice. On the contrary, when the regulatory ability is high, the government regulator has accurate information on the bank's risk. Accordingly, the bank's ability to shift risk is weakened and the eDIS could internalize the bank's cost of increase in risk. Hence, then the iDIS is not the government regulator's optimal choice.

Since more and more countries introduce the eDIS, it is an important question that to exploit whether the regulatory prescriptions from previous studies remain accurate when regulatory ability and banking market structure affect bank's risk-taking decisions under the eDIS.

3.3 How do regulatory ability and banking market structure affect the bank's risk taking under the eDIS?

First, we need to develop the equilibrium effective and ineffective regions of the eDIS. We can get Proposition 2 based on the results of Proposition 1.

Proposition 2: The equilibrium ineffective region of the eDIS (II') and equilibrium effective region of the eDIS (III') are shown in Fig. 4. In addition, we present the equilibrium region when the eDIS has risk-based premium structure in sub graph (a) and the equilibrium regulatory region when the eDIS has flat premium structure is presented in sub graph (b). Where $M'=\frac{p''}{p''-2p'}\frac{1-p*}{p*}$, $N'=\frac{(1+\theta')Dp''-2p'(1+\lambda'\theta')}{p''D-2p'}$.

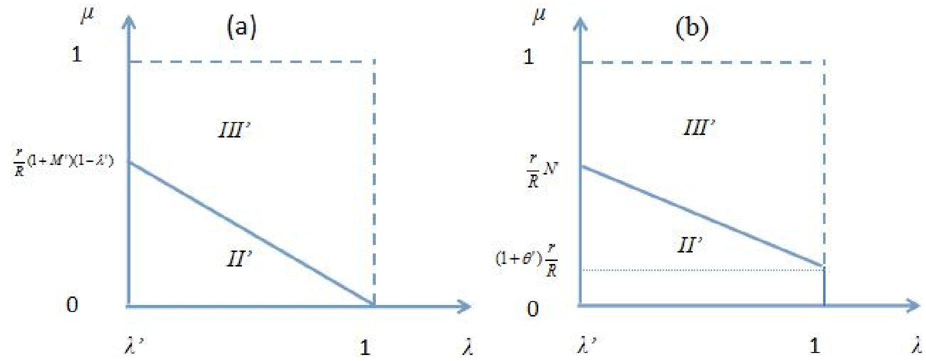

Fig.4 The equilibrium effective and ineffective regions under the eDIS

Proposition 2 indicates that the excess of competition in banking leads to the existence of ineffective region of the eDIS. Intuitively, since the reduction of the bank's monopoly rent decreases the bank's profits, therefore, it enhance the risk incentive distortion of the bank. Furthermore, based on Proposition 2 we analyze the characteristics of bank's risk taking in the equilibrium effective and ineffective regions of the eDIS.

Corollary 1:

(1) In the effective region of the eDIS (III'), the bank takes excessive risk ($a\in(0,1)$).

(2) In the in effective region of the eDIS (II'), the bank takes extreme risk and a=0.

Proof. See the Appendix 1.

In line with other studies (e.g. Arping, 2010; Chan et al., 1992; Merton, 1977; Pennacchi, 2006), Corollary 1 implies that the there is a moral hazard problem under the eDIS. In particular, combined with Proposition 2 the findings indicate that due to more competitive banking market structure, the bank takes the extreme risk, which could lead to the occurrence of banking crisis. Therefore, it provides a theoretical support for the finding of Beck et al. (2006).

Next, we focus on how regulatory ability and banking market structure influence affect the bank's risk taking in the effective region of the eDIS, and we can get:

Proposition 3: In the effective region of the eDIS (III'), more competitive banking market structure and the improvement of regulatory ability decrease the bank's excessive risk taking. The effects of regulatory ability and banking market structure on the bank's risk are interdependent.

Proof. See the Appendix 1.

Therefore, as a complement of the competition-fragility hypothesis, the result indicates that the regulatory ability could moderate the negative effect of banking market structure on the bank's excessive risk taking.

4 Empirical analysis

4.1 Research hypotheses

In order to make the analysis tractable, we want to develop some hypotheses and test the main theoretical predictions based on the cross-country empirical data.

First, Proposition 1 of the model presented in section 3 indicates that the determinant of the eDIS reform is the regulator's regulatory ability; therefore, we want to investigate the hypothesis

H1: Regulatory ability is the determinant of the eDIS adoption.

Second，Proposition 3 of the model in section 3 examines how the regulatory ability moderates the effects of market structure on bank’s risk taking; therefore, we want to test the hypothesis

H2: Under the eDIS, more concentrated banking market structure and higher regulatory ability could reduce the risk of banking. In addition, the interactive effect of regulatory ability and banking market structure on the risk of banking is negative during normal times.

At last, Proposition 2 presented in section 3 suggests that high degree of competition is the reason why the bank chooses extreme risk under the eDIS. It is could also be recognized as the further research of H2. Therefore, we examine the hypothesis

H3: The more competitive banking market structure increases the probability of the banking crisis occurrence.

In order to test the above hypothesis, we firstly want to provide the brief description of the data and variables.

4.2 Data and variables

The information on the DISs comes from the latest database built by Demirgüç-kunt et al. (2015), which covers 190 countries and ends in 2013. we create and set dummy DI_{it} which equals 1 when the country *i* enacts eDIS in a given year *t*, otherwise DI_{it}=0.

We are faced with a challenge to choose an appropriate proxy variable for the government regulator’s regulatory ability. Based on the definition of regulatory ability, we can find it measures the regulator’s ability to evaluate the true risk of the bank. The high ability of the risk evaluation depends an effective regulatory system, which comprises amounts of sound policies to be formulated and implemented, so we use Regulatory Quality (RegQ) as a proxy of regulatory ability, which comes from the latest World Government Indicators (WGI)[7] and covers 220 countries over the period 1996-2014.

In addition, we use the Lerner index (Lerner_eDIS) to measure the market structure of banking in countries under the eDIS, which is widely used by scholars (Anginer et al., 2014b; Beck et al., 2013; Jiménez et al., 2006). Beck et al. (2013) points out that the Lerner index measures the pricing ability of banks and it is more in line with the assumption of our model. Also, we use Cn5_eDIS, which is calculated as a country's five largest banks’ total assets to the all banks’ total assets (Mirzaei et al., 2013), to measure the market structure of the banking in countries under the eDIS in order to do a robust test just as other scholars.

Risk of banking is measured by Z-score (Anginer et al., 2014b; Demirgüç-Kunt and Detragiache, 2002; Fang et al., 2014) and the sound banking will have a high Z-score. Information on the banking crisis comes from the database compiled by Laeven and Valencia (2013), which covers 147 banking crises over the period 1970-2011. We set the banking crisis dummy $Crisis_{it}$ that equals 1 if the country *i* occurs a banking crisis in given year *t*, otherwise, it equals 0. In addition, the dummy $Crisis_{it}$_eDIS indicates the banking crisis occurs in the countries under the eDIS. Furthermore, we set and manually calculate a variable Ex-crisis, which is the number of banking crisis that occurred in the country before the given year for the H1.

Following Fratzscher et al. (2016), we control for the institutional variables: the Voice and accountability (Voice), the Government effectiveness (Goveff) and the Rule of law (Law). These variables come from the WGI as well. In addition, Demirgüç-Kunt et al. (2008) use the Policy

[7] Based on the definition of Kaufmann et al. (2011), RegQ measures the sound policies and regulations formulation and implementation ability of the government. See further discussion in Kaufmann et al. (2011).

score (Pscore) to characterize the country's institutional environment, so in this paper we use this variable to do the robust test. This index comes from the Policy IV database and covers 167 countries over period 1800-2015. In addition, we follow the method of Forssbæck (2011) and create Sumreg to control for the banking regulation, which is the sum of the Overall Restrictions on Banking Activities, the Overall Capital Stringency and the Official Supervisory Power. The data come from the World Bank surveys on bank regulation conducted in 1999, 2003, 2007 and 2011 and cover 188 countries[8].

In order to control macroeconomic conditions, we follow prior research (Demirgüç-Kunt and Detragiache, 2002; Houston et al., 2010) and include the following variables: the GDP per capital (GDPp), the real interest rates (ReInt), the inflation rate (Inflation), the real GDP growth rate (GDPg), the ratio of broad money M2 to foreign exchange reserves (M2F) and the total amount of trades in goods and services (Trade). These data also come from the WDI database.

In particular, for H1, we follow Demirgüç-Kunt et al. (2008) and control the country's fiscal deficit (Surplus) and use the share of the population aged 65 and over (Pop65) to control the clout which comes from elderly people, the data come from WDI database. Besides, sometimes a country's policy may be influenced by international organizations when there is interest exchange between them. For example, the Euro Union members enjoy many benefits (Anderson and Reichert, 1995), but the Euro Union requires plainly the EU accession countries to implement the eDIS in 1994. During the fourth to sixth expansion of the Euro Union (1995-2012), all accession candidate countries established the eDIS before joining the European Union, so we set a dummy EU_{it} to represent this pressure, if EU_{it}=1, it means that the country *i* is a EU accession countries in year *t*, otherwise EU_{it}=0. In addition, the World Bank started an adjustment lending program and stressed that the participating countries should enact the eDIS, therefore, we set dummy WB_{it} to indicate whether the country has accepted the World Bank lending program, if the country *i* joined the program in the year *t*, we have WB_{it} =1, and WB_{it}=0 otherwise. The data come from Demirgüç-Kunt et al. (2008). A detailed description of the above variables is given in Appendix 2.

4.3 Descriptive statistics

The final sample used in this paper is an unbalanced panel data set covering 190 countries over the period 1996 to 2011. We winsorize all continuous variables at the 1% and 99% levels. Table 1 show the summary statistics for the variables.

Table1. Summary statistics

Variable	Mean	Std.Dev.	Min	Max	No. Obs
DI	0.437	0.496	0	1	3040
RegQ	48.40	28.56	1	99.5	2406
Lerner_eDIS	0.229	0.137	-1.6087	0.8351	1100
Cn5_eDIS	67.49	19.94	23.41	100	1191
Z-score	11.11	7.861	-3.219	36.83	2632
Crisis	0.0697	0.255	0	1	3040
Crisis_eDIS	0.1136	03175	0	1	1329
Ex-crisis	0.591	0.679	0	4	3040
Inflation	8.513	12.80	-11.65	81.56	2946
GDPg	4.127	4.366	-8.856	19.46	2951
GDPp	11198.62	16241.49	234.77	77119.35	2913
ReInt	7.640	10.58	-25.94	49.18	2275
M2F	18.98	86.32	.3843	702.89	2180
Trade	88.33	49.37	21.85	336.25	2835
Pop65	7.152	4.881	1.574	18.79	2897
Surplus	-1.840	4.560	-15.05	15.70	1767
Pscore	3.370	6.456	-10	10	2535
Law	47.72	28.81	.5	99.5	2447
Voice	48.39	28.91	1	99.5	2454
GovEff	48.27	28.82	1	99.5	2407
Sumreg	22.32	3.854	12	31	509
EU	0.0612	0.240	0	1	3040
WB	0.0582	0.234	0	1	3040

[8] See further discussion in Barth et al. (2013).

Notes. This table presents summary statistics for the variables used in the paper. See Appendix 2 for a detailed explanation of variables and data sources.

This sample contains the 54 countries, which experienced eDIS transition over the period 1996-2011[9]. We define RegQ_t as every country's regulatory quality in year *t* when the country introduces eDIS and RegQ_a is every country's average regulatory quality from 1996 to *t* year when the country introduces eDIS. We present the descriptive statistics of both RegQ_t and RegQ_a in Table 2.

Table 2. Descriptive statistics of RegQ_t and RegQ_a

Variable	Mean	Std.Dev.	Min	Max	p25	p50	p75
RegQ_t	44.50	28.51	2	100	21.8	40.45	66.45
RegQ_a	43.71	27.44	2.5	99.64	23	39.92	60.30

Note. The p25, p50 and p75 are short for 25th percentile, 50th percentile and 75th percentile.

We can see that at least 50% of the countries' RegQ is less than 40.45 in the year of scheme transition, while at least 50% of the countries' RegQ_a before the scheme transition is less than 39.92. In addition, we present histograms and corresponding kernel density of RegQ_t and RegQ_a in Fig.5. The existence of mode justifies the fact that the there is a threshold of RegQ in the transition of DIS.

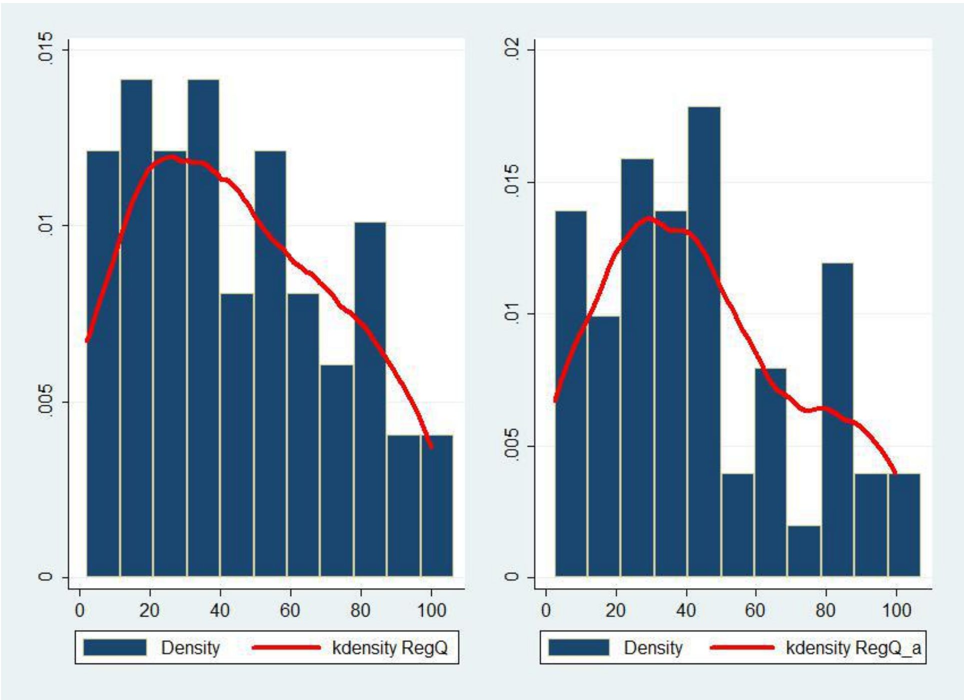

Fig.5 The histograms and kernel density of RegQ_t and RegQ_a

Next, in order to test H2, we delete the observations in which the dummy variable $Crisis_{it}$ equals 1, and dummy variable DI_{it} equals 0. In addition, we get Z-score (Z-score_n), RegQ (RegQ_n), Lerner index (L_eDIS_n) and Cn (Cn5_n). Table 3 report the descriptive statistics:

Table 3. Descriptive statistics of Z-score_n, RegQ_n, L_eDIS_n and Z-score_n and Cn5_n

	Mean	Std.Dev.	Min	Max	No. Obs	p25	p50	p75	p90
Z-score_n	10.99	7.944	-1.166	37.39	1118	5.20	9.13	14.60	22.19
RegQ_n	58.77	28.52	1.961	99.5	982	37.7	60.5	84.8	94.6
L_eDIS_n	0.241	0.116	-0.005	0.664	956	0.163	0.232	0.306	.377
Cn5_n	67.72	19.95	23.41	100	1042	52.00	68.21	84.52	94.7

Note. The p25, p50, p75 and p90 are short for 25th percentile, 50th percentile, 75th percentile and 90th percentile.

Table 4 reports the correlation matrix of these variables[10]. We find that Z-score_n is significant

[9] See Appendix 3 for the countries' name.
[10] The full correlation matrix is not reported here but available from authors.

positively associated with RegQ_n and L_eDIS_n, while Z-score_n is positively associated with Cn5_n but not significant.

Table 4. Correlation matrix

	Z-score_n	RegQ_n	Lerner_n	Cn5_n
Z-score_n	1			
RegQ_n	0.0649**	1		
L_eDIS_n	0.0837***	-0.1543***	1	
Cn5_n	0.011	0.1741***	0.0497	1

Notes. This table show the bivariate correlation between the variables used in section 5.2 and the significance level of each correlation coefficient. In the Panel A and Panel B, the observations are eliminated, which contain crisis=1. The definition of variables is presented in Appendix 2.

** Significant at 5%
*** Significant at 1%

5 Empirical findings

According to the descriptive statistical analysis above, we find that the empirical data is broadly consistent with our theoretical predictions. However, they are not significant statistically and our theoretical predictions are affected by many factors that are not controlled in the descriptive statistical analysis. Therefore, in this section, with empirical methods, we try to formulate the empirical specifications for each hypothesis presented in section 4 and report the empirical findings.

5.1 Regulatory ability is the determinant of the eDIS adoption.

As the first step of our empirical analysis, we make use of survival analysis to verify that the government regulator's regulatory ability is the determinant of the transition of the DIS. The key to the survival analysis model is to calculate the hazard rate $h(t)$, which is the average probability that a country instantly transits from the implicit deposit scheme to the eDIS over the interval [t, $t+\Delta t$]:

$$h(t) = \lim_{\Delta t \to 0^+} \frac{P(t \leq T < t + \Delta t | T \geq t)}{\Delta t}$$

where t is not the calendar time but the duration of the iDIS in every country. Since many countries did not reform their iDIS in the period that we studied, we do not know the exact time for the change of the DIS in these countries. Fortunately, the estimation of hazard model takes into account the fact that these observations are right censored (Leung et al., 2003).

Following Demirgüç-Kunt et al. (2008), we estimate the model as follows:

$$h(t) = h_0(t)\exp(\beta_1 RegQ_i + \beta_2 Tcrisis_i + \beta_3 EPressure_i + \beta_4 MEcon_i + \beta_5 InsEnviron_i) \qquad (13)$$

Since our data is the annual snapshot data, in order to carry out the survival analysis, we have to carry out the duration data transformation first (Ongena and Smith, 2001). As the most important independent variable, we use the RegQ as the proxy for regulatory ability. $Tcrisis_i$ is a set of the risk variables, including the dummy variable Crisis and the Ex-crisis. $EPressure_i$ is a set of the external pressure controls represented by WB and EU. $MEcon_i$ is a set of the countries' macroeconomic condition controls including the Pop65, GDPp, GDPg, Inflation and ReInte. In addition, $PEnviron_i$ is a set of political environment controls, including the GovEff, Law and Voice.

Firstly, we estimate (13) using the parametric model (also used by Leung et al., 2003). The key to the parametric model is to assume the specific distribution of the baseline hazard $h_0(t)$ reasonably, and then get the β coefficients with maximum likelihood estimation. Therefore, we will use three widely used parametric models as candidate models and carry out estimation respectively, then find the optimal model among them. The three parametric specifications for baseline hazard $h_0(t)$ are as follows:

Exponential model

$$h_0(t)=1 \qquad (14)$$

Weibull model

$$h_0(t)=pt^{p-1} \qquad (15)$$

Gompertz model

$$h_0(t)=\exp(\gamma t) \qquad (16)$$

Especially, as the special case of the Weibull model (when p=1) and the Gompertz model (when γ=0), the Exponential model indicates that the conditional probability of the transition of the scheme does not change in response to the change of duration. The Weibull model and the Gompertz model assume that the baseline hazard varies monotonically in response to the change of the duration. When there is a positive coefficient, the hazard of scheme transition increases in response to the increase of the duration; on the contrary, when there is a negative coefficient, the hazard of scheme transition decreases in response to the increase of the duration. The parameter estimates are reported with robust standard errors (clustering at the country level).

Secondly, we will compare the three models using Akaike information criterion (AIC), and the definition of AIC is

$$AIC=-2(log\ likelihood)+2(k+a+1), \qquad (17)$$

where k is the number of variables, a is the number of auxiliary parameters in the corresponding model, and the model with the smallest AIC is the optimal one among the three models involved. Finally, the estimation results are presented in Table5.

Table5. Parametric hazard model of DIS transition

	(1) Exponential	(2) Weibull	(3) Gompertz
RegQ	0.0389** (0.0189)	0.0562*** (0.0200)	0.0519** (0.0202)
Institutional environment I	YES	YES	YES
Other Controls	YES	YES	YES
p		2.100	
γ			0.157
Obs	681	681	681
Countries	74	74	74
No.of adoption	33	33	33
Log likelihood	-47.97	-42.03	-43.75
χ^2	129.2***	76.22***	87.06***
AIC	125.95	116.07	119.50

Notes. Stand.error is adjusted for clustering at country level. The regressions control Institutional environment I (Voice, Goveff, Law) and other controls including Crisis characters（Crisis, Ex-crisis）Macro conditions (Surplus,Pop65, GDPp, GDPg, ReInt, Inflation),Outside pressures (EU, WB). See Appendix2 for a complete description of explanatory variables and data sources. See Appendix3 for the complete list of countries.

* Significant at 10%
** Significant at 5%
*** Significant at 1%

We can see that the Weibull model is a preferred parametric model (specification in column (2) of Table5), and the empirical results confirm H1 and support our theoretical prediction in Proposition 1. For example, in specification (8) when we increase a one-standard deviation of RegQ (28.6), the increase of the hazard rate is exp(28.6*0.056)=4.96 points, so RegQ is the determinant of the transition of the DIS.

As a robustness check, we first use an alternative variable Pscore to control the political environment (see column (1) in Table 6). Besides since Demirgüç-Kunt et al. (2008) propose a hypothesis that the regulatory environment would have an influence on the transition of the DIS, we control Sumreg and try to address the issue of potential omitted variables. The results are shown in column (2) of Table 6.

Table6. H1 Robust check

	(1)	(2)	(3)
RegQ	0.00547	0.0522*	0.0514***
	(0.0131)	(0.0289)	(0.0191)
Institutional environment I	NO	YES	YES
Institutional environment II	YES	NO	NO
Crisis characters	YES	YES	YES
Macro conditions	YES	YES	YES
Outside pressures	YES	YES	YES
Regulatory environment	NO	YES	NO
p	1.95	2.41	n/a
Obs	572	461	681
Countries	62	58	74
No.of adoption	30	23	33
Log likelihood	-44.26	-20.89	-100.7
χ^2	45.56***	967.2***	70.74***
AIC	116.53	75.77	n/a
pseudo R^2	n/a	n/a	0.200

Notes. Columns (1) and (2) are Weibull distribution models. Column (3) is Cox model. Stand.errors are adjusted for clustering at country level. The regressions control Institutional environment I (Voice, Goveff, Law), Institutional environment II (Pscore), Regulatory environment (Sumreg) and other controls including Crisis characters (Crisis, Ex-crisis) Macro conditions (Surplus,Pop65, GDPp, GDPg, ReInt, Inflation),Outside pressures (EU, WB). See Appendix2 for a complete description of explanatory variables and data sources. See Appendix3 for the complete list of countries.

* Significant at 10%
** Significant at 5%
*** Significant at 1%

Consistent with the basic model, we find that the Weibull model is still the optimal one among the three parametric models for it has the smallest AIC value. In both specifications the RegQ shows a positive sign, so the robust check supports our view (although the positive effect is not significant in specification 1 at conventional levels). As a further robust check, we also use the Cox proportional-hazards model to test our hypothesis (Equation (13)). In this model we do not need assume a specified baseline hazard $h_0(t)$ for it is estimated nonparametrically. The results also confirm our view (see column (3) in Table 6). Besides, since the proportional-hazard assumption is the key to the effectiveness of the Cox proportional-hazard model, we test the proportional-hazards assumption for specification (3) using the Schoenfeld residuals method. The result are reported in Table 7 and show that the specification meet the proportional hazard assumption.

Table7. Test of proportional-hazards assumption

	ρ	χ2	Df	Prob>χ2
RegQ	-0.0802	0.320	1	0.572
Crisis	0.0354	0.0900	1	0.763
Ex-crisis	0.0735	0.230	1	0.631
Surplus	0.0595	0.350	1	0.554
EU	0.116	0.520	1	0.470
WB	-0.192	3.360	1	0.0668
Pop65	0.0875	0.520	1	0.472
GDPp	0.106	0.670	1	0.412
GDPg	-0.104	0.490	1	0.485
ReInt	-0.00835	0	1	0.944
Inflation	0.265	2.950	1	0.0857
GovEff	-0.0716	0.320	1	0.574
Law	0.0567	0.170	1	0.680
Voice	0.0440	0.0600	1	0.811
Global test		9.410	14	0.804

Notes. The proportional-hazard assumption is not met when the hull hypothesis is rejected. The default rejection criterion for the null hypothesis is p<0.05 (e.g.

Toso et al., 2012; Wallis et al., 2015).

5.2 Under the eDIS, more concentrated banking market structure and higher regulatory ability could reduce the risk of banking. In addition, the interactive effect of regulatory ability and banking market structure on the risk of banking is negative during normal times.

In this section, we focus on the effects of regulatory ability and banking market structure on the banking risk in normal times. Therefore, in this part we test the H2 based on the model of Barth et al. (2004). Our models are presented as follows:

$$Risk_{it} = \beta_1 MS_{it} + \beta_2 RA_{it} + \beta_3 MS_{it} \times RA_{it} + \beta_4 MEcon_{it} + \beta_5 InsEviron_{it} + \beta_6 Regulation_{it} + u_i + \varepsilon_{it} \quad (19)$$

Following the classic models (Anginer et al., 2014b; Laeven and Levine, 2009), we use the Z-score_n as the measurement of the banking risk, the L_eDIS_n to represent the banking market structure and the RegQ_n as the proxy for the regulatory ability.

Also, $MEcon_{it}$ is a set of Macroeconomic controls including the GDPp, GDPg, Inflation, ReInt, Trade. In addition, we also control the M2F to describe the foreign exchange risk faced by banks. Besides, many scholars proved the institutional and regulatory factors have a causal relationship with the stability of the banking industry (e.g. Fang et al., 2014; Fratzscher et al., 2016; Li et al., 2016), so we control the political environment $PEviron_{it}$ including the GovEff, Law, Voice, and regulatory environment $Regulation_{it}$ including the Sumreg, u_i is the fixed effect of the country. Cross-sectional dependent is a problem of lots of panel data sets, which are comprised of nonrandom sampled countries (Driscoll and Kraay, 1998). We follow prior literature (e.g. Chen et al., 2016; Perera and Wickramanayake, 2016) and report Driscoll-Kraay standard errors in parentheses which are robust to cross-sectional dependent, heteroscedasticity and autocorrelation (Hoechle, 2007). The results are shown in the following Table 8:

Table8. OLS regressions of the effects of regulatory ability, banking market structure on banking risk

	(3) Z-score_n	(4) Z-score_n
L_eDIS_n	5.637*** (0.973)	39.47*** (6.224)
RegQ_n	0.212*** (0.0169)	0.374*** (0.0605)
L_eDIS_n×RegQ_n		-0.450*** (0.0957)
Macro controls	YES	YES
Regulatory environment	YES	YES
Institutional environment I	YES	YES
Obs	100	100
Countries	56	56
R^2	0.264	0.303
F	92.55***	21.75***

Notes. Driscoll-Kraay standard errors are in parentheses. Fixed country effects and an intercept are not reported but included in all regressions. The regressions control Macro Controls (Trade, M2F, GDPp, GDPg, ReInt, Inflation), Regulatory environment (Sumreg), Institutional environment I (GovEff, Law, Voice), Institutional environment II (Pscore). See Appendix2 for a complete description of explanatory variables and data sources. See Appendix3 for the complete list of countries.

* Significant at 10%
** Significant at 5%
*** Significant at 1%

We can find that the coefficient of the L_eDIS_n is positive and statistically significant under the eDIS. These results support our theoretical prediction that the increase of the banking concentration decreases risk of banking. For example, in specification (1) of Table 10 the coefficient of Lerner indicates that under the eDIS, with a one-standard deviation increase in L_eDIS_n (0.116), Z-score_n increases approximate 8.2% of a one-standard deviation (7.944). In addition, we find RegQ_n enters specification (1) and (2) positively and significantly, the results support our theoretical prediction either. For example, in specification (1) of Table 10, if the RegQ_n increases a one-standard deviation (28.52) then Z-score_n increases approximately 76.5% of a one-standard deviation (7.944). Since the mean of Z-score_n is 10.99, therefore, this effect is economically significant as well.

However, different from the competition-fragility hypothesis, we find that the interactive effect between L_eDIS_n and RegQ_n on the Z-score_n is negative and significant in specification (2) of Table 10. The result confirms our theoretical prediction that the improvement of regulatory ability could decrease the positive effect of concentration on banking's risk reduction. For example, in specification (2) of Table 10, when the RegQ_n is 90^{th} percentile (94.6) the margin effect of L_eDIS_n on Z-score_n is negative. At this time, a one-standard deviation increases in L_eDIS_n decreases 4.5% of a one-standard deviation of Z-score_n (7.944) in the risk of banking. On the other hand, we are also different from competition-stability hypothesis. Since the mean of RegQ_n is 58.8, so the positive effect of L_eDIS_n on Z-score_n is dominant. Indeed, we find the moderating effect of regulatory ability on the relationship between banking market structure and risk of banking.

Furthermore, as the robustness check, we use the Cn5_n and the Pscore as the alternative variables to represent the banking market structure and political environment respectively. The results are shown in Table 9.

Table9. OLS regressions of the effects of regulatory ability, banking market structure on risk of banking: alternative measure of banking risk and banking market structure

	(1)	(2)	(3)	(4)	(5)	(6)
	Z-score_n	Z-score_n	Z-score_n	Z-score_n	Z-score_n	Z-score_n
L_eDIS_n	1.525	50.62***				
	(1.188)	(5.039)				
Cn5_n			0.05282**	0.1647***	0.0374	0.137***
			(0.02596)	(0.0207)	(0.0247)	(0.0187)
RegQ_n	0.118***	0.384***	0.1056***	0.2271***	0.138***	0.242***
	(0.0214)	(0.0418)	(0.0142)	(0.0299)	(0.0157)	(0.0174)
L_eDIS_n×RegQ_n		-0.695***				
		(0.0575)				
Cn5_n×RegQ_n				-0.0020***		-0.00175***
				(0.0005)		(0.000581)
Macro controls	YES	YES	YES	YES	YES	YES
Regulatory environment	YES	YES	YES	YES	YES	YES
Institutional environment I	NO	NO	YES	YES	NO	NO
Institutional environment II	YES	YES	NO	NO	YES	YES
Obs	90	90	81	81	100	100
Countries	51	51	47	47	58	58
R^2	0.335	0.401	0.602	0.597	0.359	0.366
F	2.964***	55.79***	48.28***	40.11***	11.12***	6.638***

Notes. Driscoll-Kraay standard errors are in parentheses. Fixed country effects not reported but included. The regressions control Macro Controls (Trade, M2F, GDPp, GDPg, ReInt, Inflation), Regulatory environment (Sumreg), Institutional environment I (GovEff, Law, Voice), Institutional environment II (Pscore). See Appendix2 for a complete description of explanatory variables and data sources. See Appendix3 for the complete list of countries.

* Significant at 10%
** Significant at 5%
*** Significant at 1%

In Table 9, we find that under the eDIS, the signs and statistical significance of the main explanatory variables are very similar to our previous empirical results.

5.3 The more competitive banking market structure increases the probability of the banking crisis occurrence.

Distinct from H2, H3 focuses on the effect of the banking market structure on the occurrence of banking crisis. It is the further research of H2. We test H3 reliant on the logit model (e.g. Beck et al., 2006; Schaeck et al., 2009). The log-likelihood function of the logit model is:

$$LnL = \sum_{t=1...T} \sum_{i=1...n} \{h(i,t)\ln[G(\beta' X(i,t))] + (1-h(i,t))\ln[1-G(\beta' X(i,t))]\} \quad (18)$$

where $h(i,t)$ is a dummy variable which equals 1 if country i has bank crisis in year t, otherwise $h(i,t)$ equals 0. $X(i,t)$ is a independent variable and $G(.)$ is the cumulative probability distribution function. In order to understand the magnitudes of the relationship between the banking market structure and the probability of a banking crisis easily, we report marginal coefficient estimates calculated at sample mean.

Table10. Logit regressions: banking market structure and the probability of banking crisis occurrence

	(1)	(2)	(3)
Lerner_eDIS	-0.3221***	-0.2354***	-0.1101
	(0.0661)	(0.0576)	(0.0671)
Institutional environment I	NO	YES	YES
Regulatory environment	NO	NO	YES
Macro controls	YES	YES	YES
Obs.	712	585	419
pseudo R^2	0.2176	0.2924	0.4304
%correct	91.29	92.48	96.18
$\chi2$	77.33***	85.64***	42.80***

Notes. The regressions control Macro controls (GDPp, GDPg, ReInt, Inflation, Trade, M2F), Institutional environment I (GovEff, Law, Voice), Regulatory environment (Sumreg). See Appendix2 for a complete description of explanatory variables and data sources. See Appendix3 for the complete list of countries. Robust standard errors are reported in parentheses.

* Significant at 10%
** Significant at 5%
*** Significant at 1%

Different from Beck et al. (2006) and Schaeck et al. (2009)[11], we use the variable Lerner_eDIS to represent the banking market structure and we can find that it negatively and significantly enters all of the specifications in Table 10. Specification (1) is the benchmark and only controls macroeconomic conditions including the GDPp, GDPg, ReInt, Inflation, Trade, M2F. Specification (2), (3) and (4) gradually add institutional characteristics: the Goveff, Voice and Law. In Specification (5), we add the Sumreg to control banking regulation environment[12]. These results support the H2 and empirically confirm our theoretical expectation that high competitive banking market structure leads to the existence of ineffective region of eDIS, therefore, banking takes extreme risk that could trigger banking crisis more easily. The results of the estimation indicate that a one-standard deviation increase in Lerner_eDIS (0.137) lead to a decrease of the probability of a banking crisis ranges approximately from 3.2% to 4.4%. Given that the probability of banking crisis is low (11%), the reduction is economically important. These results are robust when we replace the variables of banking market structure and institutional environment (see Table 11).

Table11. H3 robustness check

[11] The fraction of assets held by the three largest banks in each country, averaged over the sample period is used to measure the banking market structure by both Beck et al. (2006) and Schaeck et al. (2009). Besides, Schaeck et al. (2009) use H-statistic to measure the competitive of banking either.

[12] Since the sample size of Sumreg and Crisis are small and easily leads to collinearity. So in this regression, linear interpolation of missing value in Sumreg is used. The method is a common solution for such problem (e.g. Borisova et al., 2015; Altissimo et al., 2010; Anginer et al., 2014).

	(1)	(2)	(3)
Lerner_eDIS	-0.2892***	-0.2663***	
	(0.0777)	(0.0790)	
Cn5_eDIS			-0.0153
			(0.0156)
Institutional environment I	NO	NO	YES
Institutional environment II	YES	YES	NO
Regulatory environment	NO	YES	YES
Macro controls	YES	YES	YES
Obs.	649	451	448
pseudo R^2	0.2299	0.3328	0.2283
% correct	91.06	93.35	98.23
χ^2	73.68***	50.67***	36.48***

Notes.The regressions control Macro controls (GDPp, GDPg, RelInt, Inflation, Trade, M2F), Institutional environment I (GovEff, Law, Voice), Institutional environment II (Pscore), Regulatory environment (Sumreg). See Appendix2 for a complete description of explanatory variables and data sources. See Appendix3 for the complete list of countries. Robust standard errors are reported in parentheses.

* Significant at 10%
** Significant at 5%
*** Significant at 1%

6 Conclusion

This paper analyzes and tests how regulatory ability and banking market structure affect the eDIS adoption and then how the two factors affect banks' risk taking under the eDIS.

In the theoretical part, we develop a "government regulator--bank" dynamic game model to answer the questions. (i) In the respect of the eDIS adoption, we find that there exists a threshold of regulatory ability: if the government regulator's regulatory ability is above the threshold the iDIS is not the optimal choice. (ii) When the eDIS is effective in preventing crises, the effects of banking market structure and regulatory ability on the bank's risk taking are interdependent, (iii) although the excessive competitive banking market structure makes the eDIS ineffective in preventing crises.

In the empirical part, we construct a panel data set covering the 190 countries over the time range from 1996 to 2011. We test the hypothesis derived from the theoretical part and the empirical results support the main theoretical predictions. (i)With survival analysis, we find regulatory ability is the determinant of the eDIS adoption. The proxy variable of regulatory ability is the WGI's regulatory quality. (ii) The results also indicate that during normal times a negative effect of regulatory ability on bank risk, whereas the effect of market structure on bank risk is negative either, as predicted. Moreover, the results support the prediction that the increase of regulatory ability weakens the negative effect of banking market structure on banking risk under the eDIS. (iii) In addition, under the eDIS, the banking with more competitive market structures are more prone to experience a crisis.

Our study suffers from several limitations and we hope to address them in further research. On one hand, this study investigate the behavior of the represented bank and regulator, so we hope to develop a more general model and capture the heterogeneity of both banks and regulators. Correspondingly, on the other hand, we hope to do the empirical analysis based on the bank-level data and test the theoretical predictions.

Appendix 1

Lemma 1: The credit criteria of the optimum social welfare is $\alpha^f \in [0,1)$ and satisfy $[p(\alpha^f)'D(\alpha^f) - p(\alpha^f)]R + r = 0$.

Proof:

When $\alpha \in [0,1]$, the problem of optimum social welfare transfer to :

Max $W = pDR - Dr$.

According to first-order condition

$$\frac{dW}{d\alpha} = (p'D + pD')R + r,$$

$$\frac{d^2W}{d\alpha^2} = (p''D - 2p')R < 0,$$

So W is a concave function. and $\lim_{\alpha \to 1^-} W(\alpha) = 0 > W(1)$, obviously $\alpha^f \neq 1$, and the optimum risk level (the value of credit criteria) is $\alpha^f \in [0,1)$ and satisfy first-order condition $[p(\alpha^f)'D(\alpha^f) - p(\alpha^f)]R + r = 0$.

Q.E.D.

Proposition 1: The government regulator's regulatory ability has a threshold λ_r'. In the effective region of DIS (III), if $\lambda \in (\lambda_r', 1)$ iDIS ($\theta = 0$) is not the government regulator's optimal choice.

Proof:

When the DIS has the risk-based premium structure:

We use Lagrange multiplier method and Karush-Kuhn-Tucker conditions to solve optimum problem as follows:

$$\max_{\alpha^*,\ \theta} W^* = p^* D^* R - D^* r$$

$$\text{s.t.} \begin{cases} \phi^* = 0, \\ \theta \in [0,1], \\ \psi^* < 0。 \end{cases}$$

Assume $L = p^*D^*R - D^*r + \eta_1\varphi^* + \eta_2(-\psi^*) + \eta_3(1-\theta) + \eta_4\theta$, So:

$$\frac{\partial L}{\partial \alpha^*} = \frac{\partial W^*}{\partial \alpha^*} + \eta_1 \frac{\partial \phi^*}{\partial \alpha^*} + \eta_2\left(-\frac{\partial \psi^*}{\partial \alpha^*}\right) = 0,$$

$$\frac{\partial L}{\partial \theta} = \eta_1 \frac{\partial \phi^*}{\partial \theta} - \eta_2 \frac{\partial \psi^*}{\partial \theta} - \eta_3 + \eta_4 = 0,$$

$$\frac{\partial L}{\partial \eta_1} = \phi^* = 0,$$

$$\frac{\partial L}{\partial \eta_2} = -\psi^* > 0,\ \eta_2 \geq 0,\ (-\psi^*)\eta_2 = 0,$$

$$\frac{\partial L}{\partial \eta_3} = 1 - \theta,\ \eta_3 \geq 0,\ (1-\theta)\eta_3 = 0,$$

$$\frac{\partial L}{\partial \eta_4} = \theta,\ \eta_4 \geq 0,\ \theta\eta_4 = 0,$$

In this process, because $-\psi^* > 0, \eta_2 = 0$.

In the proof, we use lemma 3(a), lemma 3(b), corollary3(a):

Lemma 3(a): $\eta_1 \geq 0$.

Proof:

Since $\frac{\partial L}{\partial \alpha^*} = \frac{\partial W}{\partial \alpha^*} + \eta_1 \frac{\partial W}{\partial \alpha^*}$, so $\eta_1 = -\frac{\partial W^*}{\partial \alpha^*} / \frac{\partial \phi^*}{\partial \alpha^*}$

And $\frac{\partial W^*}{\partial \alpha^*} \geq 0$, $\frac{\partial \varphi^*}{\partial \alpha^*} < 0$

So $\eta_1 \geq 0$

Q.E.D.

Because we need to decide the positive and negative situation of

$$\frac{\partial \varphi^*}{\partial \theta} = r[\lambda(p^{*\prime}D^* - 1 + p^*) - (1-\lambda)\frac{(1-p^*)D^*}{p^*}p^*]$$

Therefore, we get lemmas as follows:

Lemma 2(b): there is $\lambda' \subseteq (0,1)$, making $\frac{\partial \varphi^*}{\partial \theta}=0$

Proof:

$\lambda(p^{*\prime}D^*-1+p^*)-(1-\lambda)\frac{(1-p^*)D^*}{p^*}p^{*\prime}$

$=\frac{\lambda(p^{*\prime}D^*+1-p^*)p^*-(1-\lambda)(1-p^*)D^*p^{*\prime}}{p^*}$

$\approx\frac{\lambda(p^{*\prime}D^*+p^*)-(D^*p^{*\prime}-p^*D^*p^{*\prime})}{p^*}$

Let $f(\alpha^*(\lambda))=\frac{(1-p^*)D^*p^{*\prime}}{p^*+D^*p^{*\prime}}$

$\frac{d}{d\lambda}(f(\alpha^*))$

$=\frac{d}{d\alpha^*}(\frac{D^*p^{*\prime}(1-p^*)}{p^{*\prime}D^*+p^*})\frac{d\alpha^*}{d\lambda}$

$=\frac{-[p^{*\prime}(1-p^*)+p^{*\prime}D^*p^{*\prime}](D^*p^{*\prime}+p^*)+p^*(1-p^*)D^*p^{*\prime\prime}}{(p^{*\prime}D^*+p^*)^2}\frac{d\alpha^*}{d\lambda}$,

According to $\phi^*(\alpha^*,\lambda)=0$,

$\frac{d\alpha^*}{d\lambda}=-\frac{\phi^*_\lambda}{\phi^*_{\alpha^*}}$, and in this equation,

$\phi^*_\lambda=(1-A)r[p^{*\prime}D^*+(1-p^*)+\frac{(1-p^*)D^*r}{p^*}p^{*\prime}]\geq 0$, $\phi^*_{\alpha^*}<0$,

$\therefore \frac{d\alpha^*}{d\lambda}\geq 0$, $\frac{d}{d\lambda}(f(\alpha^*))\leq 0$;

f: $\lambda\in(0,1)\rightarrow\alpha^*(\lambda)\in(0,1)$

So according to Tarsky's fixed point theorem, we know the existence of $\lambda'\in(0,1)$, making

$\lambda'(p^{*\prime}D^*-1+p^*)-(1-\lambda')\frac{(1-p^*)D^*}{p^*}p^{*\prime}=0$,

In other words, $\lambda'=f(\alpha^*(\lambda'))$。

Q.E.D.

Lemma 3(a):

If $\lambda\in(0,\lambda')$, $\lambda<f(\alpha^*(\lambda))$, that $\frac{\partial\phi^*}{\partial\theta}\leq 0$,

If $\lambda\in(\lambda',1)$, $\lambda>f(\alpha^*(\lambda))$, that $\frac{\partial\phi^*}{\partial\theta}\geq 0$。

Proof:

According to lemma 3(b), we know $\frac{d}{d\lambda}(f(\alpha^*))\leq 0$, thus when $\lambda\in(0,\lambda')$, $\lambda<f(\alpha^*(\lambda))$,

And according to,

$\frac{\partial\phi^*}{\partial\theta}=r[\lambda(p^{*\prime}D^*-1+p^*)-(1-\lambda)\frac{(1-p^*)D^*}{p^*}p^{*\prime}]$, $\therefore$ $\frac{\partial\phi^*}{\partial\theta}\leq 0$, when $\alpha^*=1$, $\frac{\partial\phi^*}{\partial\theta}=0$;

Similarly, when $\lambda\in(\lambda',1)$, $\lambda>f(\alpha^*(\lambda))$ and $\frac{\partial\phi^*}{\partial\theta}\geq 0$;

Q.E.D.

Based on lemmas above, optimum solution of deposits insurance scheme as follows:

（1）When $\theta=1$, then $\eta_3\geq 0$, $\eta_4=0$, $A=0$, because of

$\frac{\partial W^*}{\partial\alpha^*}$

$=Ar(p^{*\prime}D^*+1-p^*)+(1-\lambda)(1-A)r[p^{*\prime}D^*+(1-p^*)+\frac{(1-p^*)D^*r}{p^*}p^{*\prime}]$

$=(1-\lambda)r[p^{*\prime}D^*+(1-p^*)+\frac{(1-p^*)D^*}{p^*}p^{*\prime}]$, and

$\eta_1=-\frac{\partial W^*}{\partial\alpha^*}/\frac{\partial\phi^*}{\partial\alpha^*}$,

If α*=1, then $p^*=1, D^*=0$, thus $\eta_1=0$.

According to $\frac{\partial L}{\partial\theta}=\eta_1\frac{\partial\phi^*}{\partial\theta}-\eta_3=0$, $\eta_3=0$. But,

$\phi^*(\alpha^*=1)=\mu\frac{\partial W^*}{\partial\alpha^*}|_{\alpha^*=1}=(r-R)\mu<0$, which is contradicted.

If α*∈ [0,1], $\frac{\partial W^*}{\partial\alpha^*}>0$, ∴ $\eta_1>0$, According to lemma 3(a), we also know that

If λ∈ (0,λ'), λ<f(α*(λ)), $\frac{\partial\phi^*}{\partial\theta}<0$, so $\eta_3<0$, which is contradicted;

If λ∈ (λ',1), λ>f(α*(λ)), $\frac{\partial\phi^*}{\partial\theta}>0$, so $\eta_3>0$,

(2) When $\theta=0$, ∴ $\eta_3=0$, $\eta_4\ge0$, $A=1$, because of

$\frac{\partial W^*}{\partial\alpha^*}$

$=Ar(p^{*\prime}D^*+1-p^*)+(1-\lambda)(1-A)r[p^{*\prime}D^*+(1-p^*)+\frac{(1-p^*)D^*r}{p^*}p^{*\prime}]$

$=r(p^{*\prime}D^*+1-p^*)$, and

$\eta_1=-\frac{\partial W^*}{\partial\alpha^*}/\frac{\partial\phi^*}{\partial\alpha^*}$,

If α*=1, then $p^*=1$, $D^*=0$, so $\eta_1=0$.

Then, according to $\frac{\partial L}{\partial\theta}=\eta_1\frac{\partial\phi^*}{\partial\theta}+\eta_4=0$, $\eta_4=0$.

But $\phi^*(\alpha^*=1)=\mu\frac{\partial W^*}{\partial\alpha^*}|_{\alpha^*=1}=(r-R)\mu<0$, which is contradicted.

If α*∈[0,1], $\frac{\partial W^*}{\partial\alpha^*}>0$, so $\eta_1>0$, According to lemma 3(a), we also know that

If λ∈ (0,λ'), λ<f(α*(λ)), $\frac{\partial\phi^*}{\partial\theta}<0$, so $\eta_4>0$;

If λ∈ (λ',1), λ>f(α*(λ)), $\frac{\partial\phi^*}{\partial\theta}>0$, so $\eta_3<0$, which is contradicted.

(3) When $\theta\in$ [0,1], then $\eta_3=0$, $\eta_4=0$, $A=1-\theta$, because of

$\frac{\partial W^*}{\partial\alpha^*}$

$=Ar(p^{*\prime}D^*+1-p^*)+(1-\lambda)(1-A)r[p^{*\prime}D^*+(1-p^*)+\frac{(1-p^*)D^*r}{p^*}p^{*\prime}]$, and

$\eta_1=-\frac{\partial W^*}{\partial\alpha^*}/\frac{\partial\phi^*}{\partial\alpha^*}$,

If α*=1, then $p^*=1$, $D^*=0$, so $\eta_1=0$.

Then according to $\frac{\partial L}{\partial\theta}=\eta_1\frac{\partial\phi^*}{\partial\theta}=0$,

but $\phi^*(\alpha^*=1)=\mu\frac{\partial W^*}{\partial\alpha^*}|_{\alpha^*=1}=(r-R)\mu<0$, which is contradicted.

If α*∈ [0,1], $\frac{\partial W^*}{\partial\alpha^*}>0$, so $\eta_1>0$, According to lemma 3(a), we also know that

If λ∈ (0,λ'), λ<f(α*(λ)), $\frac{\partial\phi^*}{\partial\theta}<0$, so $\frac{\partial L}{\partial\theta}<0$, which is contradicted;

If λ∈ (λ',1), λ>f(α*(λ)), $\frac{\partial\phi^*}{\partial\theta}>0$, so $\frac{\partial L}{\partial\theta}>0$, which is contradicted.

In sum, when λ∈ (λ',1), the optimum deposits insurance scheme of governments is $\theta=1$; While λ ∈(0,λ'), the optimum deposits insurance scheme of governments $\theta=0$.

(2) When the DIS has the flat premium structure:

$$\phi^* = (p^{*\prime} D^* R - p^* R + r)\mu - r - p^{*\prime} D^* r - r\theta p^{*\prime} D^* + p^* r(1+\theta\lambda)$$
$$= \mu \frac{\partial w^*}{\partial \alpha^*} - r - p^{*\prime} D^* r(1+\theta) + p^* r(1+\theta\lambda)$$
$$\varphi^* = (2p^{*\prime} - p^{*\prime\prime} D^*)[r(1+\theta\lambda) - R\mu] - p^{*\prime\prime} r\theta(1-\lambda) D^*$$

Max $w^*=p^*D^*R - D^*r$

$$\text{st.}\begin{cases}\phi^* = 0,\\ \varphi^* < 0,\\ \theta \in [0,1).\end{cases}$$

$$L = w^* + \eta_1\phi^* + \eta_2(-\varphi^*) + \eta_3(1-\theta) + \eta_4\theta$$

$$\frac{\partial L}{\partial \alpha^*} = \frac{\partial w^*}{\partial \alpha^*} + \eta_1 \frac{\partial \phi^*}{\partial \alpha^*} + \eta_2(-\frac{\partial \varphi^*}{\partial \alpha^*}) = 0,$$

$$\frac{\partial L}{\partial \theta} = \eta_1 \frac{\partial \phi^*}{\partial \theta} - \eta_2 \frac{\partial \varphi^*}{\partial \theta} - \eta_3 + \eta_4 = 0,$$

$$\frac{\partial L}{\partial \eta_1} = \phi^* = 0$$

$$\frac{\partial L}{\partial \eta_2} = -\varphi^* > 0, \eta_2 \ge 0, (-\varphi^*)\eta_2 = 0$$

$$\frac{\partial L}{\partial \eta_3} = 1-\theta, \eta_3 \ge 0, (1-\theta)\eta_3 = 0$$

$$\frac{\partial L}{\partial \eta_4} = \theta, \eta_4 \ge 0, \theta\eta_4 = 0$$

In these equations, because $-\varphi^*>0$, $\eta_2=0$.

$$\frac{\partial \phi^*}{\partial \theta} = -p' Dr + pr\lambda$$

$$\lambda' = \frac{p' D}{p}$$

$$\frac{\partial}{\partial \alpha}(\frac{p' D}{p}) = \frac{(p'' D - p')p - (p')^2 D}{p^2} < 0$$

$$\lambda'_{\max} = \frac{p' D}{p}|_{\alpha=0} = \frac{p(\alpha=0)'}{p(\alpha=0)} < 1$$

$\theta=0, \eta_3=0, \eta_4 \geq 0$

$$\frac{\partial W^*}{\partial \alpha^*} + \eta_1 \frac{\partial \phi^*}{\partial \alpha^*} = 0$$

If $\alpha \in [0,1)$

$$\mu \frac{\partial w^*}{\partial \alpha^*} = r + p^{*\prime} D^* r - p^* r > 0, \frac{\partial \phi^*}{\partial \alpha^*} < 0$$

$\eta_1 > 0$

$$\eta_1 \frac{\partial \phi^*}{\partial \theta} + \eta_4 = 0$$

$$\text{when } \lambda < \lambda' = \frac{p' D}{p}, \frac{\partial \phi^*}{\partial \theta} < 0$$

If $\alpha^*=1$,

$\mu \frac{\partial w^*}{\partial \alpha^*} = r + p^{*\prime} D^* r - p^* r = 0$, since $p'(\alpha^*=1)=0$

$\psi^* = 2p^{*\prime}(\alpha=1)[r - R\mu]=0$, which is contradicted.

$\theta \in (0,1)$, $\eta_3=0, \eta_4=0$

If $\alpha \in [0,1)$

$$\mu\frac{\partial w^*}{\partial\alpha^*}$$
$$= r + p^{*\prime} D^* r(1+\theta) - p^* r(1+\theta\lambda)$$
$$= r + p^{*\prime} D^* r(1+\theta) - p^* r(1+\theta\lambda) + p^{*\prime} D^* r\lambda\lambda - p^{*\prime} D^* r\lambda\lambda$$
$$= r - p^* r + p^{*\prime} D^* r(1+\theta) - p^* r\theta\theta + p^{*\prime} D^* r\lambda\lambda - p^{*\prime} D^* r\lambda\lambda$$
$$= r - p^* r + p^{*\prime} D^* r[1+(1-\lambda)\theta] + (p^{*\prime} D^* - p^*) r\lambda\theta$$
$$\approx r - p^* r + p^{*\prime} D^* r(1+\theta) - p^{*\prime} D^* r\lambda\lambda$$
$$= r - p^* r + p^{*\prime} D^* r[1+(1-\lambda)\theta] > 0$$

So $\eta_1>0$, then $\frac{\partial L}{\partial\theta}=\eta_1\frac{\partial\varphi^*}{\partial\theta}=0$ is contradicted.

If α=1, $\mu\frac{\partial w^*}{\partial\alpha^*}=0$ and $\psi^*=0$ is contradicted.

Q.E.D.

Corollary 1:

(1) In the effective region of eDIS (III'), the bank takes excessive risk ($a\in(0,1)$).

(2) In the ineffective region of eDIS (II'), the bank takes extreme risk and $a=0$.

Proof:

(1) When the eDIS has the risk-based premium structure

If $\lambda\in(\lambda',1)$, $\theta=1$.

$$\phi^*=\mu\frac{\partial W^*}{\partial\alpha^*}-(1-\lambda)r[p^{*\prime}D^*+(1-p^*)+\frac{(1-p^*)D^*}{p^*}p^*]=0,$$

$$\frac{\partial W^*}{\partial\alpha^*}=\frac{1-\lambda}{\mu}r[p^{*\prime}D^*+(1-p^*)+\frac{(1-p^*)D^*}{p^*}p^*]>0,$$

Because W is concave function, so $\alpha^*<\alpha^f$.

When the eDIS has the flat premium structure,

If $\lambda\in(\lambda',1)$, for any $\theta\in(0,1)$

$$\mu\frac{\partial w}{\partial\alpha}=r+p'Dr(1+\theta)-pr(1+\theta\lambda)>0$$

Thus $\alpha<\alpha^f$.

(2) When the eDIS has risk-based premium structure

If $\lambda\in(\lambda',1)$, $\theta=1$.

$\pi(0,1)=\mu(pR-r)+(1-p)r=p(r'-r)$

$\pi(1,1)=0$

$\pi(0,0)=p(r'-r)-(1-p)r$

$$\pi(1,0)=-\frac{1-p}{p}r$$

$\pi(0,1)>\pi(1,1)$ and $\pi(0,0)>\pi(1,0)$, so $\alpha=0$ is the bank's optimal choice.

When the DIS has the flat premium structure,

If $\lambda\in(\lambda',1)$, for any $\theta\in(0,1)$

$\pi(0,1)=\mu(pR-r)+(1-p)r=p(r'-r)$

$\pi(1,1)=0$

$\pi(0,0)=p(r'-r)-pr\theta$

$\pi(1,0)=-pr\theta$

$\pi(0,1)>\pi(1,1)$ and $\pi(0,0)>\pi(1,0)$, so $\alpha=0$ is the bank's optimal choice.

Q.E.D.

Proposition 3: In the valid region of eDIS, more competitive banking market structure and the improvement of regulatory ability decrease the bank's excessive risk taking. The effects of regulatory ability and banking market structure on the bank's risk are interdependent.

Proof:

When the eDIS has the risk-based premium structure

If $\lambda\in(\lambda',1)$

$$\phi^* = \mu \frac{\partial W^*}{\partial \alpha^*} - (1-\lambda) r[p^{*\prime} D^* + (1-p^*) + \frac{(1-p^*)D^*}{p^*} p^{*\prime}] = 0,$$

$$\frac{\partial W^*}{\partial \alpha^*} = \frac{1-\lambda}{\mu} r[p^{*\prime} D^* + (1-p^*) + \frac{(1-p^*)D^*}{p^*} p^{*\prime}],$$

Let $N_l = \frac{1-\lambda}{\mu} r[p^{*\prime} D^* + (1-p^*) + \frac{(1-p^*)D^*}{p^*} p^{*\prime}]$, then

$$\frac{\partial N_1}{\partial \mu} < 0, \quad \frac{\partial N_1}{\partial \lambda} < 0, \quad \frac{\partial^2 N_1}{\partial \mu \partial \lambda} > 0;$$

Similarly, when the eDIS has the risk-based premium structure

If $\lambda \in (\lambda', 1)$

$$N_1 = \mu \frac{\partial w}{\partial \alpha} = \frac{1}{\mu}(r + p' Dr(1+\theta) - pr(1+\theta\lambda))$$

$$\frac{\partial N_1}{\partial \mu} < 0, \quad \frac{\partial N_1}{\partial \lambda} < 0, \quad \frac{\partial^2 N_1}{\partial \mu \partial \lambda} > 0;$$

Q.E.D.

Appendix 2

Table A1. Data definitions and sources

Variable	Definition	Source
RegQ	Regulatory quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.	WGI
Lerner_eDIS	A measure of the market structure of banking in countries under the eDIS. It compares output pricing and marginal costs (that is, markup). An increase in the Lerner index indicates a deterioration of the competitive conduct of financial intermediaries.	GFDD
Cn5_eDIS	Assets of five largest banks as a share of total commercial banking assets in countries under the eDIS. Total assets include total earning assets, cash and due from banks, foreclosed real estate, fixed assets, goodwill, other intangibles, current tax assets, deferred tax, discontinued operations and other assets.	GFDD
Z-score	It captures the probability of default of a country's commercial banking system. Z-score compares the buffer of a country's commercial banking system (capitalization and returns) with the volatility of those returns.	GFDD
Crisis or Crisis_eDIS	Equals 1 in years that the country is experiencing a systemic Banking crisis, and 0 otherwise. Crisis_eDIS indicates the banking crisis occurs in the countries under the eDIS.	Laeven and Valencia (2013)
Ex-crisis	Based on the data come from Laeven and Valencia (2013),the authors calculate the number of banking crisis that occurred in the country before the given year	Manually calculated
M2F	The ratio of M2 to foreign exchange reserves.	WDI
Trade	Net trade in goods is the difference between exports and imports of goods.	WDI
Inflation	Inflation, GDP deflator (annual %).	WDI
Surplus	Cash surplus or deficit is revenue (including grants) minus expense, minus net acquisition of nonfinancial assets.	WDI
GDPg	Real GDP growth rate (in %).	WDI
GDPp	GDP per capita (constant 2010 thousands of USD).	WDI
ReInt	The lending interest rate adjusted for inflation as measured by the GDP deflator.	WDI
Law	Rule of law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.	WGI
Voice	Voice and accountability captures perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.	WGI
Goveff	Government effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.	WGI
Pop65	Share of population age 65 and over.	WDI
Pscore	Index combining democracy and autocracy scores. It ranges from −10 to 10, where negative scores are assigned to countries under autocracies and positive values to countries under democracies and −10 and 10 are the extreme cases of these two systems. Autocracies sharply restrict or suppress competitive political participation. Their chief executives are chosen in a regularized process of selection within the political elite, and once in office they exercise power with few institutional constraints.	Polity IV database
Sumreg	Based on the data come from Barth et al.(2013), the authors calculate the sum of Capital	Manually

	Regulation, Supervisory Power, and Prompt Corrective Power indices.	calculated
WB	Equals 1 during and following the year that the World Bank started an adjustment lending program with the country for reforms to establish deposit insurance (in addition to possibly other objectives), and 0 otherwise. Equals 1 for the following countries and periods (starting dates between brackets): Albania (2002), Bolivia (1998), Bosnia-Herzegovina (1996), Croatia (1995), El Salvador (1996), Jordan (1995), Lithuania (1996), Nicaragua (2000), Poland (1993), Romania (1996), Russia (1997), Ukraine (1998).	World bank
EU	Equals 1 for the years 1994 and onwards for EU candidate countries only (i.e., Albania、Bosnia and Herzegovina、 Bulgaria、 Croatia、 Cyprus、 Czech Republic、 Estonia、Hungary、 El Salvador、 Lithuania、 Macedonia, FYR、 Malta、 Montenegro、 Poland、Romania、 Serbia、 Slovak Republic、 Slovenia、 Turkey、 Kosovo、 Iceland), and 0 otherwise. The year 1994 was the year when the EU Directive on Deposit Insurance came into force. Especially the application of Iceland for the accession into EU issued 2009, but was frozen due to election of new government in 2013	European Commission (1994)

Notes: WDI stands for World Development Indicator; WGI stands for World Government Indicator; GFDD stands for Global Financial Development Database.

Appendix 3

Table A2. List of countries, regions and each one's choice of the DIS

Afghanistan*	Canada#	Georgia	Kuwait	Nepal*	Slovak Republic#	United Kingdom#
Albania*	Central African Republic*	Germany#	Kyrgyz Republic*	Netherlands#	Slovenia*	United States#
Algeria*	Chad*	Ghana	Lao PDR*	New Zealand	Solomon Islands	Uruguay*
Angola	Chile#	Gibraltar*	Latvia*	Nicaragua*	Somalia	Uzbekistan*
Antigua and Barbuda	China, PR	Greece#	Lebanon#	Niger	South Africa	Vanuatu
Argentina#	Colombia#	Grenada	Lesotho	Nigeria#	Spain#	Venezuela, RB#
Armenia*	Comoros	Guatemala*	Liberia	Norway#	Sri Lanka	Vietnam*
Australia*	Congo, Dem. Rep.	Guinea	Libya*	Oman#	St. Kitts and Nevis	Yemen, Rep.*
Austria#	Congo, Rep.*	Guinea-Bissau	Liechtenstein	Pakistan	St. Lucia	Zambia
Azerbaijan*	Costa Rica	Guyana	Lithuania#	Palau	St. Vincent and the Grenadines	Zimbabwe*
Bahamas, The*	Cote d'Ivoire	Haiti	Luxembourg#	Panama	Sudan#	
Bahrain#	Croatia*	Honduras*	Macedonia, FYR#	Papua New Guinea	Suriname	
Bangladesh#	Cyprus*	Hong Kong SAR, China*	Madagascar	Paraguay*	Swaziland	
Barbados*	Czech Republic#	Hungary#	Malawi	Peru#	Sweden#	
Belarus#	Denmark#	Iceland#	Malaysia*	Philippines#	Switzerland#	
Belgium#	Djibouti	India#	Maldives	Poland#	Syrian Arab Republic	
Belize	Dominica	Indonesia*	Mali	Portugal#	Tajikistan*	
Benin	Dominican Republic	Iran, Islamic Rep.	Malta*	Qatar	Tanzania#	
Bhutan	Ecuador*	Iraq	Marshall Islands	Romania#	Thailand*	
Bolivia	Egypt, Arab Rep.	Ireland#	Mauritania*	Russian Federation*	Timor-Leste	
Bosnia and Herzegovina*	El Salvador*	Israel	Mauritius	Rwanda	Togo	
Botswana	Equatorial Guinea*	Italy#	Mexico#	Samoa	Tonga	

Brazil#	Eritrea	Jamaica*	Micronesia, Fed. Sts.	San Marino	Trinidad and Tobago#
Brunei Darussalam*	Estonia*	Japan#	Moldova*	Sao Tome and Principe	Tunisia
Bulgaria#	Ethiopia	Jordan*	Mongolia*	Saudi Arabia	Turkey#
Burkina Faso	Fiji	Kazakhstan*	Montenegro*	Senegal	Turkmenistan*
Burundi	Finland#	Kenya#	Morocco#	Serbia*	Tuvalu
Cabo Verde	France#	Kiribati	Mozambique	Seychelles	Uganda#
Cambodia	Gabon*	Korea, Rep.*	Myanmar	Sierra Leone	Ukraine*
Cameroon*	Gambia, The	Kosovo	Namibia	Singapore*	United Arab Emirates

Notes. This table lists the names of the full sample studied in this paper, which consists 190 countries. # indicates that a country enacted explicit deposit insurance scheme before 1996. * indicates a country enacted explicit deposit insurance scheme during 1996-2013, otherwise the country enacted implicit deposit insurance scheme, end-2013. Especially, only Mongolia and Sri Lanka enacted explicit deposit insurance scheme during 2012-2013.

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