BASEL II: Internal Rating Based Approach

Juwon Kwak

*Yonsei University**

In Ho Lee

Seoul National University†

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Abstract

The aim of this paper is to examine the impact of Basel II, especially focusing on the Internal Rating Based Approach. We present an economic model that analyzes the Internal Rating Based Approach. We found that Internal Rating Based Approach may induce banks to engage in "cherry picking" behavior, which may, in turn, increase the overall risk level. We further show how Internal Rating Based Approach may alter the business conditions of various economic agents and its effects on social welfare.

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* Department of Economics, e-mail : juwonkwak@yonsei.ac.kr

† Department of Economics, e-mail : ihl@snu.ac.kr

1 Introduction

Since 2007, Basel II, the newly adopted international standard of bank regulation, has replaced the 1988 Basel Accord. The key difference between Basel II and the 1988 Basel Accord is that Basel II adopts the Internal Rating Based Approach (IRBA) which allows each bank to use its own internal model and information to measure the risk weights of its investment assets. This paper focuses on the effect of the IRBA on the credit market.

First, we examine the effectiveness of the IRBA in reducing the risk level of banks' investments. The main purpose of bank regulation is to deter banks from taking excessive risks. We argue that the IRBA may invoke the banks to *cherry pick* the high-risk borrowers among the borrowers with same credit rating by screening out the low-risk borrowers, which may in turn increase the overall risk level of banks' investment portfolios.

Cherry picking behavior of banks refers to practices that shift a bank's portfolio toward the riskier of two loans when supervisors give both loans a same risk weights(Stevens, 2000). This Cherry picking behavior may occur for two reasons.

The first reason is because of information asymmetry between banks and regulatory agency. If banks have more information about the loans than the regulatory agency, they can cherry pick the riskier ones from the same risk bucket. This first reason has been analyzed by Koehn and Santomero (1980), Kim and Santomero (1988), and Rochet (1992). They showed that if risk weights are not correctly calculated, banks can actually take more risks. Calculating risk weights correctly means that riskier asset is given a higher risk weights, and without the private information of banks, regulatory agency may put assets with different risk levels in a same risk bucket.[1]

The second reason, which is newly mentioned in this paper, is the screening device that banks have. Banks can always screen out less desirable borrowers with various screening devices, even when they have no more information than the regulatory agency. As Stiglitz and Weiss (1981) showed, banks can screen low-risk borrowers by adjusting interest rates. Other terms in debt covenants can also be used as a screening device. Therefore, unless the regulatory agency take account of all possible screening devices, calculating risk weight correctly may not be possible.

The existence of screening device is the key reason that deters the IRBA from decreasing the overall risk level. Since IRBA is a truth telling mechanism that induces banks to reveal their private information, it would eliminate or at least alleviate the first reason of banks' cherry picking behavior.

However, the second reason still remain unsolved because although banks may have revealed their private information, they can still utilize screening devices to Cherry pick the high-risk borrowers. Therefore, Cherry picking problem can be aggravated. If the burden of regulation is solely borne by the unsophisticated banks that cannot afford IRBA, those unsophisticated banks would try to cherry pick the high-risk borrowers to pass on the burden to borrowers. We show that in some cases, this effect would be overwhelming.

Second, we examine the effects of the IRBA on different types of lenders and borrowers. We analyze the various effects of the IRBA on good credit type and bad credit type borrowers. We also examine how sophisticated banks, which can afford to implement the IRBA, and unsophisticated banks, which cannot, may face different business conditions after the adoption of Basel II.

The main idea of IRBA is to reduce the burden of regulation when banks can verify that they have invested in

[1] A similar point has been argued by Chan, Greenbaum, and Thakor (1992) and Freixas and Rochet (1998). However, these two works study the methods of designing a fairly priced incentive compatible deposit insurance contract (a truth telling mechanism) that would induce banks to reveal their hidden information. IRBA is also a truth-telling mechanism.

a safe asset. The benefit of the reduction of regulatory burden would be shared among the banks and the investees. Those would be the sophisticated banks and good credit type borrowers. However, the unsophisticated banks that cannot afford IRBA would have no choice but to accommodate those bad credit type borrowers and the whole burden of regulation would be shared among the unsophistcated banks and bad credit borrowers. Therefore, their business condition would be aggravated.

Some other academic works (Hakenes and Schnabel, 2005; Repullo and Suarez, 2004; and Rime, 2003) focused on the IRBA of Basel II. Hakenes and Schnabel (2005) is the most closely related work to this paper. They pointed out the problem with the optionality of adopting the IRBA. Their works assume that sophisticated banks and unsophisticated banks share the same information about the borrowers. However, the key feature of the IRBA is its permission for the banks to use their private information, which is not observable by outsiders. Therefore, their work do not show the key difference between the IRBA and a risk-sensitive Standard Approach (SA). This paper assumes that the sophisticated banks and unsophisticated banks have asymmetric information.[2]

Section 2 introduces the basic model that we use and Section 3 shows a simple benchmark case that explicitly solves for the loan market equilibrium when there are two types of borrowers in the model of Stiglitz and Weiss (1981). Section 4 analyzes the main effects of the IRBA. Section 5 studies the welfare effects and presents some policy recommendations that can maximize social welfare. Section 6 presents the conclusion.

2 The Model

The model we construct is a modified version of the one analyzed in Stiglitz and Weiss(1981). There is a continuum of borrowers whose size is 2. Each borrower is characterized by the type of project he has. There are two types of projects, *high-risk* and *low-risk*. We identify the type of the borrower by the type of the project, denoted by θ: if $\theta = H$, the borrower is a high-risk type and if $\theta = L$, the borrower is a low risk type. If $\theta = i$, the project succeeds with a probability P_i and a return R_i where $i \in \{H, L\}$. If it fails, the return is zero. The high-risk project is a mean preserving spread of the low-risk project: $P_H R_H = P_L R_L$, where $R_H > R_L > 1$ and $P_H < P_L$. The population of high-risk types and low-risk types is 1 each. Each project requires a lump sum investment of 1.

The risk type (θ) is a private information of the borrower, which is not observable by the lenders. However, the lender observes a signal, s, which provides imperfect information about the borrower's type. In the real world, this signal can be interpreted as a credit rating. We denote the borrower with $s = G$ as a *good credit type* and the borrower with $s = B$ as a *bad credit type*, respectively. The probability of observing a good signal when the borrower is a low-risk type ($\theta = L$) is α and the probability of observing a bad signal when the borrower is a high-risk type $(\theta = H)$ is also α:

$$\Pr[s = G|\theta = L] = \Pr[s = B|\theta = H] = \alpha$$

[2] Several theoretical papers (Lowe, 2004; Daníelsson, Shin, and Zigrand, 2004; and Kashyap and Stein, 2004) have discussed the macroeconomic effect of Basel II, especially with a focus on the procyclicality and the fact that Basel II does not take account of the endogeneity of financial risks. The main argument of these works is that Basel II uses the VAR model to estimate the amount of risks that banks are taking. Since almost every bank uses a similar VAR model to calculate the risk level, a single moderate shock on the economy can stimulate banks' selling of their assets and a macroeconomic downturn.

We assume that $1 > \alpha > \frac{1}{2}$, which implies that the signal s provides imperfect information about the risk type of the borrower.

A slight abuse of the law of larger numbers implies that α fraction of the borrowers has $(s, \theta) = (G, L)$, α fraction of the borrowers has $(s, \theta) = (B, H)$, $1 - \alpha$ fraction of the borrowers has $(s, \theta) = (G, H)$, and $1 - \alpha$ fraction of the borrowers has $(s, \theta) = (B, L)$. Therefore, the market is segmented by the signals. We call the market for the good credit types, the *good credit market* and the market for the bad credit types, the *bad credit market*.

The borrower's payoff is $\Phi(s, \theta) = P_\theta(R_\theta - r_s)$, where r_s is the (gross) interest rate charged on the borrower with signal s. The borrower of type (s, θ) will borrow if and only if $\Phi(s, \theta) \geq 0$, that is, $r_s \leq R_\theta$. When $r_G \in [1, R_L]$, the demand for the loan in the good credit market is 1 and when $r_G \in (R_L, R_H]$, the demand is $1-\alpha$. When $r_B \in [1, R_L]$, the demand for the loan in the bad credit market is 1 and when $r_B \in (R_L, R_H]$, the demand is α. Therefore, the lender can screen out the low-risk type by charging $r_s \in (R_L, R_H]$ or pool them by charging $r_s \in [1, R_L]$.

There is a continuum of lenders whose size is also 2. The amount of capital each lender can lend is 1. The unique feature of the present model as compared to Stiglitz and Weiss (1981) is that the lenders incur the cost of capital, c, which is distributed uniformly on $[1, 2]$. Let $P(s, r_s)$ be the probability of the project's success of the borrower with signal s when the interest rate charged on the borrower is r_s. The expected profit of the lender with the cost of capital c is $\pi_c^s = P(s, r_s)(r_s) - c$, when lending to the borrower with signal s.[3]

If the interest rate charged satisfies $r_s \in [1, R_L]$, then both types of borrowers borrow in market s, and the success probability of the project is given by $P(G, r_G) = \overline{P} = (1 - \alpha)P_H + \alpha P_L$ in the good credit market and $P(B, r_B) = \underline{P} = (1 - \alpha)P_L + \alpha P_H$ in the bad credit market, respectively.[4]

If the interest rate charged satisfies $r_s \in (R_L, R_H]$, then only borrowers of type H borrow in market s and the success probability of the project is P_H in that market.

3 Benchmark Case

As a benchmark, we analyze a simple case in which every borrower produces the same signal. Assume that the size of borrowers is 1 and let β be the proportion of high-risk type borrowers and r be the interest rate imposed on borrowers. As we have seen in the previous section, both types of borrowers borrow when $r \in [1,\ R_L]$, and the probability of the project's success $P(r)$ is $\hat{P} = (1 - \beta)P_L + \beta P_H$. If $r \in (R_L,\ R_H]$, then only type H borrowers borrow and the probability of the project's success $P(r)$ is P_H. Note that $\hat{P} > P_H$.

Assume that the population of the lenders is 1. The expected profit of the lender with cost c is $\pi_c = P(r)r - c$. Since the cost on capital c is uniformly distributed on $[1, 2]$, the supply of capital is $x = P(r)r - 1$.

Proposition 1 *The equilibrium in the loan market is characterized as follows.*

1. $1 \leq \hat{P}R_L - 1$, *then* $r^* = \frac{2}{\hat{P}}$ *and the loan amount is 1.*
2. $\beta \leq \hat{P}R_L - 1 < 1$, *then* $r^* = R_L$ *and credit rationing occurs with the loan amount of* $\hat{P}R_L - 1$ *which is strictly smaller than 1 but greater than* β.

[3] If $\pi_c^s \geq 0$ (i.e. $c \leq P(s, r_s)r_s$), then the lender would lend capital. Therefore, the amount of loan supply would be $P(s, r_s)r_s - 1$ because the cost of capital is uniformly distributed in $[1, 2]$. Note that the amount of loan supply equals the profit of a lender whose cost of capital is 1.

[4] We adopt the tie-breaking rule that the borrower borrows when he is indifferent between borrowing and not borrowing

3. $\hat{P}R_L - 1 < \beta \le P_H R_H - 1$, *then* $r^* = \frac{1+\beta}{P_H}$ *and the loan amount is* β.

4. $P_H R_H - 1 < \beta$, *then* $r^* = R_H$ *and credit rationing occurs with the loan amount of* $P_H R_H - 1$ *which is strictly smaller than* β.

Proof. Notice that the demand for the loan is given by 1 for $r \in [1, R_L]$ and β for $r \in (R_L, R_H]$. Similarly the supply for the loan is given by $\hat{P}r - 1$ if $r \in [1, R_L]$ and $P_H r - 1$ if $r \in (R_L,\ R_H]$.

We first solve for the equilibrium ignoring the possibility of credit rationing. The equilibrium condition for $r \in [1, R_L]$ is $\hat{P}r - 1 = 1$ and the condition for $r \in (R_L,\ R_H]$ is $P_H r - 1 = \beta$. Hence $r^* = \frac{2}{\hat{P}}$ and the equilibrium loan amount is 1 when $r^* \in [1, R_L]$ and $r^* = \frac{1+\beta}{P_H}$ and the equilibrium loan amount is β when $r^* \in (R_L,\ R_H]$. The condition $r^* = \frac{2}{\hat{P}} \in [1, R_L]$ is rewritten as $\hat{P}R_L - 1 \ge 1$ and the condition $r^* = \frac{1+\beta}{P_H} \in (R_L,\ R_H]$ is rewritten as $P_H R_L - 1 < \beta \le P_H R_H - 1$ for future references.

We now take account of the possibility of credit rationing. When $\hat{P}R_L - 1 \ge 1$, the equilibrium loan is 1 for $r^* = \frac{2}{\hat{P}}$; borrowers of both types are supplied the loan at the market equilibrium and the market clears and hence it is an equilibrium.

If $\hat{P}R_L - 1 < 1$, then the demand for the loan remains 1 for $r^* \in [1, R_L]$, while the supply is less than 1 since $\hat{P}r^* - 1 < 1$ even for $r^* = R_L$; there is excess demand. Under this circumstance, the lenders may raise the interest rate so that the market clears at a higher interest rate or the lenders may exercise credit rationing at $r^* = R_L$. Credit rationing occurs if the supply at the interest rate $r^* = R_L$ is greater than the supply at the interest rate higher than R_L which is β:

$$\hat{P}R_L - 1 \ge \beta.$$

Remember that the loan market with only high-risk type borrowers clears at the interest rate $r^* = \frac{1+\beta}{P_H}$ if $P_H R_L - 1 < \beta \le P_H R_H - 1$. Since $\hat{P}R_L - 1 \le P_H R_H - 1$, the equilibrium with $r^* = \frac{1+\beta}{P_H}$, which is not credit rationed, holds when $\hat{P}R_L - 1 < \beta$. Hence the credit rationing equilibrium with the interest rate $r^* = R_L$ and the equilibrium loan amount of $\hat{P}R_L - 1$ occurs if $1 > \hat{P}R_L - 1 \ge \beta$.

If $\hat{P}R_L - 1 < \beta$, then the loan market equilibrium is given by the interest rate $r^* = \frac{1+\beta}{P_H}$ and the equilibrium loan amount of β. However, this equilibrium ceases to hold if $P_H R_H - 1 < \beta$ since the demand for loan is β while the supply is $P_H r^* - 1$, which is smaller than β. Hence the loan market equilibrium with the interest rate $r^* = \frac{1+\beta}{P_H}$ and the equilibrium loan amount of β occurs if $\hat{P}R_L - 1 < \beta \le P_H R_H - 1$.

Finally credit rationing occurs with only high-risk type borrowers if $P_H R_H - 1 < \beta$; the equilibrium interest rate is R_H and the loan amount is $P_H R_H - 1$.

Collecting the results completes the proof. ■

The proposition explicitly solves for the loan market equilibrium when there are two types of borrowers in the model of Stiglitz and Weiss (1981). As is well known, the loan market equilibrium may be characterized by credit rationing since raising the interest rate may alter the pool of loan applicants into becoming riskier.

Corollary 1 $r \in [1, R_L)$ *or* $r \in (R_L, R_H)$, *then the market is cleared. However, if* $r = R_L$ *or* $r = R_H$, *then the market is not cleared and credit rationing occurs.*

The proof of this corollary is straightforward from Proposition 1.

4 Internal Rating Based Approach

Now, suppose that there are two types of lenders. One type of lender can observe the signal s and the other type cannot observe the signal s. We call a lender who can observe the signal s, an *Informed Lender* and the one who cannot observe, a *Uninformed Lender*. Assume that the observing ability is independent of the cost of capital and the population of the informed lenders and uninformed lenders is 1 each. Also, assume that the observing ability is also observable by the borrowers so that the uninformed lender cannot pretend to be an informed lender. The informed lenders can be interpreted as sophisticated banks that can afford to implement the IRBA whereas the uninformed lenders represent unsophisticated banks that have no choice but to adopt the SA.

Before starting the analysis, we define some actions that the lenders can take. If a lender in the good credit market moves to the bad credit market and follows the strategy of the lenders in the bad credit market or vice versa, we call this action *"change the market"*. If a lender who screens out the low risk types starts pooling both types by lowering the interest rate or vice versa within the same market, we call this action *"switch the action"*.

Suppose the regulation agency imposes a high minimum capital ratio or high deposit insurance fee on the lenders who enter the bad credit market. These kinds of regulations increases the capital cost of lenders. This is the main feature of any risk-sensitive prudential regulation, imposing *regulatory tax*, which increases cost of capital, on risky investment.[5] Then the capital cost of those who enter the bad credit market will increase. Assume that the regulatory tax is $\delta > 0$ for any lender who enters the bad credit market or those who cannot verify that they entered the good credit market. Therefore, uninformed lenders always have to bear the regulatory tax, δ. This means that the lender whose cost of capital is c, when entering the good credit market, will have to bear the cost of capital $c + \delta$, when entering the bad credit market.

4.1 The equilibria

Let Ψ_I and Ψ_U be the strategy of informed lenders and uninformed lenders, respectively. The strategies that informed lenders can pursue is a vector of two elements, $\Psi_I = (a_G, a_B)$, where $a_s \in \{S, P, N\}$. S is screening, P is pooling, N is not entering, and a_s is an action that is taken in the s market. $\Psi_I = (S, P)$ means that informed lenders screen in the good credit market and pool in the bad credit market. Therefore there are eight possible strategies for informed lenders because, (N, N) surely is not an equilibrium. The strategies that uninformed lenders can take can be expressed by a single element, a, where $a \in \{S, P\}$. For the strategies,(Ψ_I, Ψ_U) to be nash-equilibrium, they must satisfy the following conditions.

a) *Higher profit condition* : Note that the informed lenders can mimic the uninformed lenders while uninformed lenders cannot mimic the informed. Therefore, the profit of the informed lenders should be as large as or greater than the uninformed lenders' profit. We call this condition a Higher profit condition.

b) *Impossibility of Intramarket Arbitrage Condition* : Impossibility of Intramarket Arbitrage Condition (Intramarket Condition) means that the lenders cannot make more profit just by switching from screening to pooling or vice

[5] Note that, the regulatory tax does not mean that regulatory agency, in fact, tax the banks but, an analogy used to capture the effect of the increase in capital cost by regulation.

versa within the same market they are involved in. If they cannot make more profit, they would have no incentive to switch the action.

c) *Impossibility of Intermarket Arbitrage condition* : Impossibility of Intermarket Arbitrage Condition (Intermarket Condition) means that the lenders in the good credit market and the lenders in the bad credit market should have equal profit so that they cannot make arbitrage profit just by changing the market as long as they are homogeneous. For example, if informed lenders enter both markets, no matter which market they enter, the profits should be equal.

However, this does not mean that informed lenders' profit must be equal to the uninformed lenders' profit in the opposite market. Intermarket condition only holds among the homogeneous lenders.

Before, analyzing the equilibria, we first examine which strategies cannot be an equilibrium, i.e., which are the strategies that do not satisfy the above three conditions. There are eight possible strategies for informed lenders, because $\Psi_I = (N, N)$ surely cannot be an equilibrium.

Lemma 1 *The interest rate set by uninformed lenders cannot be lower than the interest rate set by informed lenders.*

Proof. Suppose the interest rate set by uninformed lenders is lower, then since uninformed lenders cannot distinguish good credit types from bad credit types, every borrower would go to uninformed lenders. It will cause the informed lenders to lower interest rate. Therefore, it would not be an equilibrium for sure. ■

First, consider the strategies $\Psi_I = (N, S)$ or (N, P). Because of the regulatory tax, informed lenders can always save cost of capital by entering the good credit market. Therefore, those two strategies would not be equilibria.

Lemma 2 *Informed lenders always enter the good credit market. Therefore,* $\Psi_I = (N, S)$ *and* $\Psi_I = (N, P)$ *are not equilibria.*

Proof. We prove this lemma by showing that $\Psi_I = (N, S)$ and $\Psi_I = (N, P)$ are not equilibria.

If informed lenders pool in the bad credit market, since $\overline{P} > \underline{P}$, informed lenders can make an arbitrage profit by entering the good market. Therefore, (N, P) breaks the intermarket condition.

Suppose informed lenders screen out in the bad credit market ($\Psi_I = (N, S)$). If uninformed lenders impose a lower interest rate, it contradicts Lemma 1. If uninformed borrowers impose a higher or equal interest, their profit would be higher so it will break the higher profit condition. Therefore, it proves the lemma. ■

Now, consider the strategy, $\Psi_I = (S, P)$. It means that the interest rate in the good credit market is higher. However, since the probability of success when the borrowers are pooled in the good market ($\overline{P}$) is higher than the probability of success in the bad market ($\underline{P}$), if borrowers are pooled in the bad market, informed lenders would also pool in the good market. Therefore, $\Psi_I = (S, P)$ is not an equilibrium.

Lemma 3 *The interest rate in the bad credit market has to be higher than or equal to the interest rate in the good credit market. Therefore,* $\Psi_I = (S, P)$ *cannot be an equilibrium.*

Proof. We consider two possible cases: first, when informed lenders enter both market and second, when informed lenders only enter the good market.

Suppose the informed lenders enter both markets, then the profits from both markets have to be equal owing to intermarket condition and the interest rate in the bad credit market has to be higher because of the regulatory tax.

Suppose the informed lenders only enter the good credit market ($\Psi_I = (S, N)$ or $\Psi_I = (P, N)$), then, if uninformed lenders set a lower interest rate, it will break Lemma 1. Therefore, uninformed lenders have to set a higher or equal interest rate which would be the interest rate in the bad credit market. This eliminates the informed lenders' strategy (S, P). ■

Lastly, we consider the strategy $\Psi_I = (P, P)$.

Lemma 4 *The uninformed lenders cannot enter the good credit market.*

Proof. According to Lemma 3, the interest rate in the bad credit market has to be higher than or equal to the interest rate in the good credit market. We consider two feasible cases: first, when the interest rate in the bad credit market is higher and second, when the interest rates are equal.

Suppose the interest rate is higher in the bad credit market and also assume that the uninformed lenders set the interest equal to the interest in the good credit market, then it would contradict Lemma 1. Therefore, the uninformed lenders will set the interest equal to the bad credit market in the equilibrium.

Suppose the interest rates are equal. The profit from the bad credit market must be lower because of the regulatory tax. If some informed lenders enter the good credit market or some uninformed lenders enter the good credit market, or both, then, either higher profit condition or the intermarket condition is broken. ■

Lemma 4 eliminates the informed lenders' strategy (P, P). Suppose the informed lenders pool in both markets. The profits in both markets should be the same because of the intermarket condition. However, since $\overline{P} > \underline{P}$, in order to make the profits equal, the interest rate in the good credit market has to be lower. If the interest rate is lower than R_L, the supply of capital has to be 1 at the equilibrium, and the good credit market has to be cleared by Corollary 1. If the amount of capital supplied is 1, it means that some of the capital supplied in the good credit market is supplied by the uninformed lender because the maximum possible capital supply by the informed lenders, when loan applicants are pooled, is $\overline{P}R_L - 1 < 1$. It contradicts Lemma 4.

We have proven that $(N, S), (N, P), (P, P)$, and (S, P) are not equilibria. Now we show that rest of the strategies are equilibria and the conditions under which, they are equilibria. We also find the equilibrium interest rates.

Proposition 2 *The equilibria are as follows.*

Regulatory Tax(δ)	r_G	r_B	Ψ_I	Ψ_U
Case 1. $\alpha < \overline{P}R_L - 1$				
a) $\delta \leq (\underline{P}R_L - 1) - \alpha$	R_L	R_L	(P, N)	P
b) $(\underline{P}R_L - 1) - \alpha < \delta < (P_H R_H - 1) - \alpha$	R_L	$\frac{1+\alpha+\delta}{P_H}$	(P, N)	S
c) $\delta \geq (P_H R_H - 1) - \alpha$	R_L	R_H	(P, N)	S
Case 2. $0.5 \leq \overline{P}R_L - 1 \leq \alpha$				
a) $\delta < P_H R_H - \overline{P}R_L$	R_L	$\frac{\overline{P}R_L+\delta}{P_H}$	(P, S)	S
b) $\delta \geq P_H R_H - \overline{P}R_L$	R_L	R_H	(P, N)	S
Case 3. $1 - \alpha \leq \overline{P}R_L - 1 < 0.5$				
a) $\delta < (P_H R_H - 1) - 0.5$	$\frac{1.5}{P_H}$	$\frac{1.5+\delta}{P_H}$	(S, S)	S
b) $(P_H R_H - 1) - 0.5 \leq \delta < P_H R_H - \overline{P}R_L$	$R_H - \frac{\delta}{P_H}$	R_H	(S, S)	S
c) $\delta \geq P_H R_H - \overline{P}R_L$	R_L	R_H	(P, N)	S
Case 4. $\overline{P}R_L - 1 < 1 - \alpha$				
a) $\delta < (P_H R_H - 1) - 0.5$	$\frac{1.5}{P_H}$	$\frac{1.5+\delta}{P_H}$	(S, S)	S
b) $(P_H R_H - 1) - 0.5 \leq \delta \leq (P_H R_H - 1) - (1 - \alpha)$	$R_H - \frac{\delta}{P_H}$	R_H	(S, S)	S
c) $\delta > P_H R_H - 1 - (1 - \alpha)$	$\min(R_H, \frac{2-\alpha}{P_H})$	R_H	(S, N)	S

Proof. The above lemmas show that $(N, S), (N, P), (P, P)$, and (S, P) are not equilibria. Now we show that $(S, N), (P, N), (S, S)$, and (P, S) are equilibria and find the conditions on which they are. The rest of the proof is shown in the Appendix. ■

Note that $\overline{P}R_L - 1$ is the profit of a lender who pools solely in the good market and whose cost of capital is 1. $1 - \alpha$ and α are the net profit of a lender who screens in the bad marker and good market respectively. As mentioned in footnote 3, these are also the amount of loan supply.

Case 1 is when pooling in the good market gives more profit than screening in the bad market. In this case, informed lenders do not enter the bad market, so the increase in the regulatory tax does not affect the informed lenders' strategy. However, the increase of regulatory tax would turn the uninformed lenders' strategy from pooling to screening.

Case 2 is when screening in the bad market gives more profit than pooling in the good market, so more informed lenders would move from the good market to the bad market, decreasing the interest rate in the bad market ($\frac{\overline{P}R_L+\delta}{P_H}$) until the profits in both markets are equal. As regulatory tax increases, lenders in the bad market increases interest rate to transfer the burden of regulation on to the borrowers. However, when the interest rate in the bad market hits the ceiling (R_H), lenders in the bad market cannot transfer the burden of regulation by increasing interest rate and the informed lenders cannot make as much profit in the bad market as in the good market. Therefore, they leave the bad market.

Case 3 and 4 are the cases when screening in both markets gives more profit than pooling in the good market. If informed lenders screen in both markets, their profits from both markets should be equal because of the intermarket condition, but there are more demand in the bad market. Therefore, more informed lenders in the good market would move to bad market and the interest rate in the good market would increase while the interest rate in the bad market would decrease until the profits from both markets are equalized. By Corollary 1, the demand ($1 = \alpha + (1-\alpha)$) equals the supply ($2(P_H r_G - 1) = 2(P_H r_B - 1 - \delta)$) and the profit equals 0.5.

The difference between Case 3 and Case 4 is that in Case 3, $\Psi_I = (P, N)$ earns more profit than $\Psi_I = (S, N)$. Therefore, when the increase in the regulatory tax makes the informed lender to leave the bad market, in Case 3, they pool in the good market whereas in Case 4, they screen.

4.2 Cherry picking behavior

In Case 1 of Proposition 2, when the regulatory tax is small and the revenue from pooling in the bad market is high, the uninformed lenders would pool in the bad market. However, as the regulatory tax increases, the uninformed lenders increase the interest rate to pass on the burden of regulatory tax to the borrowers and at certain threshold level ($((\underline{P}R_L - 1) - \delta)$), uninformed lenders switch from pooling to screening. This increase in the interest rate changes the pool of loan applicants into becoming riskier which means that the uninformed lenders switch from pooling to screening. Therefore, the regulatory tax may induce the lenders to take more risks, resulting in more bank failures.

Proposition 3 *An increase in regulatory tax can increase the ratio of failure in Case 1.*

Proof. It can be easily verified that if the ratio of the high-risk type increases, the failure rate also increases. Let h_i be the ratio of the high-risk type in Case 1($1 + \alpha < \overline{P}R_L$) where $i \in \{a, b, c\}$. h_a is the ratio of high-risk type when a) $\delta \leq \underline{P}R_L - 1 + \alpha$, h_b when b) $\underline{P}R_L - (1+\alpha) < \delta < P_H R_H - (1+\alpha)$, h_c when c) $\delta \geq P_H R_H - (1+\alpha)$. $a,\ b,\ c$ correspond to a), b), and c) of Case 1. Also let $\delta_a = \delta$ in a) of Case 1, $\delta_b = \delta$ in b) and $\delta_c = \delta$ in c).

With a little computation, we can find that $h_a = \frac{(1-\alpha)(\overline{P}R_L - 1) + \alpha(\underline{P}R_L - 1 - \delta_a)}{\overline{P}R_L - 1 + \underline{P}R_L - 1 - \delta_a}$, $h_b = \frac{(1-\alpha)(\overline{P}R_L - 1) + \alpha}{\overline{P}R_L - 1 + \alpha}$ and $h_c = \frac{(1-\alpha)(\overline{P}R_L - 1) + P_H R_H - 1 - \delta_c}{\overline{P}R_L - 1 + P_H R_H - 1 - \delta_c}$. Note that, $\frac{dh_a}{d\delta_a} = \frac{(1-2\alpha)(\overline{P}R_L - 1)}{(\overline{P}R_L - 1 + \underline{P}R_L - 1 - \delta_a)^2} < 0$. In case a), as δ_a increases, the ratio of high-risk type decreases and the failure rate also decreases.

However, $h_a|_{\delta_a = \underline{P}R_L - (1+\alpha)} = \frac{(1-\alpha)(\overline{P}R_L - 1) + \alpha^2}{\overline{P}R_L - 1 + \alpha} < h_b$. Therefore, if δ exceeds the critical point ($\delta = \underline{P}R_L - (1+\alpha)$), then the ratio of high-risk type increases and the failure rate also increases. ■

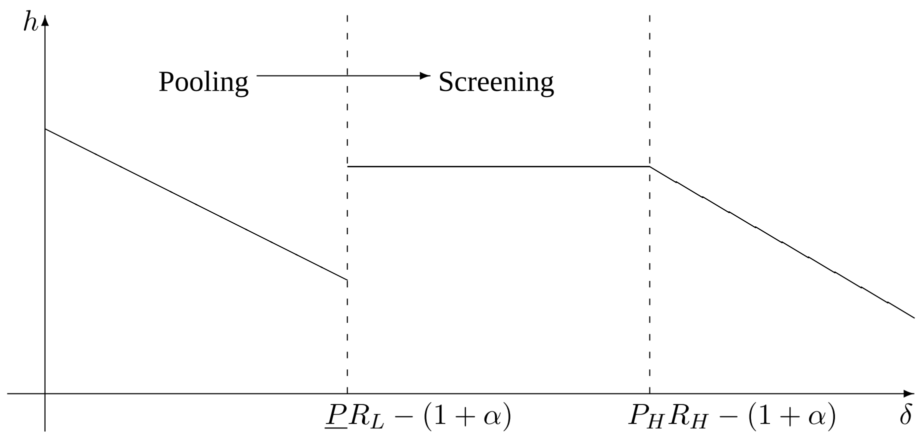

Figure 1: The effect of regulatory tax on the ratio of high-risk types, h, when $1 + \alpha < \overline{P}R_L$.

In case 1, the uninformed lenders do not screen out when the regulatory tax is low, i.e. $\delta \leq \underline{P}R_L - (1+\alpha)$. However, when the regulatory tax increases above the critical point ($\underline{P}R_L - (1+\alpha)$), the uninformed lenders start to screen out in order to pass on the burden of the regulatory tax to the borrowers. From this point, only the high-risk types borrow from the uninformed lenders. This increases the ratio of high-risk types and the overall failure rate.

This phenomenon can be interpreted as a type of cherry picking behavior. Federal Reserve Board defines cherry picking behavior as :

> Cherry picking refers to practices that shift a bank's portfolio toward the riskier of two loans when supervisors would put both loans in the same "risk bucket". Banks have an incentive to accommodate the credit needs of high-quality borrowers in ways that avoid straight loans in order to achieve a lower weight (Stevens, 2000).

As far as we know, previous theoretical works have pointed out this problem explicitly or implicitly from the viewpoint of the hidden information of banks. They argued that the cherry picking problem occurs because of the information asymmetry between banks and regulatory agencies.

Some have mentioned that under full information, regulatory agencies can solve the cherry picking problem by calculating the risk weights correctly (Koehn and Santomero, 1980; Kim and Santomero, 1988; and Rochet, 1992).[6] Since then, some have analyzed the truth-telling mechanism that can induce banks to reveal their private information (Chan, Greenbaum and Thakor, 1992; and Freixas and Rochet, 1998).

In this case, IRBA has made the banks to truthfully reveal their private information. However, Cherry picking problem remained unsolved. If lenders have a screening device such as interest rate, correctly calculating risk weights (regulatory tax) may not be possible. Of course, the regulatory agency can measure the risk weights based on the credit rate as well as the interest rates. However, the lenders have other means of screening apart from the interest rate such as period of repayment, collateral, etc. In fact, every term in the debt covenant can be used as a screening device. Therefore, unless regulatory agencies take account of every possible screening device, calculating risk weights correctly may not be possible.

Corollary 2 *In case 2 and 3, the regulatory tax reduces the failure rate.*

Proof. Proof omitted. ■

In case 2 and 3, when the regulatory tax increases over a critical point ($P_H R_H - \overline{P} R_L < \delta$), the informed lenders move away from the bad credit market and enter the good credit market. At this point, the informed lenders cannot transfer the regulatory tax on to the borrowers. Therefore, they leave the bad credit market.

This increases the supply of capital in the good credit market and reduces the interest rate, which means that the informed lenders have to switch from screening to pooling in the good credit market. Therefore, the failure rate decreases.

4.3 Effects of the IRBA

In case 2, 3, and 4, when the increase of regulatory tax is low, lenders transfer the burden of regulatory tax on to the borrowers by raising the interest rate. However, there exists a ceiling for the interest rate in the bad market so a limitation exists on transferring the burden of regulatory tax on to the borrowers. Therefore, if the regulatory tax is

[6] In this model, calculating risk weight is analogous to calculating regulatory tax, δ.

above a certain threshold, informed lenders will leave the bad credit market. When informed lenders leave the bad credit market, they block out the uninformed lenders from entering the good credit market by setting lower interest rate. Since the uninformed lenders cannot observe the signal that the borrowers generate, they cannot mimic the informed lenders.

Basel II allows banks to use the IRBA. If sophisticated banks use the internal model to evaluate the risk weights, these banks can act as the informed lenders. Since the sophisticated banks, which can afford the internal model, can reduce the cost of capital, they will induce good credit types by offering low interest rates. In this case, the bad credit types have no choice but to accommodate the unsophisticated banks that cannot afford the internal model.

Overall, Basel II regulation deepens the disparity between the bad market and the good credit market and the disparity between the informed lenders and the uninformed lenders. If the informed lenders transfer from the bad credit market to the good credit market, the supply in the good credit market increases. As supply increases, the interest rate goes down. On the other hand, the supply in the bad credit market decreases and the interest rate goes up in the bad credit market. Therefore, the difference in the interest rates and the amounts of loans supplied between these two markets becomes even greater.

Proposition 4 *The IRBA has more severe effects on the bad credit borrowers and the uninformed lenders as compared to the good credit borrowers and informed lenders.*

In January 2001, the Basel Committee on Banking Supervision released a second consultative paper (BIS, 2001). This 2001 proposal stimulated much controversy. More than 250 comments have been made on this proposal. Among the comments, quite many argued that the treatment for loans to small- and medium-size enterprises is foreseen to be too severe (Fabi, Laviola and Reedtz, 2003). This shows that the Basel II can be adverse to bad credit borrowers. Also Berger (2006) argues that the bifurcated system can have significantly adverse effects on the competitive position of large non-IRBA banks. These empirical result confirm Proposition 4. This paper shows that the uninformed lenders and bad credit borrowers are adversely affected by the bifurcated system, the IRBA.

5 Welfare Analysis

Now suppose that the bank failure causes social cost, σ. [7] Let W be the social welfare and x, the amount of loan lent. Also let $\omega = P_H R_H = P_L R_L$. Let $x_i = x_i^H + x_i^L$, where x_i is the amount of capital lent to the informed lenders, x_i^H is the amount lent by the informed lenders to the high-risk types, and x_i^L is the amount lent by the informed lenders to the low-risk types. Also let $x_u = x_u^H + x_u^L$ where, x_u is the amount lent by the uninformed lenders, x_u^H is the amount lent by the uninformed lenders to the high-risk types, and x_u^L is the amount lent by the informed lenders to the low-risk types.

$$
\begin{aligned}
W &= (x_i + x_u)\omega - \frac{1}{2}{x_i}^2 - \frac{1}{2}{x_u}^2 - x_i - x_u \\
&\quad -(1-P_H)x_i^H\sigma - (1-P_L)x_i^L\sigma - (1-P_H)x_u^H\sigma - (1-P_L)x_u^L\sigma
\end{aligned}
$$

[7] If there is no social cost associated with bank failure, the social welfare would decrease as regulatory tax increases because it would only reduce the loan amount.

Note that the first line of the equation is the total revenue minus the total cost that the lenders take privately. The second line is the total social cost. We call the former, the private cost. Now we analyze the effect of regulatory tax on social welfare.

$$\begin{aligned}\frac{dW}{d\delta} &= \frac{dx_i}{d\delta}\frac{dW}{dx_i} + \frac{dx_u}{d\delta}\frac{dW}{dx_u} \\ &= \frac{dx_i}{d\delta}(\omega - x_i - 1 - (1-P_H)\sigma\frac{dx_i^H}{dx_i} - (1-P_L)\sigma\frac{dx_i^L}{dx_i}) \\ &\quad + \frac{dx_u}{d\delta}(\omega - x_u - 1 - (1-P_H)\sigma\frac{dx_u^H}{dx_u} - (1-P_L)\sigma\frac{dx_u^L}{dx_u})\end{aligned}$$

From the above equation, we can find three facts about the effect of regulatory tax on social welfare.

First, the IRBA allows inefficient sophisticated banks with a high capital cost to stay in the business while crowding out relatively efficient unsophsticated banks with low capital cost. The higher profit condition requires $\omega \geq x_i + 1 \geq x_u + 1$. Also it can be easily verified from Proposition 4 that $\frac{dx_u}{d\delta} \leq \frac{dx_i}{d\delta} \leq 0$. Therefore,

$$(\omega - x_u - 1)\frac{dx_u}{d\delta} \leq (\omega - x_i - 1)\frac{dx_i}{d\delta} \leq 0$$

Because of the higher profit condition, the marginal surplus from the informed lenders is lower than the uninformed lenders. However, regulatory tax reduces the amount supplied by uninformed lenders more than informed lenders. Therefore, even more uninformed lenders with relatively low private cost will be out of business and the informed lenders with relatively high private cost will stay. This factor can be considered a loss of social welfare caused by the IRBA.

Second, the increase of regulatory tax would increase the social welfare when the loan amount is sufficiently large. As mentioned above, $\frac{dx_j}{d\delta} \leq 0$, where $j \in \{i, u\}$. When x_j is sufficiently large, so that $(\omega - x_j - 1 - (1-P_H)\sigma\frac{dx_j^H}{dx_j} - (1-P_L)\sigma\frac{dx_j^L}{dx_j})$ is negative, $\frac{dW}{d\delta}$ would be positive and vice versa when x_j is small.

The marginal private cost of capital increases with the amount of loan lent whereas, the marginal revenue, $\omega = P_H R_H = P_L R_L$, is constant. Therefore, when marginal private cost is low so that the revenue can compensate for the private cost and the social cost, regulatory tax inefficiently reduces the amount of loan lent. However, when the amount of capital lent is large and therefore, the private cost is large, regulatory tax only reduces the social welfare.

Third, if prudential regulation decreases the amount of loan lent to the high-risk types, the prudential regulation has positive effects on social welfare. Notice that because $x_j^H + x_j^L = x_j$, $\frac{dx_j^H}{dx_j} + \frac{dx_j^L}{dx_j} = 1$. Therefore,$-(1-P_H)\sigma\frac{dx_j^H}{dx_j} - (1-P_L)\sigma\frac{dx_j^L}{dx_j}$ is a weighted average between $(1-P_H)\sigma$ and $(1-P_L)\sigma$. Note that $(1-P_H)\sigma > (1-P_L)\sigma$. Therefore, if prudential regulation reduces the amount of capital lent to the high-risk types more as compared to the amount of capital lent to the low-risk types, the regulatory tax would have a positive effect on social welfare. It is because high-risk types generate more social cost.

6 Conclusion

This paper analyzes the effects of Basel II, especially focusing on the IRBA. We found following results. First, we found that the IRBA may increase the risk level of investment in some cases. In the earlier theoretical works, the possibility of such cases was studied. In these works,it was due to the information asymmetry between banks and the regulatory agency.

In this paper, however, such cases may occur even when the IRBA has solved the information asymmetry problem. When banks have a screening device, they can utilize that screening device to choose the riskier borrowers within the same credit rating. In this case, unless, the regulatory agency takes account of every possible screening device, calculating risk weights (regulatory tax) correctly may not be possible.

Second, we found that unsophisticated banks that cannot afford the IRBA, cannot enter the good market and have no choice but to accommodate the bad credit types. The sophisticated banks, which can afford the internal model, will induce good credit type borrowers by offering low interest rates to avoid regulatory burden. In this case, the bad credit type borrowers have no choice but to go to the unsophisticated banks. Therefore, sophisticated banks and good credit type borrowers may face a better business condition while the unsophisticated banks and bad credit type borrowers may face harsher business conditions.

Appendix

1. The informed lenders only enter the good credit market and screen out the low-risk types, $\Psi_I = (S, N)$.

Since the informed lenders screen out, the uninformed lenders must screen out because of Lemma 1. There exist four possible equilibria. First, $r_G \in (R_L, R_H)$ and $r_B \in (R_L, R_H)$. Second, $r_G \in (R_L, R_H)$ and $r_B = R_H$. Third, $r_G = R_H$ and $r_B = R_H$. Fourth, $r_G = R_H$ and $r_B \in (R_L, R_H)$. However, the fourth possibility ($r_G = R_H$ and $r_B \in (R_L, R_H)$) is not possible because of Lemma 3.

i) $r_G \in (R_L, R_H)$ and $r_B \in (R_L, R_H)$

The uninformed lenders cannot enter the good credit market because of Lemma 4 and the interest rate set by the uninformed lenders has to be higher than that set by the informed lenders because of Lemma 1. Therefore, all the bad credit types will go to the uninformed lender and good credit types will go to the informed lenders.

We know that both markets are cleared by Corollary 1. By market clearing conditions, we have $r_G = \frac{2-\alpha}{P_H}$ and $r_B = \frac{1+\alpha+\delta}{P_H}$. The profit in the good credit market is $2 - \alpha - c$ whereas the profit in the bad credit market is $1 + \alpha - c$. This result contradicts the higher profit condition. Therefore, it cannot be an equilibrium.

ii) $r_G \in (R_L, R_H)$ and $r_B = R_H$

The uninformed lenders set the interest rate to R_H by Lemma 1. In this case, the interest rate in the good credit market is $\frac{2-\alpha}{P_H}$ by Corollary 1 and market clearing condition. The informed lenders' profit is $2 - \alpha - c$ and the uninformed lenders profit is $P_H R_H - c - \delta$. To satisfy the higher profit condition,

$$\begin{aligned} P_H R_H - c - \delta &< 2 - \alpha - c \\ \delta &> P_H R_H - (2 - \alpha) \end{aligned}$$

Now, we check the intramarket condition. It is trivial that the intramarket condition is satisfied in the bad credit market. The profit the informed lenders can earn in the good market, if they switch, is $\overline{P} R_L - c$. Therefore, the intramarket condition in the good credit market is

$$\begin{aligned}\overline{P}R_L - c &< 2-\alpha-c \\ \overline{P}R_L &< 2-\alpha\end{aligned}$$

There also exists a ceiling for the r_G.

$$\begin{aligned}\frac{2-\alpha}{P_H} &< R_H \\ 2-\alpha &< P_H R_H\end{aligned}$$

Lastly, the bad credit market should not be cleared. However, since $\delta > P_H R_H - (2-\alpha)$, the supply $P_H R_H - 1 - \delta$ is always smaller than the demand, α.

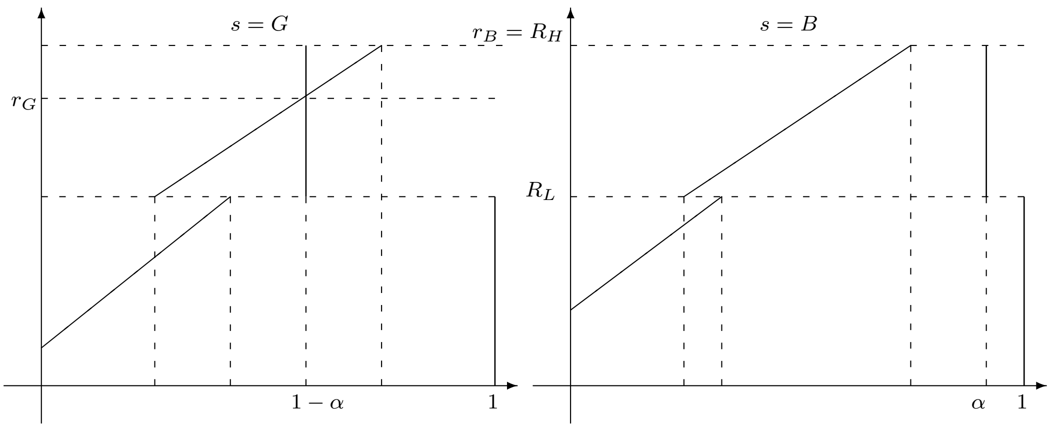

Figure 2: Market Equilibrium When $\overline{P}R_L < 2-\alpha < P_H R_H$ and $\delta > P_H R_H - (2-\alpha)$

iii) $r_G = R_H$ and $r_B = R_H$

It can be easily verified that this case is identical to ii) except for the condition that $2-\alpha < P_H R_H$ is changed to $2-\alpha \geq P_H R_H$.

2. The informed lenders only enter the good credit market and pool, $\Psi_I = (P, N)$.

Since the informed lenders only enter the good credit market and pool, their profit is $\overline{P}R_L - c$. If the informed lenders switch to screening, the informed lenders' profit would be $\min(P_H R_H - c, 2-\alpha-c)$ depending on whether the market is cleared or not. To satisfy the intramarket condition,

$$\begin{aligned}\min(P_H R_H - c, 2-\alpha-c) &\leq \overline{P}R_L - c \\ 2-\alpha &\leq \overline{P}R_L\end{aligned}$$

The uninformed lenders have three choices: set $r_B = R_L$, $r_B \in (R_L, R_H)$, or $r_B = R_H$ by Lemma 3 and 4.

i) $r_B = R_L$

Although the interest rates in both markets are equal, all the good credit types will go to the informed lender and all the bad credit types will go to the uninformed lenders. Note that the supply by informed lenders will be

$\overline{P}R_L - 1$. Since the uninformed lenders have to bear the increase of cost of capital and $\underline{P} < \overline{P}$, the capital supply by the uninformed lenders would be less and there would be larger credit rationing in the bad credit market. Therefore, all the good credit types will choose to go to the informed lenders.

The uninformed lenders' profit is $\underline{P}R_L - c - \delta$. If the uninformed lenders switch to screening, the profit would be $\min(P_H R_H - c - \delta, 1 + \alpha - c)$. The intramarket condition for the uninformed lenders is

$$\begin{aligned} \min(P_H R_H - c - \delta, 1 + \alpha - c) &\leq \underline{P}R_L - c - \delta \\ \delta &\leq \underline{P}R_L - (1 + \alpha) \end{aligned}$$

Note that the profit of the informed lenders is $\overline{P}R_L - c$. Therefore, the higher profit condition is satisfied.

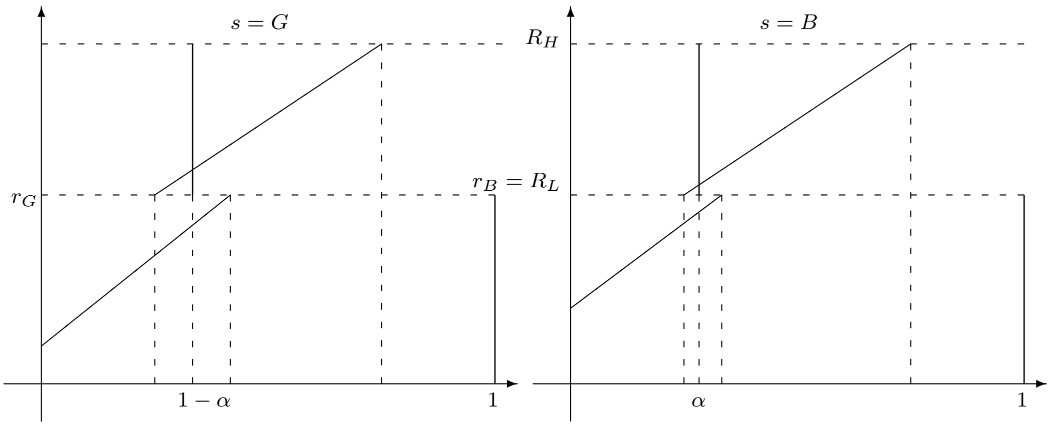

Figure 3: Market Equilibrium When $\delta \leq \underline{P}R_L - (1 + \alpha)$ and $2 - \alpha \leq \overline{P}R_L$

ii) $r_B \in (R_L, R_H)$

In this case, the interest rate in the bad credit market is $\frac{1+\alpha+\delta}{P_H}$ and the uninformed lenders profit is $1 + \alpha - c$ by Corollary 1 and market clearing condition. The higher profit condition is

$$\begin{aligned} 1 + \alpha - c &< \overline{P}R_L - c \\ 1 + \alpha &< \overline{P}R_L \end{aligned}$$

For this strategy to be an equilibrium, two more conditions must be satisfied. First, the intramarket condition in the bad credit market must be satisfied. If the uninformed lenders switch to pooling, the profit would be $\underline{P}R_L - c - \delta$. Therefore, the intramarket condition is

$$\begin{aligned} \underline{P}R_L - c - \delta &< 1 + \alpha - c \\ \delta &> \underline{P}R_L - (1 + \alpha) \end{aligned}$$

Second, there is a ceiling, R_H, for the interest rate in the bad market.

$$\begin{aligned} \frac{1 + \alpha + \delta}{P_H} &< R_H \\ \delta &< P_H R_H - (1 + \alpha) \end{aligned}$$

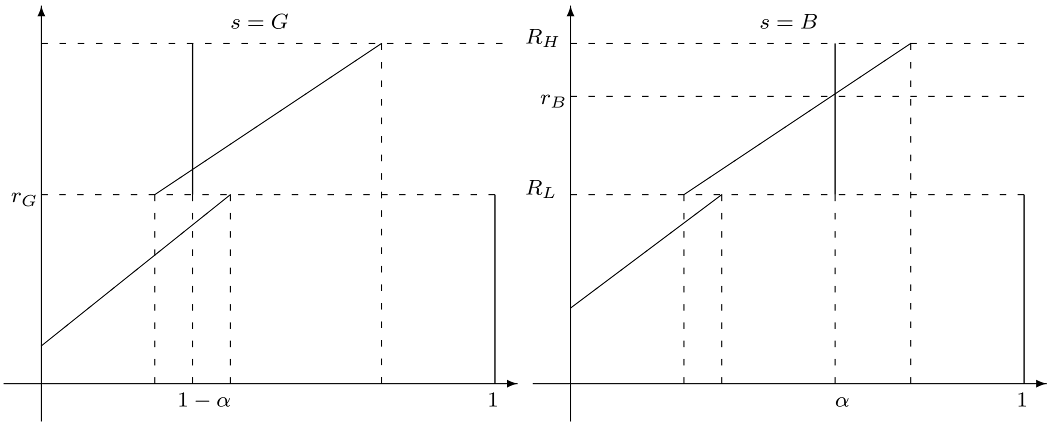

Figure 4: Market Equilibrium When $\underline{P}R_L - (1+\alpha) < \delta < P_H R_H - (1+\alpha)$ and $1+\alpha < \overline{P}R_L$.

iii) $r_B = R_H$

When the interest rate in the bad credit market is R_H, the profit of the uninformed lenders is $P_H R_H - c - \delta$. To satisfy the higher profit condition, the profit of the informed lenders, which is $\overline{P}R_L - c$, should be higher. Therefore, the following condition holds.

$$\begin{aligned} P_H R_H - c - \delta &\leq \overline{P}R_L - c \\ \delta &\geq P_H R_H - \overline{P}R_L \end{aligned}$$

In addition, the bad credit market should not be cleared. In other words, the demand (α) should be larger than the supply ($P_H R_H - 1 - \delta$) because of Corollary 1.

$$\begin{aligned} P_H R_H - 1 - \delta &\leq \alpha \\ \delta &\geq P_H R_H - (1+\alpha) \end{aligned}$$

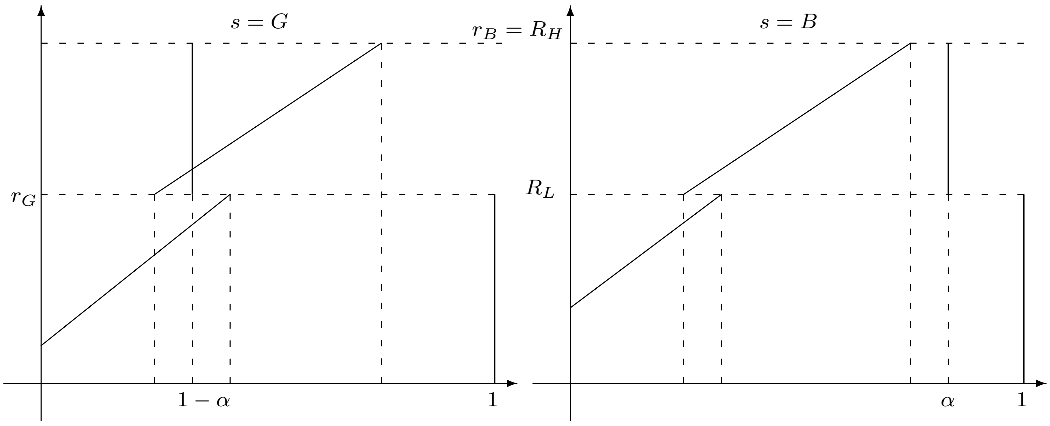

Figure 5: Market Equilibrium When $\delta \geq P_H R_H - min(1+\alpha, \overline{P}R_L)$.

3. The informed lenders enter both markets and screen out the low risk types in both markets, $\Psi_I = (S, S)$.

In this case, the profits from both markets should be equal. The profit in the good credit market is $P_H r_G - c$ and the profit in the bad credit market is $P_H r_B - c - \delta$. Since those two profits should be equal owing to intermarket condition, the interest rate in the good credit market must be lower than the interest rate in the bad credit market. The upper bound for the interest rates is R_H. This is because the interest rate in the bad credit market is always higher than the interest rate in the good credit market, and the interest rate in the good credit market can never reach R_H and is always in the range of (R_L, R_H).

i) $r_B \in (R_L, R_H)$

Since $r_B \in (R_L, R_H)$ and $r_G \in (R_L, R_H)$, owing to Corollary 1, both markets are cleared. The total demand is 1 and the total supply is $2(P_H r_G - 1) = 2(P_H r_B - 1 - \delta)$. Therefore, the market clearing conditions are

$$\begin{aligned} 2(P_H r_G - 1) &= 1 \\ r_G &= \frac{1.5}{P_H} \\ 2(P_H r_B - 1 - \delta) &= 1 \\ r_B &= \frac{1.5+\delta}{P_H} \end{aligned}$$

As mentioned above, there is an upper bound for the interest rates.

$$\begin{aligned} \frac{1.5+\delta}{P_H} &< R_H \\ \delta &< P_H R_H - 1.5 \end{aligned}$$

In addition, the intramarket condition must hold. The profits are $1.5 - c$ in both markets. If the informed lenders in the good credit market switch to pooling, the profit would change to $\overline{P}R_L - c$. Therefore,

$$\begin{aligned} \overline{P}R_L - c &< 1.5 - c \\ \overline{P}R_L &< 1.5 \end{aligned}$$

Note that the uninformed lenders must set their interest rate to be $\frac{1.5+\delta}{P_H}$ by Lemma 4.

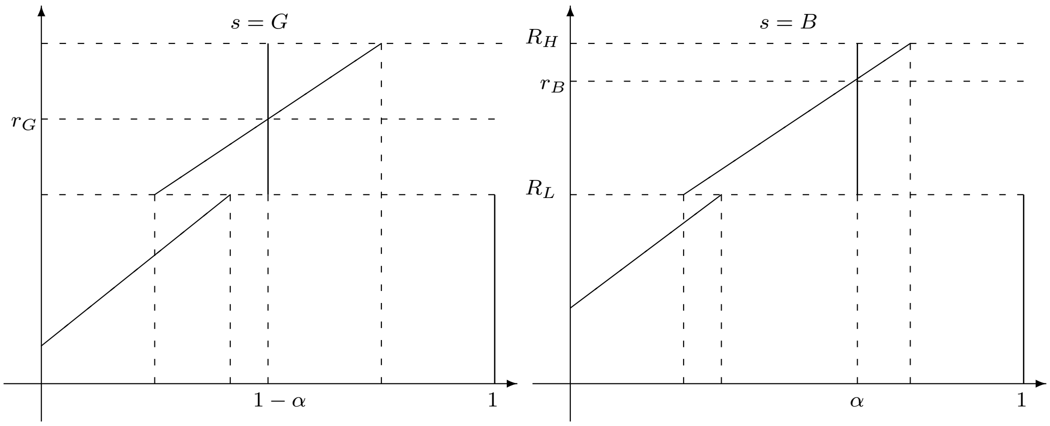

Figure 6: Market Equilibrium When $\overline{P}R_L < 1.5$ and $1.5 + \delta < P_H R_H$

ii) $r_B = R_H$

Since $r_B = R_H$ and the profits in both markets are equal, the interest rate in the good credit market is $R_H - \frac{\delta}{P_H}$ by intermarket condition. In order to set the interest rates to these points, the good credit market must be cleared and the bad credit market must not be cleared. The demand in the bad credit market is α and the supply is $2(P_H R_H - 1 - \delta) - (1-\alpha)$. Since the bad credit market is not cleared, the supply should be less than the demand.

$$2(P_H R_H - 1 - \delta) - (1-\alpha) \leq \alpha$$
$$\delta \geq P_H R_H - 1.5$$

Now, we check the intramarket condition. If the informed lenders in the good credit market switch to pooling, the profit would be $\overline{P}R_L - c$. If they keep screening, the profit would be $P_H R_H - c - \delta$. Therefore, the intramarket condition is

$$\begin{aligned} \overline{P}R_L - c &< P_H R_H - c - \delta \\ \delta &< P_H R_H - \overline{P}R_L \end{aligned}$$

It is obvious that if above equation holds, the intramarket condition in the bad credit market also holds. Also, note that if $\delta \geq P_H R_H - 1.5$ and $\delta < P_H R_H - \overline{P}R_L$, $\overline{P}R_L < 1.5$.

By Lemma 4, the whole capital in the good credit market should be supplied solely by the informed lenders. The total supply of capital by the informed lenders is $P_H R_H - 1 - \delta$. The amount supplied in the good credit market is $1 - \alpha$.

$$1 - \alpha \leq P_H R_H - 1 - \delta$$
$$\delta \leq P_H R_H - (2 - \alpha)$$

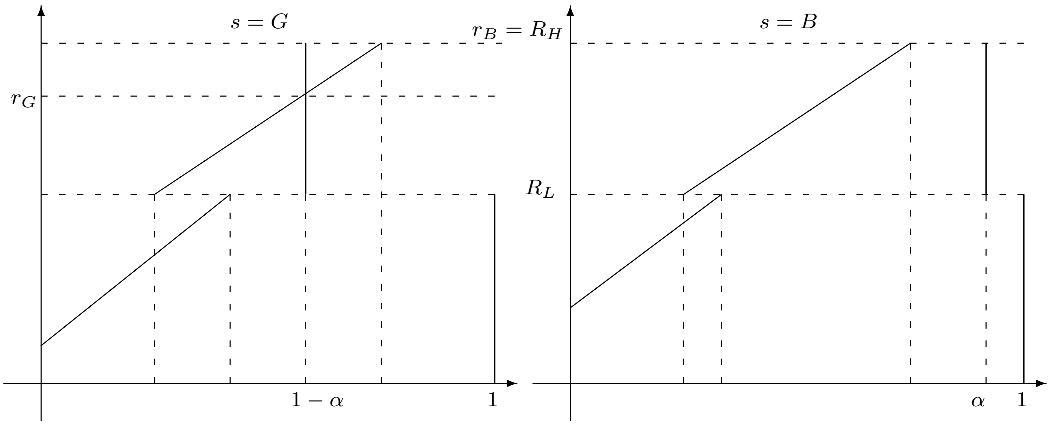

Figure 7: Market Equilibrium When $P_H R_H - 1.5 \leq \delta \leq P_H R_H - (2-\alpha)$ and $\delta < P_H R_H - \overline{P} R_L$

4. The informed lenders enter both markets and screen out the low risk types only in the bad credit market, $\Psi_I = (P, S)$.

Since the informed lenders enter both markets, the profits from both markets should be equal. Additionally, the informed lenders choose to pool in the good credit market and their profit is $\overline{P}R_L - c$. Therefore,

$$\begin{aligned} \overline{P}R_L - c &= P_H r_B - c - \delta \\ r_B &= \frac{\overline{P}R_L + \delta}{P_H} \end{aligned}$$

Note that the interest rate in the bad credit market cannot go beyond R_H. Therefore,

$$\begin{aligned} r_B = \frac{\overline{P}R_L + \delta}{P_H} &< R_H \\ \delta &< P_H R_H - \overline{P}R_L \end{aligned}$$

Now, we check the intramarket condition for the informed lenders in the good credit market. In order for them to have no incentive to switch, the supply should be more than the demand, when the informed lenders switch. Since the profit is $\overline{P}R_L - c$, the total supply is $2(\overline{P}R_L - 1) - \alpha$. Also the total demand is $1 - \alpha$ when the informed lenders switch. Therefore, the intramarket condition is

$$\begin{aligned} 1 - \alpha &\leq 2(\overline{P}R_L - 1) - \alpha \\ 1.5 &\leq \overline{P}R_L \end{aligned}$$

In this equilibrium, the uninformed lenders have no choice but to screen out owing to Lemma 4. Therefore, the amount supplied in the bad credit market must be less than the amount supplied by the uninformed lenders. The amount supplied by the uninformed lender is $\overline{P}R_L - 1$ and the amount supplied in the bad credit market is α.

$$\begin{aligned} \overline{P}R_L - 1 &\leq \alpha \\ \overline{P}R_L &\leq 1 + \alpha \end{aligned}$$

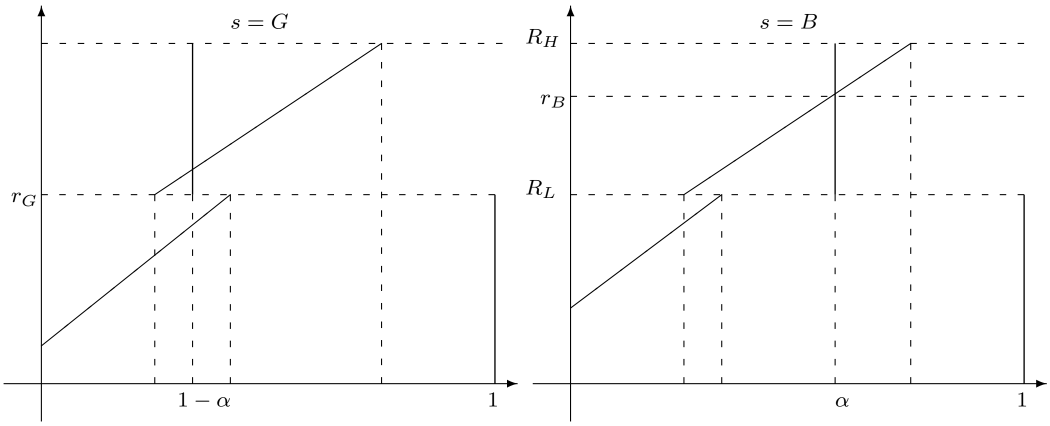

Figure 8: Market Equilibrium When $1.5 \leq \overline{P}R_L \leq 1+\alpha$ and $\delta < P_H R_H - \overline{P}R_L$.

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