Capital Structure and Competition in the Banking Industry: Theory and Empirics

Shirley J. Ho
Department of Economics
National Chengchi University, Taiwan

Su-Chu Hsu
Auditing Office, Bank of Taiwan
&
Department of Money and Banking
National Chengchi University, Taiwan

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Abstract

This paper incorporates the observation that in banking industries, debts are usually affected by current return and cannot be predetermined before competition. In a portfolio choice model, we have analyzed how two banks sequentially decide their capital structures through choosing equity levels, and then the levels of risky investment which is subject to the rival's competition. Taking equity as control variable gives us a different aspect to examine the impact of banks' financial decisions; In addition to the impact on the critical value of shock from uncertain demand, the banks' financial decisions also affect banks' cash flow reserve, as well as the costs paid to equityholders and debtholders. Our main result agrees with Brander and Lewis' point that leverage is positively related to a bank's profit, however, we have shown that when the CAR requirement is binding, this result will be overturned. This gives us a convenient approach to check if the bank's risk management is restricted by the CAR requirement, by testing the relationship between banks' capital structure and risky investment level. We tested our theoretical results using 1996-2006 data from Taiwan's banking industry.

· *JEL classification*: G32; L13

Keywords: Financial structure, Competition, Early withdrawals, Bankruptcy, Capital adequacy ratio.

1 Introduction

Brander and Lewis (1986) provided the first attempt to examine the impact of oligopolistic firms' financial structures on their competition in product market. It is concluded that a firm can use debt to commit to an aggressive output level and induce a favorable output reduction from its rival. This is contrary to the well known assertion by Modigliani and Miller (1958, 1963) that capital structure has no impact on firm value in a world without taxes and information asymmetries. Many empirical studies have tested this conclusion on various industries, but they do not consistently support this theoretical conclusion (see Opler and Titman, 1994; Phillips, 1995). The subsequent literature has challenged Brander and Lewis' conclusion by considering different formats on bankruptcy cost (Brander and Lewis, 1988), the form of competition, the type of uncertainty (Poitevin,1989; Showalter, 1995; Wanzenried, 2003; the possibility of collusion (Maksimovic, 1988; Spagnolo, 2000), and the dynamic concern (Bolton and Scharfstein, 1990).[1]

Following this line of research, we first call for attention to the long noticed evidence that banks usually have higher debt equity ratios for equivalent levels of risk than the average firms (Jensen and Meckling, 1976). Since the existing literature has ignored this specific property, most research on capital structure has focused on nonfinancial corporations (see Myers, 2001). Moreover, it can be checked that debts in the banking industry usually consist of deposits with various maturities. New depositors can join in or early withdrawals can occur when depositors remove their money for better returns elsewhere (see Diamond and Dybvig, 1983).

This indicates that debt levels will change with bank's current return and therefore cannot be predetermined before competition as assumed in the literature. Hence, in a two stage framework, our paper assumes that two banks choose their equity levels first, and then decide how to allocate their capital between cash flow reserve and risky investment which is subject to the rivals' competition. We consider the possibility that too many early withdrawals might cause the banks go bankruptcy, and the impact from the capital adequacy ratios (henceforth, CAR) requirement by Basel I and Basel II Accords (1988, 2004). We ask the same questions as

[1] For simplification, we have omitted the discussion on taxes, agency cost, bankruptcy cost and debt renegotiation. For thorough reviews on the literature, we refer to Myers (1984), Harris and Raviv (1991), Cestone (1999), Myers (2001), and Franck and Huyghebaert (2004).

in the existing literature but focus on the banking industry: How will banks' financial structure affect their investment decisions in risky and competitive markets? How will banks' financial decision change with the business status? What is the impact from the CAR requirement?

Assuming debt to vary with banks' current return and taking equity as the control variable for financial decision give us a different aspect to examine the impact of firms' financial decisions. In Brander and Lewis (1986), increasing debt has two impacts on firm value: to decrease the critical value of shock (representing the uncertain demand) and to increase the debt repayment. Since debt is predetermined before competition, the repayment will not affect firms' output levels. The only impact on the critical value of shock will lift up the expected demand, increase marginal revenue, and increase output and profit. Hence, debt financing can commit a firm to an aggressive output stance (see Phillips, 1995). In our model, the equity level is constant and set prior to risky competition. Equity issuing has three impacts on bank value. First, higher equity level can increase a bank's cash flow reserve, which also decreases the critical value of shock. The former increases the bank value directly, and the latter will lift up the expected demand and marginal revenue, and also increase risky investments and returns. Second, higher equity level means more dividends to give away to equityholders, and this will decrease the marginal revenue, their investments and returns. The third impact is on the debt repayment, indirectly through its impact on the return and the debt level.

For the combination of the three effects, Lemma 3 concludes that equity issuing will decrease banks' equilibrium risky investment, showing the domination of the latter two impacts. However, fully debt or equity financing is not optimal (Proposition 5), since issuing equity can increase the cash flow reserve and decrease the chance of bankruptcy especially when the business status is bad. Corollary 6 also demonstrates that the equilibrium equity level is higher in a better business status. Finally, Basel I and Basel II Accords (1988, 2004) suggested that banks should follow a minimum risk-based capital requirement that the CAR be at least greater than 8%. Proposition 7 shows that if the CAR requirement is binding, then the result from Lemma 3 will be overturned, and the equilibrium risky investment will be positively related to equity level. This gives us a deeper interpretation for the empirical tests on banking industry: if the risky investment or return is negatively related to equity level, then the CAR requirement is not effectively binding; Otherwise, the CAR requirement is binding and the banks' risk management is affected.

We then test our theoretical results using panel data from Taiwan's banking industry. Our research is the first attempt to cover Taiwan's four core financial businesses[2]: banks, securities firms, property insurance firms and life insurance firms. We examine the regression results for the whole period (1996-2006), before the first financial reform ((1996-2000) and after the first financial reform (2001-2006), to examine the impacts of the first financial reform on banking firms' capital structure. Our first result justifies our theoretical assumption that debts are increasing function of firms' return. Second, as described by Proposition 7, the restrictions on CAR have indeed affected firms' management strategies, as market share and leverage are positively related. Third, the bank values are significantly and positively related to firm size, leverage and financial cost. Lastly, although the regression results show that capital structure is negatively related to the states of business cycle, they are insignificant. The reason could be that, since the industry is highly monitored especially in bad states, changes in capital structure need to be approved by the authority,

Section 2 describes a two stage game where two banks simultaneously choose their equity levels first, and then allocate their capital between cash flow reserves and risky investments, which are subject to the rivals' competition. Section 2.1 characterizes the subgame perfect equilibrium of this game and discuss the equilibrium properties. Section 3 provides the empirical tests of our theoretical results using data from Taiwan's banking industry. Section 4 concludes the paper. For the ease of presentation, long derivations and proofs are contained in the Appendix.

2 The Model

Bank 1 and 2 are competing in a two stage game. In the first stage, the banks simultaneously choose the levels of equity s_i (with a face value V_i), which together with an initial debt level D_i^0 determined by, say, bank i's last period revenue, compose bank i's initial capital stock $(s_iV_i + D_i^0)$ in the first stage.[3] The bank acts like a portfolio manager who allocates the received capital

[2]See the Act of financial holdings companies, Article 4, Term 1-3.

[3]It is assumed that there is no internal capital.

between cash flow reserve and risky investment, which is subject to the rivals' competition (see Pyle, 1971; Hart-Jaffee, 1974; Freixas and Rochet, 1998). That is, in the second stage the banks simultaneously choose their levels of risky investment which is characterized by a differentiated market with uncertain demand. This investment is assumed irreversible and the return will be realized at the end of stage 2. As will be described shortly, we will consider the possibility that early withdrawals can happen before the end of stage 2, and hence the current debt level will depend on the banks' current return from the risky investment.

Competition between Banks Let q_i denote bank i's risky investment, and the remained capital $s_iV_i + D_i^0 - q_i$ is the initial cash flow reserve. The risky investment is characterized by a differentiated market with uncertain demand. Denote $R_i(q_1, q_2, z_i)$ as the operating return for this risky investment, which is the difference between revenue and variable cost: $R_i(q_1, q_2, z_i) = P_i(q_1, q_2, z_i)q_i - C_i(q_i)$. The random variable z_i represents bank i's state of demand, which is identically and independently distributed on the interval $[\underline{z}, \overline{z}]$ according to a distribution function $F(z_i)$ with density $f(z_i)$. We will make the conventional assumptions on demand and cost functions in the Assumption.

Assumption $\partial P_i/\partial q_i < 0$, $\partial P_i/\partial q_j < 0$, $\partial^2 P_i/\partial q_i \partial q_j < 0$, $\partial C_i/\partial q_i > 0$ and $\partial^2 C_i/\partial q_i^2 \geq 0$.

The Assumption describes that bank i's inverse demand function is decreasing in both q_i and q_j, and the cost is increasing and convex in its investment. In addition, we assume that higher values of z_i will lead to higher demand and the marginal demand is higher in better states of the world, that is, $\partial P_i/\partial z_i > 0$ and $\partial^2 P_i/\partial q_i \partial z_i > 0$. As an illustrative example for this differentiated competition, consider the following linear demand and quadratic cost functions.

$$P_i(q_1, q_2, z_i) = \alpha - \beta q_i - \gamma q_j + z_i, \text{ and } C_i(q_i) = \frac{q_i^2}{2}. \tag{1}$$

Under the Assumption, the return on risky investment has the conventional properties: $\frac{\partial^2 R_i}{\partial q_i^2} < 0$, $\frac{\partial^2 R_i}{\partial q_i \partial s_i} = 0$, and $\frac{\partial^2 R_i}{\partial q_i \partial q_j} < 0$.

The CAR and Early Debt Withdrawals We will address two specific issues: the impact of the CAR requirement and the possibility of early deposit withdrawal. First, Basel I and Basel II Accords (1988, 2004) suggested that banks should follow a minimum risk-based capital requirement that the CAR, a measure of the amount of a bank's capital expressed as a percentage of its risk weighted credit exposures, be at least greater than 8%.[4] In our terminology, this requirement is:

$$s_iV_i/R_i(q_1, q_2, z_i) \geq 0.08, \quad \text{or alternatively,} \quad R_i(q_1, q_2, z_i) \leq 12.5(s_iV_i). \tag{2}$$

Given s_i and that $R_i(q_1, q_2, z_i)$ is concave, if the requirement is binding, there will be a lower bound and an upper bound on q_i. Since only the upper bound can affect the determination of equilibrium, we will focus on this case and denote this upper bound by $\overline{q}_i(q_j, s_i)$.

Lemma 1 *The upper bound from the CAR requirement, $\overline{q}_i(q_j, s_i)$, is increasing in s_i and decreasing in q_j.*

Second, according to Diamond and Dybvig (1983), the withdrawal decision will depend on the bank's current return, demand uncertainty and other depositors' withdrawal decisions. Under the first-come-first-serve rule, early withdrawers can fully retrieve their money until the bank's cash flow reserve is used up, then the bank declares bankruptcy and the debtholders get the remaining value. To simplify, we will eschew the detailed discussion on depositors' withdrawal decisions, and assume directly that the remaining debt is $D_i(R_i(q_1, q_2, z_i))$. Since the amount of withdrawals will depend on bank's current return, the remaining debt is therefore a function of current return. For simplification, we assume that $D_i' > 0$ and $D_i'' < 0$, meaning that higher return can attract more deposits but in a decreasing rate.

Recall that bank i's initial cash flow is $s_iV_i + D_i^0 - q_i$. Notice that the amount of early withdrawals $[D_i^0 - D_i(R_i(q_1, q_2, z_i))]$ can also be negative and be interpreted as deposit increase. The current cash flow becomes $s_iV_i + D_i^0 - q_i - [D_i^0 - D_i(R_i(q_1, q_2, z_i))]$, or in short, $s_iV_i + D_i(R_i(q_1, q_2, z_i)) - q_i$. There is a level of debt associated with each value of $R_i(q_1, q_2, z_i)$, until z_i drops down to $z^1(s_i, q_1, q_2)$, when the amount of early debt withdrawal exceeds the cash flow reserve. $z^1(s_i, q_1, q_2)$ is the critical value of random shock for the breakeven condition, given by

$$s_iV_i + D_i(R_i(q_1, q_2, z_i))\text{-}q_i = 0. \tag{3}$$

[4]See http://en.wikipedia.org/wiki/Capital_adequacy_ratio#cite_note-investopedia-0.

The bank will announce bankruptcy when $z_i < z^1(s_i, q_1, q_2)$ and we will assume that $\underline{z} < z^1(s_i, q_1, q_2) < \overline{z}$.

Lemma 2 *$z^1(s_i, q_1, q_2)$ is decreasing in s_i, and decreasing and convex in q_i.*

Proof. By the implicit function theorem, we know that $\frac{\partial z^1(s_i,q_1,q_2)}{\partial q_i} = -D_i' \frac{\partial R_i}{\partial q_i} / D_i' \frac{\partial R_i}{\partial z} < 0$, and $\frac{\partial^2 z^1(s_i,q_1,q_2)}{(\partial q_i)^2} = -D_i' \frac{\partial^2 R_i}{(\partial q_i)^2}(D_i' \frac{\partial R_i}{\partial z})/(D_i' \frac{\partial R_i}{\partial z})^2 > 0$. ■

In other words, the probability of bankruptcy $F(z^1(s_i, q_1, q_2))$ will be decreasing in s_i, and decreasing and convex in q_i. However, we need to compare $z^1(s_i, q_1, q_2)$ with the critical value defined in Brander and Lewis' (1986) equation (2), which describes the breakeven condition of firm value. In our portfolio choice framework, the bank value consists of the return from risky investment and cash flow reserve. In addition, there are two kinds of capital costs: the dividends paid to equityholders and the repayment to debtholders. For simplification, these capital prices are assumed to be competitive and exogenously given, that is, let e_i be the share of return given to equityholders as dividends and r_i be the interest rate paid to debtholders.[5] In good states (to be defined shortly), the total amount of repayment paid to debtholders is $(1+r_i)D_i(R_i)$, and equityholders get dividends from what is left after debtholders' claims, i.e., $s_i e_i[R_i(q_1, q_2, z_i) - (1 + r_i)D_i(R_i)]$. Overall, bank i's value is:

$$\begin{aligned}&\{[R_i(q_1, q_2, z_i) + s_i V_i + D_i(R_i(q_1, q_2, z_i)) - q_i] \\ &-s_i e_i[R_i(q_1, q_2, z_i) - (1 + r_i)D_i(R_i(q_1, q_2, z_i))] - [(1 + r_i)D_i(R_i(q_1, q_2, z_i))]\}.\end{aligned} \tag{4}$$

The first square bracket denotes the sum of the return on risky investment and cash flow reserve. The second square bracket contains the total dividends, and the third bracket contains the repayment to debtholders.

Let $z^2(s_i, q_1, q_2)$ denote the critical value of shock for (4) to be zero. The difference between (3) and (4), i.e., $R_i(q_1, q_2, z_i)$- $s_i e_i[R_i(q_1, q_2, z_i)$- $(1+r_i)D_i(R_i(q_1, q_2, z_i))]$- $(1+r_i)D_i(R_i(q_1, q_2, z_i))$, can be either positively or negatively related to z_i, depending on the relative sizes of s_i, e_i, R_i' and D_i'. Hence we will define $\underline{z}(s_i, q_1, q_2) \equiv \max\{ z^1(s_i, q_1, q_2), z^1(s_i, q_1, q_2)\}$. It can be checked that $\underline{z}(s_i, q_1, q_2)$ is decreasing in s_i, and decreasing and convex in q_i.

[5] We have not considered the effect of big equity holders, which is believe to cause the managers to choose risky assets.

The Expected Bank Value In good states of world when $z_i \geq \underline{z}(s_i, q_1, q_2)$, the bank value is as given by (4); In bad states when $z_i < \underline{z}(s_i, q_1, q_2)$, the bank will declare bankruptcy, so the bank value will be zero. The expected bank value is hence

$$V_i = \int_{\underline{z}(s_i,q_1,q_2)}^{\overline{z}} \{[R_i(q_1, q_2, z_i) + s_i V_i + D_i(R_i(q_1, q_2, z_i)) - q_i] \\ -s_i e_i [R_i(q_1, q_2, z_i) - (1 + r_i) D_i(R_i(q_1, q_2, z_i))] - [(1 + r_i) D_i(R_i(q_1, q_2, z_i))]\} dF(z_i).$$

Alternatively, the value function can be rewritten as:

$$V_i = \int_{\underline{z}(s_i,q_1,q_2)}^{\overline{z}} \{(1 - s_i e_i)[R_i(q_1, q_2, z_i) - (1 + r_i) D_i(R_i(q_1, q_2, z_i))] \\ + s_i V_i + D_i(R_i(q_1, q_2, z_i)) - q_i\} dF(z_i). \quad (5)$$

As described, we have followed Pyle (1971) and Hart-Jaffee (1974) in treating banks like portfolio managers, so the bank value contains both the return from risky investment and the cash flow reserve. The integration in the expected value is taken from $\underline{z}(s_i, q_1, q_2)$ till $\overline{z}$. Brander and Lewis (1986) called this part of value as the equity value. They have distinguished between equityholders and debtholders; due to limited liability, equityholders are residual claimants in good states of the world and debtholders become residual claimants in bad states. Brander and Lewis compared the maximizing results for both equity value (integrated from $\underline{z}(s_i, q_1, q_2)$ to $\overline{z}$) and debt value (integrated from $\underline{z}$ to $\underline{z}(s_i, q_1, q_2)$). They concluded that the output level in debt value is obviously below that in equity value. Differently, Showalter (1995) and Wanzenried (2003) assumed that firms act on behalf of equityholders in the second stage, so the output level is chosen to maximize the equity value. However, in the first stage, firms choose the debt level to maximize the full value, where the integration is taken from $\underline{z}$ to $\overline{z}$. Showalter (1995) explained that this is so because debtholders can anticipate the output decisions by firms, and change accordingly the cost of funds. So firms should internalize the competing interests between debtholders and equityholders, and choose debt to maximize the full value of the firm. Instead, Wanzenried (2003) explained that, since the potential debtholders are foresighted, the firms need to present the overall value including the possibility of bankruptcy when selling bonds to raise funds.

Since "agency cost" is not the fucus of our paper, we will not discuss in further details the difference between equityholders and debtholders. Instead, we will assume that in both stages the bank manager maximizes the same expected bank value in (5). This also reflects the fact that unlike the ordinary firms, the interaction between banks, the public and other industries are complicated and sensitive. The negative returns are not tolerated as the ordinary firms. When bank failures happen, the deposit insurance company or in some cases the government (see Too-Big-To-Fail doctrine) will soon take over. These would be good supports for the setting in (5) where the integration is taken from $\underline{z}(s_i, q_1, q_2)$ till $\overline{z}$.

By backward induction, we first derive the equilibrium in the risky differentiated market, then determine the first stage equity level using the second stage results. The derivatives $\partial V_i/\partial q_i$, $\partial^2 V_i/\partial q_i^2$, $\partial^2 V_i/\partial q_i \partial q_j$ and $\partial^2 V_i/\partial q_i \partial s_i$ are contained in the Appendix.

2.1 Equilibrium

Given the capital decision s_i, bank i's value maximization condition is given by $\partial V_i/\partial q_i = 0$ and $\partial^2 V_i/\partial q_i^2 < 0$, which is satisfied under the Assumption. Let $q_i(q_j, s_i)$ be bank i's best response function. Lemma 3 describes the properties of $q_i(q_j, s_i)$.

Lemma 3 *$q_i(q_j, s_i)$ is negatively related to q_j and s_i.*

Proof. Since $\partial^2 V_i/\partial q_i^2 < 0$, $\partial^2 V_i/\partial q_i \partial q_j < 0$ and $\partial^2 V_i/\partial q_i \partial s_i < 0$, the result follows immediately from the implicit function theorem that $\frac{\partial q_i(qj,si)}{\partial q_j} = -\frac{\partial^2 V_i/\partial q_i \partial q_j}{\partial^2 V_i/\partial q_i^2} < 0$ and $\frac{\partial q_i(q_j,s_i)}{\partial s_i} = -\frac{\partial^2 V_i/\partial q_i \partial s_i}{\partial^2 V_i/\partial q_i^2} < 0$. ■

In other words, we have the conventional downward slopping reaction function, and as s_i increases, $q_i(q_j, s_i)$ shifts toward the left. The equilibrium risky investment, (q_1^*, q_2^*), is given by

$$q_i^* \in q_j(q_i^*, s_j) \quad \text{for } i, j = 1, 2.$$

Notice that Lemma 3 also describes that the equilibrium risky investment is negatively related to q_j and s_i. Recall that in Brander and Lewis (1986), firms choose debt levels prior to product competition. Since the debt level is predetermined and constant, the only impact of debt is to lift up the expected demand, and increase output and profit. Hence, firm's outputs or profits will increase with financial leverage, which is measured by a debt to equity or value ratio. In our model, banks choose the level of s_i prior to competition in risky investment. s_i has three

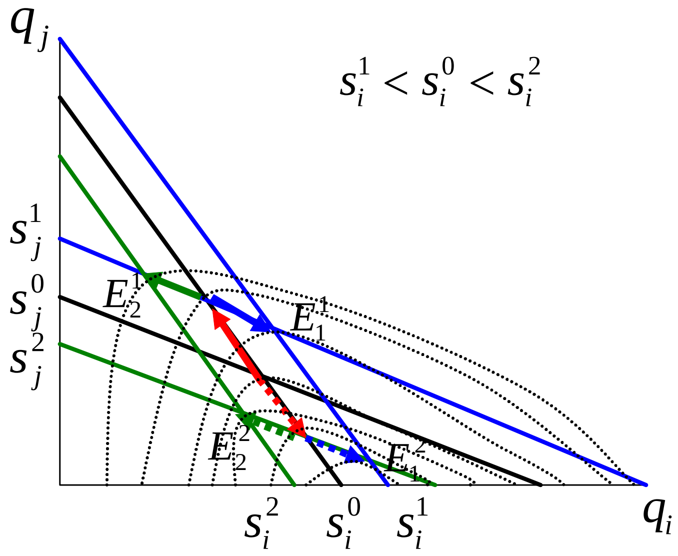

Figure 1: Bank i's equilibrium risky investment decreases with s_i.

impacts on bank value: to increase the cash flow reserve which also decreases critical value of shock, to increase the dividends to equityholders, and to increase debt level indirectly through its impact on the return. Our result shows the domination of the latter two negative effect. However, since the debt to equity ratio is negatively related to s_i, our result coincides with Brander and Lewis (1986) that banks' outputs or profits in risky investment are positively related to financial leverage.

Next we use Figure 1 to demonstrate the following lemma. In Figure 1, consider $s_i^1 < s_i^0 < s_i^2$, and the blue, dark and green line indicate bank i's best responses associated with equity levels s_i^1, s_i^0, s_i^2, respectively.

Lemma 4 *For the risky investment market, it is a dominant strategy to decrease* $s_\mathbf{i}$.

In Figure 1, when bank j decreases s_j from s_j^0 to s_j^1, the equilibrium moves to E_2^1 if bank i increases s_i to s_j^2 and moves to E_1^1 if s_i decreases to s_j^1. For bank i, E_1^1 reaches a higher profit than E_2^1, thus bank i is better off decreasing s_i when bank j decreases s_j. Similarly, when bank j increases s_j from s_j^0 to s_j^2, the equilibrium moves to E_2^2 if bank i increases s_i to s_j^2 and moves to E_1^2 if s_i decreases to s_j^1. For bank i, E_1^2 reaches a higher profit than E_2^2, thus bank i is better off decreasing s_i when bank j increases s_j. Overall, for the risky investment market, it is a dominant strategy to decrease s_i.

Despite that increasing s_i is dominated for the risky investment market, there are still positive impacts on the cash flow reserve and indirectly on debt. Given the equilibrium risky investment (q_1^*, q_2^*), the equilibrium equity level is determined by $\partial V_i(s_i, q_1^*, q_2^*)/\partial s_i = 0$, and it is non-zero.

Proposition 5 *Banks cannot be entirely equity or debt financed in equilibrium.*

Proof. See the Appendix. ■

We partly agree with Brander and Lewis (1986)'s Proposition 5 and Proposition 1 that firms will produce more output with more debts. However, our result shows that due to its impact on cash flow and indirect impact on debt, banks cannot be entirely equity or debt financed in equilibrium (see Showalter, 1995, Theorem 2)

In Corollary 6, we show that the equilibrium equity level is higher in a better business status. To examine the effect of different business status, we consider another distribution $\widehat{F}$ which dominates F in the sense that $\widehat{F}(z_i) < F(z_i)$, for $z_i \leq \underline{z}(s_i, q_1, q_2)$. In the Appendix, we demonstrate that the equilibrium s_i is greater with $\widehat{F}$.

Corollary 6 *The equilibrium equity level is higher in a better business status*

Proof. See the Appendix. ■

The Impact of CAR Here we examine how the CAR requirement from the Basel I&II Accord affects the relation between risky investment and capital structure. Recall from (4) that the CAR requirement puts an upper bound on the level of risky investment: $\overline{q}_i(q_j, s_i)$, which is increasing in s_i and decreasing in q_j. Together with Lemma 3 that $q_i(q_j, s_i)$ is negatively related to s_i, this upper bound will change the best response diagram as Figure 2. Similar to Figure 1, the blue, dark and green lines denote the bank's restricted response associated with associated with equity levels s_i^1, s_i^0, s_i^2, respectively. The response is kinked at the level $\overline{q}_i(q_j, s_i)$, and since $\overline{q}_i(q_j, s_i)$ will decrease with q_j, the restricted part is not constant. Proposition 7 describes the relation between risky investment and s_i, if the CAR requirement is binding.

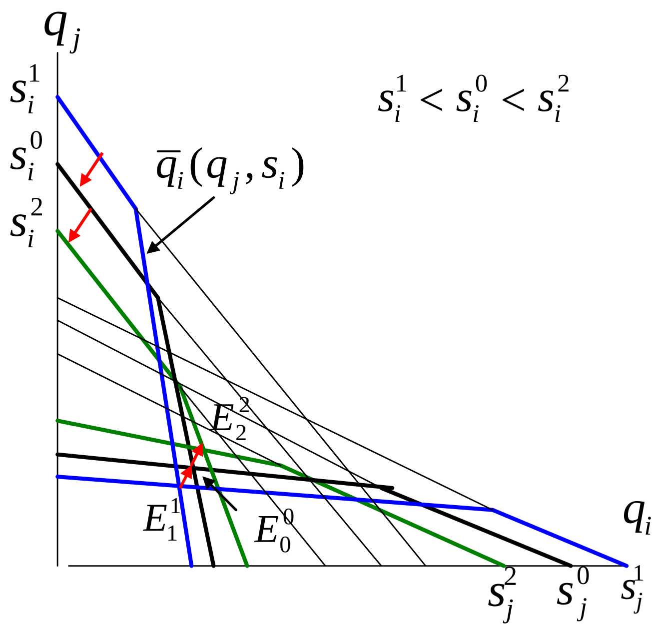

Figure 2: The impact of the CAR requirement.

Proposition 7 *If the CAR requirement is binding, then the equilibrium risky investment will be positively related to* s_i.

Proof. In Figure 2, when both banks increase equity levels from s_i^0 to s_i^2, $i = 1, 2$, the equilibrium moves from E_0^0 to E_2^2, and both banks increase their risky investments. ■

With CAR binding, each bank needs to increase equity issuing in order to increase its risky investment. Together with Lemma 3, this result gives us a deeper interpretation for empirical tests on banking industry: If the bank's risky investment or return is negatively related to equity level, then the CAR requirement is not effectively binding; Otherwise, the CAR requirement is binding and the banks' risk management is affected by this constraint.

3 Empirical Study

The banking industry is different from other industries in the following three aspects. First, the banking industry has higher leverages than the others. As described, debts such as deposits or insurance fees constitute a large proportion of the industry revenue, and these deposits or insurance fees actually increase as the firms' performance (revenue) increase. It is recorded that the average leverage ratio of Taiwan's banking industry is 88.91% for the period of 1996-2996. Second, the banking industry is highly correlated to the public and other industries. As financial intermediates, banking firms receive deposits or insurance fees from the public or other industries, which are lend out as various mortgages or invested in other safe or risky projects in other industries. Trough these intermediates, failures in any industries could induce so called "butterfly effects" to the rest. The recent global crisis caused by malfunctioning of sub mortgage loan market in USA is an obvious example to illustrate the high connection. Third, due to its highly correlation to the public and other industries, the financial structure of the banking industry is often carefully monitored and restricted by rigid regulation. It is then interesting to examine if these rules on the capital adequacy ratios or the deposit insurance system will affect or distort the management strategies in firms.

Due to their extraordinarily high leverages, banking industries are often treated as special cases by the existing literature on capital structure and receive less attention. Nevertheless, their highly correlation with other industries and large contribution to GDP[6] have motivated us to reexamine the feasibility of the existing models in Section 2. In this section we will provide empirical supports by testing the theoretical results using data from Taiwan's banking industries for the period 1996-2006. In addition, our empirical tests also cover two subperiods: 1996-2000 and 2001 -2006. The cutting point is the year of "the first financial reform"; After the 1997 South Asia financial crisis, the Executive Yuan approved "the Act of Financial Reform Fund[7]" in 2001 to improve the healthiness of banking industries. Serial actions include reaching the so called "258 targets", namely, to reduce overdue loans ratio to 5% and increase capital adequacy ratio to 8% in 2 years. More importantly, the government promoted the establishment of financial holdings companies to encourage mergers and acquisitions among the existing firms, which greatly changed the competitive structure of the banking industries. In order to examine the impacts of the first financial reform on banking firms' capital structure and competitive

[6]The banking industries contributed over 10.04% of GDP in Taiwan. Data source: 2008 National Income Statistics by the Census Beaurou.

[7]Related laws and regulations include the Financial Holding Company Act, the Financial Institutions Merger Law, the Company Law, the Securities Exchange Law.

strategies, we test the period before the first reform (1996-2000) and after the first reform (2001-2006).

3.1 Data Source and Discussion

Our research is the first attempt to cover Taiwan's four core financial businesses: banks, securities firms, property insurance firms and life insurance firms. We extract the financial data of financial holdings companies, banks and securities companies from the Taiwan Economic Journal Data Bank (TEJ) and the financial data of life and property insurance companies from the Insurance Year Book, issued by Taiwan Insurance Research Center. There are overall 14 financial holdings companies, 49 banks, 30 securities companies, 17 property insurance companies and 15 life insurance companies. The list of our samples is given in Table A1 and A2 in the Appendix 2. Notice that we use panel data to increase sample numbers, to trace the intertemporal variation of individual firms, and to increase the estimation efficiency (see Hsiao, 1986).

The definitions of the variables are given as follows. A summary of statistics is presented in the Appendix 2 (Tables A3 and A4). The currency used for these values is new Taiwan dollars (NTDS).

ASSET: *Total Asset* in the balance sheet. Total asset is often used to indicate firm size.

DEBT: *Total debt* in the balance sheet, representing firms' total external fund.

Leverage: *Debt to total asset ratio.* According to accountant equation, total asset is the sum of total stock and debt. This ratio indicates firm's capital structure.

STOCK: *Value of common stock* in the balance sheet. In Taiwan, the minimum required capital is 10 billions NTDs for commercial banks, 2 billions NTDs for insurance companies, and 60 billions NTDs for financial holdings companies in Taiwan.

REV: *Net operating revenues*, which is firms' sales revenue minus sales returns and allowances

RevR: *State of business cycle*, which is the growth rate of net operating revenues (REV). Campello (2003) used -log$\triangle$GDP to indicate the states of business, but this industry wise index cannot distinguish different prospects across firms. For this aim, we use RevR, each firm's revenue growth rates, to indicate the business states faced by individual company. The related literature to adopt this value can be found in Campello (2003), who concluded that in bad states of demand, higher leveraged firms encountered bigger losses in sales. On the contrary, Campello and Fluck (2004) further found that lower leveraged firms lose more market shares.

MS: *Market share*, the ratio of each firm's net operating revenue to the industrial sum of net revenues. Note that for financial holdings companies, their market share is the sum of subsidiaries' market share. Greenhalgh and Rogers (2006) reported that companies with large market share have more monopoly power and hence may not have to cost down when it faces challengers.

COST1R: *Average financial expense*. For banks, financial expense refers to interest expenses or bad debts write-off; For securities companies, it refers to total expenditure minus operational expense and non-operating expense; For insurance companies, it refers to allowance for liability reserve.

COST2R: *Average operating cos*t. The operating expenses include selling expenses, administrative expenses and other expenses such as research and development expense, salaries, rents, taxes, depreciations/amortization, uncollectible accounts and other general administrative expenses

ROE: *Retun on equity*, which is the ratio of net operating revenues to stock. This term measures firms' management efficiency.

3.2 Empirical Model

As described earlier, the banking industry is featured by the fact that debts such as deposits or insurance fees constitute a large proportion of industry revenue, and these deposits or insurance fees actually increase as the firms' performance (revenue) increase. Therefore, debts level cannot be predetermined before competition as assumed by the stream of literature pioneered by Brander and Lewis (1986). Our paper, instead, assumes that debts level is an increasing function of firms' revenue, thus leaving the security levels the only decision variable of capital structure. Hence to justify this assumption, empirical model (E1) firstly tests if debts are increasing with firms' revenue in Taiwan's banking industry case.

$$Debt = \alpha_0 + \alpha_1 \operatorname{Re} v + \epsilon_0, \tag{E1}$$

Where α_1 has to be positive to justify the model assumption. Second, Lemma 1 in Section 2 describes that if the CAR is not binding, output and security levels are positively related; while Proposition 7 says that when CAR is binding, output and security levels are positively related. The empirical model (E2) tests if the investment management in Taiwan's banking industry is affected by CAR.

$$MS = \beta_0 + \beta_1 \log Stock + \epsilon_0, \tag{E2}$$

Where if β_1 is negative, then we can conclude as Brander and Lewis (1986) and Lemma 1 in Section 2 that the leverage is negatively related to market share, indicating that the investment management is not affected by CAR; Otherwise, if β_1 is positive, then as stated by our Proposition 7, the leverage is positively related to market share, indicating that CAR is actually influencing the investment management in Taiwan's banking industry.

Third, we follow the existing literature by testing model (E3), examining the relationship between bank values and their asset size, leverage, costs, business cycle and management efficiency.

$$\begin{aligned}\log(REV) = \gamma_0 + \gamma_1 \log Asset + \gamma_2 \operatorname{Re} vR + \gamma_3 Leverage + \gamma_4 \log Cost1R \\ + \gamma_5 \log Cost2R + \gamma_6 ROE + \epsilon_0.\end{aligned} \tag{E3}$$

If banks make more loans or poses more risky assets, they will have higher revenue and hence bank value. Hence, γ_1 is expected to be positive. Next, when the business is in better states the public has more income to either invest, replace houses or deposit in banks. These activities either directly increase bank value or increase transactions with banks, and hence γ_2 is expected to be positive too. As described, banking industry has higher leverage than other industries; more deposits or higher insurance premium not only increase the debt levels, but also increase banks' revenues, indicating a positive sign for γ_3. Next, Cost1R denotes financial costs such as interest expenditures and Cost2R denotes operational expenditures such as salaries and advertisement fees. Intuitively, since both are cost terms, we should expect negative signs for both $\gamma_4$and γ_5. However, as interest rates increase, banks receives more deposits or higher revenues from making loans, which then indicates a positive sign for γ_4. Finally, ROE is commonly used indexes for management efficiency, which is expected to have positive contributions to bank values.

Finally, model (E4) examines the relationship between banks' capital structures, bank size and business states.

$$\log STOCK = \theta_0 + \theta_1 \log ASSET + \theta_2 \operatorname{Re} vR + \epsilon_0 \tag{E4}$$

The existing literature, such as Smith and Watts (1992) and Campello (2003), used total sales or asset values to measure firm size. It is believed that bigger sizes indicate higher monopoly power, and cheaper average costs due to economy of scale. Hence, θ_1 is expected to be positive. Next, Campello (2003) used -log¡μGDP to indicate the states of business, but this industry wise index cannot distinguish different prospects across firms. For this aim, we use RevR, each firm's revenue growth rates, to indicate the business states faced by each company. In bad states, banks will reduce loans and the public will reduce stock transactions or insurance, all of which suggest a positive sign for θ_2.

Table 1 Debt is an increasing function of Rev.

	1996-2006		1996-2000		2001-2006	
	Debt		Debt		Debt	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
C	1.13E+08***	1.15E+08***	63353652***	62986352***	1.56E+08***	1.51E+08***
Rev	4.887436***	4.985077***	5.179354***	5.292739***	4.731261***	4.850989***
Instrument rank		2		2		2
R-squared	0.529637	0.526944	0.585172	0.588448	0.508476	0.507911
Adjusted R-squared	0.529006	0.526241	0.583980	0.586962	0.507232	0.506662
S.E. of regression	3.22E+08	3.32E+08	2.19E+08	2.25E+08	3.87E+08	3.88E+08
Durbin-Watson stat	0.033124	0.034261	0.015208	0.015808	0.041581	0.041522
F-statistic	838.8827***		490.9021***		408.6229***	
Observations	747	675	350	279	397	396

Note: Instruments: Rev_{-1}. *** significant level 1%, ** significant level 5%, * significant level 10% 。

Table 2 Capital Structure and Market Share

	1996-2006		1996-2000		2001-2006	
	MS		MS		MS	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
C	-35.4398***	-37.50408***	-27.26869***	-28.11479***	-45.33761***	-45.92041***
log(Stock)	2.600839***	2.720643***	2.110018***	2.150695***	3.188449***	3.224739***
Instrument rank		2		2		2
R-squared	0.175695	0.188097	0.125338	0.137379	0.231742	0.230678
Adjusted R-squared	0.174587	0.188097	0.122818	0.134253	0.229797	0.228726
S.E. of regression	7.011816	6.988519	6.894522	6.8471	7.042963	7.051976
Durbin-Watson stat	0.037502	0.038845	0.041032	0.046855	0.030146	0.030133
F-statistic	158.5790***		49.72487***		1119.1504***	
Observations	746	674	349	278	397	396

Note: Instruments: c, log($stock_{t-1}$). *** significant level 1%,** significant level 5%,* significant level 10% 。

3.3 Results and Discussion

The software we used to run empirical models (E1)∼(E4) is Eviews. Notice that although our data is panel data, it is unbalanced; Due to the emergence of 14 financial holdings companies since 2001, the sample lengths for each company are not exactly the same. We hence adopt pooled data, instead of panel data, regression, and the sample sizes for periods 1996∼2006, 1996∼2000 and 2001∼2006 are 747, 350 and 397, respectively. In Tables 1∼4, we present the regression results from both the ordinarily least squared (OLS) and the two stage least squared (2SLS) methods. The reason to run 2SLS is to correct the heteroskedacity problem in pooled data.

First, Table 1 presents the OLS and 2SLS results for model (E1) during three periods. For all three periods, the parameter of net operating revenue (α_1) is significantly positive within 1% confidence level. The F-values are significant and the adjusted R-squared values are above 0.50. This suggests that debts are indeed increasing with firms' revenue in Taiwan's banking industry, supporting our theoretical assumption that debt is an increasing function of banking firm's revenue.

Second, Table 2 presents the OLS and 2SLS results for model (E2) during three periods. By examining the sign of β_1 (Stock), we can conclude whether financial firms' management strategies are affected by the regulations of CAR in Taiwan; If CAR regulation is binding, then as described by Proposition 7, market share is positively related to stock ($\beta_1 > 0$); Otherwise, as described by Lemma 1 in this paper and by Brander and Lewis (1986), market share is negatively related to stock ($\beta_1 < 0$). Notice that leverage is negatively related to stock.

For all three periods, the parameter of stock (β_1) is significantly positive within 1% confidence level. The F-values are significant, but the values of adjusted R-squared are low for all three periods. This could be the consequence of using only one explanatory variable. We will incorporate more explanatory variables to interpret financial firms' management strategies in model (E3). For model (E2), since our purpose is to test which theoretical result fits in the banking industry in Taiwan, we will not add in other ad hoc variables.

Nevertheless, the positive signs of β_1 suggest that financial firms' management strategies are affected by the regulations on CAR. The impacts are higher for the subperiod after the financial reform, as β_1 increases from an average of 2.1 before- reform to an average of 3.2 after-reform. After the reform, the establishment of financial holdings companies has strengthened the regulation impacts; The Act of Financial Holdings Company requires that the CAR for the holdings companies be at least 100%, within which the CAR must be at least 10% for bank subordinates, 200% for securities subordinates and 300% for insurance subordinates. These rules are much stricter than individual financial firms[8], and hence cause more distortion to production for the after-reform subperiod.

Third, model (E3) examines the relationship between bank values and their asset size, leverage, costs, business cycle and management efficiency and Table 3 presents the OLS and 2SLS results during three periods. The F-values are significant and the adjusted R-squared values are all above 0.50 except for 2SLS during 2001-2006. For all three periods, the parameters of ASSET (γ_1) and ROE (γ_6) are significantly positive within 1% confidence level. This suggest the conventional argument that the firm value increases with firm size and management efficiency. An interesting result is that the parameters of Cost1R (γ_4) are also significantly positive. This is because the financial cost in banking firms are usually part of debts, such as bad debts write-offs or allowance for liability reserve. Together with the fact that we argued

[8]For individual firms, the CAR must be at least 8% for banks, 150% for securities companies and 200% for insurance companies.

earlier that in banking industry, debts are increasing functions of bank returns, the positive sign of Cost1R seems clear in this aspects. Next, as most cost and expense terms, the parameters for the operating cost (γ_5) is significantly negative. The parameters for the states of business cycle (γ_6) are significantly positive for OLS during 2001-2006, but not significant for other periods. As described earlier, when the business is in better states the public has more income to either invest, replace houses or deposit in banks. These activities either directly increase bank value or increase transactions with banks, and hence γ_2 is positive. Finally, the parameters for Leverage (γ_3) are all positive except for 2SLS during 2001-2006. As said, the banking industry has higher leverage than other industries; hence more deposits or higher insurance premium not only increase the debt levels, but also increase banks' revenues. In other words, as assumed in Section 2, debt is a function of bank return, and leverage is a ratio of debt to total asset. The positive sign of γ_3 seems clear.

Table 3 Firm Values, Leverage and Other Variables

	1996-2006		1996-2000		2001-2006	
	Log(Rev)		**Log(Rev)**		**Log(Rev)**	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
C	6.929181***	7.382396***	6.373284***	6.527296***	6.971655***	0.751261
LOG(Asset)	0.427427***	0.430138***	0.464823***	0.446264***	0.427038***	0.306121
RevR	0.027575	2.093540	-0.025169	-0.548907	0.319959***	-8.226317
Leverage	0.606703***	0.563662	0.074465	-0.187500	0.751200***	3.277756
COST1R	1.525424***	1.035465	1.977989***	2.588405**	1.311331***	8.683439
Cost2R	-0.846547***	-1.396752***	-0.754905***	-0.818516***	-0.957161***	1.941639
ROE	0.087807***	0.143699***	0.090217***	0.143867***	0.075926	0.263011
Instrument rank		8		8		8
R-squared	0.796111	0.506251	0.845734	0.825785	0.782760	-5.049828
Adjusted R-squared	0.794016	0.500557	0.841932	0.820033	0.778851	-5.159256
S.E. of regression	0.706883	1.108090	0.563716	0.599368	0.777492	16.22233
Mean dependent var	16.18151	16.20916	16.12680	16.18551	16.22175	1.649603
S.D. dependent var	1.557507	1.567950	1.417876	1.412853	1.653306	1.651054
Durbin-Watson stat	0.598522	2.098903	0.651254	1.472682	0.674096	1.847264
F-statistic	379.8656***		222.4253***		200.2354***	
Observations	689	615	292	220	397	395

Note: Instruments: log($asset_{t-1}$), $RevR_{t-1}$, $Leverage_{t-1}$, $cost1r_{t-1}$, $cost2r_{t-1}$, $stockd_{t-1}$, ROE_{t-1}. *** significant level 1%,** significant level 5%,* significant level 10% 。

Model (E4) examines the relationship between banks' capital structures, bank size and business states and Table 4 presents the OLS and 2SLS results during three periods. The F-values are significant and the adjusted R-squared values are all above 0.65.

For all three periods, the parameters of ASSET (θ_1) are significantly positive within 1% confidence level. Since banking industry is highly monitored and regulated, various rules such as CAR force banking firms to increase capital while extending their business. The parameter for the after-reform period is slightly higher, as the financial holdings companies face stricter regulations on CAR. In bad states, banks will reduce loans and the public will reduce stock transactions or insurance, all of which suggest a positive sign for θ_2. Next, the parameters for the state of business cycle (θ_2) are all negative except for OLS during 2001-2006, but none of them are significant. Since the industry is highly monitored especially in bad states, changes in capital structure need to be approved by the authority, which explains the insignificance of θ_2.

Table 4 Capital Structure, Firm Size and Business Cycle

	1996-2006		1996-2000		2001-2006	
	LOG(STOCK)		LOG(STOCK)		LOG(STOCK)	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
C	5.705005***	6.384622***	5.921295***	6.819694***	5.611524***	6.117947***
LOG(ASSET)	0.564281***	0.533954***	0.549419***	0.508323***	0.571029***	0.549140***
RevR	-0.002017	-1.003258	-0.005909	-0.899670	0.078836	-1.060394
Instrument rank		3		3		3
R-squared	0.735516	0.616383	0.730085	0.569183	0.732830	0.642591
Adjusted R-squared	0.734747	0.615140	0.728230	0.565284	0.731474	0.640773
S.E. of regression	0.623320	0.744078	0.615188	0.766865	0.627870	0.725418
Mean dependent var	15.94776	16.00664	15.74378	15.83632	16.09882	16.10298
S.D. dependent var	1.210267	1.199408	1.180068	1.163098	1.211647	1.210329
Durbin-Watson stat	0.207587	0.734864	0.414235	0.778050	0.070136	0.448181
F-statistic	956.6468***		393.5589***		540.3576***	
Observations	691	620	294	224	397	396

Note: Instruments: log($asset_{t-1}$), $RevR_{t-1}$. *** significant level 1%,** significant level 5%,* significant level 10% 。

4 Concluding Remarks

This paper incorporates the observation that in banking industries, debts are usually affected by current return and cannot be predetermined before competition. In a portfolio choice model, we have analyzed how two banks sequentially decide their capital structures through choosing equity levels, and then the levels of risky investment which is subject to the rival's competition. Taking equity as control variable gives us a different aspect to examine the impact of banks' financial decisions; In addition to the impact on the critical value of shock from uncertain demand, the banks' financial decisions also affect banks' cash flow reserve, as well as the costs paid to equityholders and debtholders. Our main result agrees with Brander and Lewis' point that leverage is positively related to a bank's profit, however, we have shown that when the CAR requirement is binding, this result will be overturned. This gives us a convenient approach to check if the bank's risk management is restricted by the CAR requirement, by testing the relationship between banks' capital structure and risky investment level.

Our theoretical results are tested using panel data from Taiwan's banking industry. Our research is the first attempt to cover Taiwan's four core financial businesses: banks, securities firms, property insurance firms and life insurance firms. The first result justifies our theoretical assumption that debts are increasing function of firms' return. Our second result agrees with Proposition 7 that the restrictions on CAR have indeed affected firms' management strategies, as market share and leverage are positively related. Third, the bank values are significantly and positively related to firm size, leverage and financial cost. Lastly, although the regression results show that capital structure is negatively related to the states of business cycle, they are insignificant. The reason could be that, since the banking industry is highly monitored especially in bad states, changes in capital structure need to be approved by the authority,

Appendix 1

The expected bank value is:

$$V_i = \int_{\underline{z}(s_i,q_1,q_2)}^{\overline{z}} \{(1\text{-}s_i e_i)[R_i(q_1,q_2,z_i)\text{-}(1+r_i)D_i(R_i(q_1,q_2,z_i))] + s_i V_i + D_i(R_i(q_1,q_2,z_i))\text{-}q_i\} dF(z_i).$$

The Derivatives The first order condition of maximization is

$$\frac{\partial V_i}{\partial q_i}=\int_{\underline{z}(s_i,q_1,q_2)}^{\overline{z}}\{(1\text{-}s_ie_i)[1\text{-}(1+r_i)D'_i]\frac{\partial R_i}{\partial q_i}+D'_i\frac{\partial R_i}{\partial q_i}\text{-}1\}dF(z_i) \quad \text{(A1)}$$
$$-\frac{\partial \underline{z}(s_i,q_1,q_2)}{\partial q_i}\{(1\text{-}s_ie_i)[R_i(q_1,q_2,z_i)\text{-}(1+r_i)D_i(R_i(q_1,q_2,z_i))]+s_iV_i+D_i(R_i(q_1,q_2,z_i))\text{-}q_i\}f(\underline{z}(s_i,q_1,q_2)).$$

For further usage, notice that since $\frac{\partial \underline{z}(s_i,q_1,q_2)}{\partial q_i}<0$, so the second term in A1 is positive. Since R_i is increasing in z_i, if the F.O.C. is to be satisfied, then the term $\{(1\text{-}s_ie_i)[1\text{-}(1+r_i)D'_i]\frac{\partial R_i}{\partial q_i}+D'_i\frac{\partial R_i}{\partial q_i}\text{-}1\}f(z_i)$ must be negative when $z=\underline{z}(s_i,q_1,q_2)$, the lower bound of z_i. The second order condition is also satisfied.

$$\frac{\partial^2 V_i}{\partial q_i^2}=\int_{\underline{z}(s_i,q_1,q_2)}^{\overline{z}}\{(1\text{-}s_ie_i)[1\text{-}(1+r_i)D'_i]\frac{\partial^2 R_i}{\partial q_i^2}+D'_i\frac{\partial^2 R_i}{\partial q_i^2}+[1\text{-}(1\text{-}s_ie_i)(1+r_i)]D''_i\frac{\partial R_i}{\partial q_i}\frac{\partial R_i}{\partial q_i}\}dF(z_i)$$
$$-\frac{\partial \underline{z}(s_i,q_1,q_2)}{\partial q_i}\{(1\text{-}s_ie_i)[1\text{-}(1+r_i)D'_i]\frac{\partial R_i}{\partial q_i}+D'_i\frac{\partial R_i}{\partial q_i}\text{-}1\}f(\underline{z}(s_i,q_1,q_2))$$
$$-\frac{\partial^2 \underline{z}(s_i,q_1,q_2)}{(\partial q_i)^2}\{(1\text{-}s_ie_i)[R_i(q_1,q_2,z_i)\text{-}(1+r_i)D_i(R_i(q_1,q_2,z_i))]+s_iV_i+D_i(R_i(q_1,q_2,z_i))\text{-}q_i\}f'(\underline{z}(s_i,q_1,q_2))$$
$$-\frac{\partial \underline{z}(s_i,q_1,q_2)}{\partial q_i}\{(1\text{-}s_ie_i)[1\text{-}(1+r_i)D'_i]\frac{\partial R_i}{\partial q_i}+D'_i\frac{\partial R_i}{\partial q_i}\text{-}1\}f(\underline{z}(s_i,q_1,q_2)) \quad \text{(A2)}$$

$$\frac{\partial^2 V_i}{\partial q_i\partial q_j}=\int_{\underline{z}(s_i,q_1,q_2)}^{\overline{z}}\{(1\text{-}s_ie_i)[1\text{-}(1+r_i)D'_i]\frac{\partial^2 R_i}{\partial q_i\partial q_j}+D'_i\frac{\partial^2 R_i}{\partial q_i\partial q_j}+[1\text{-}(1\text{-}s_ie_i)(1+r_i)]D''_i\frac{\partial R_i}{\partial q_i}\frac{\partial R_i}{\partial q_j}\}dF(z_i)$$
$$-\frac{\partial \underline{z}(s_i,q_1,q_2)}{\partial q_j}\{(1\text{-}s_ie_i)[1\text{-}(1+r_i)D'_i]\frac{\partial R_i}{\partial q_i}+D'_i\frac{\partial R_i}{\partial q_i}\text{-}1\}f(\underline{z}(s_i,q_1,q_2))$$
$$-\frac{\partial^2 \underline{z}(s_i,q_1,q_2)}{\partial q_i\partial q_j}\{(1\text{-}s_ie_i)[R_i(q_1,q_2,z_i)\text{-}(1+r_i)D_i(R_i(q_1,q_2,z_i))]+s_iV_i+D_i(R_i(q_1,q_2,z_i))\text{-}q_i\}f'(\underline{z}(s_i,q_1,q_2))$$
$$-\frac{\partial \underline{z}(s_i,q_1,q_2)}{\partial q_i}\{(1\text{-}s_ie_i)[1\text{-}(1+r_i)D'_i]\frac{\partial R_i}{\partial q_j}+D'_i\frac{\partial R_i}{\partial q_j}\}f(\underline{z}(s_i,q_1,q_2)) \quad \text{(A3)}$$

$$\frac{\partial^2 V_i}{\partial q_i\partial s_i}=\int_{\underline{z}(s_i,q_1,q_2)}^{\overline{z}}\{-e_i[1\text{-}(1+r_i)D'_i]\frac{\partial R_i}{\partial q_i}\}dF(z_i)$$
$$-\frac{\partial \underline{z}(s_i,q_1,q_2)}{\partial s_i}\{(1\text{-}s_ie_i)[1\text{-}(1+r_i)D'_i]\frac{\partial R_i}{\partial q_i}+D'_i\frac{\partial R_i}{\partial q_i}\text{-}1\}f(\underline{z}(s_i,q_1,q_2))$$
$$-\frac{\partial^2 \underline{z}(s_i,q_1,q_2)}{\partial q_i\partial s_i}\{(1\text{-}s_ie_i)[R_i(q_1,q_2,z_i)\text{-}(1+r_i)D_i(R_i(q_1,q_2,z_i))]+s_iV_i+D_i(R_i(q_1,q_2,z_i))\text{-}q_i\}f'(\underline{z}(s_i,q_1,q_2)).$$
$$-\frac{\partial \underline{z}(s_i,q_1,q_2)}{\partial s_i}\{-e_i[R_i(q_1,q_2,z_i)\text{-}(1+r_i)D_i(R_i(q_1,q_2,z_i))]+V_i\}f(\underline{z}(s_i,q_1,q_2)). \quad \text{(A4)}$$

Recall that $\underline{z}(s_i,q_1,q_2)$ is decreasing in s_i, and decreasing and convex in q_i. As mentioned above, the term $\{(1\text{-}s_ie_i)[1\text{-}(1+r_i)D'_i]\frac{\partial R_i}{\partial q_i}+D'_i\frac{\partial R_i}{\partial q_i}\text{-}1\}f(\underline{z}(s_i,q_1,q_2))$ must be negative. If $F(.)$ is assumed to be concave, then we have $f'(z_i)<0$. Hence it is obvious from A3 that $\partial^2V_i/\partial q_i\partial q_j<0$. Finally, in the last term of $\partial^2V_i/\partial q_i\partial s_i$, we can interpret V_i as investors' cost of buying equity s_i, and -$e_i[R_i(q_1,q_2,z_i)\text{-}(1+r_i)D_i(R_i(q_1,q_2,z_i))]$ as the benefits to investors. We will assume that investors' benefits are at least as high as costs, so the term $\{-e_i[R_i(q_1,q_2,z_i)$-$(1+r_i)D_i(R_i(q_1,q_2,z_i))]+V_i\}$ is negative. It then can be checked that $\partial^2 V_i/\partial q_i \partial s_i < 0$. Overall, we have $\partial^2 V_i/\partial q_i^2 < 0$, $\partial^2 V_i/\partial q_i \partial q_j < 0$ and $\partial^2 V_i/\partial q_i \partial s_i < 0$.

Proof of Proposition 5 and Corollary 6: The optimal s_i is determined by $\partial V_i/\partial s_i = 0$, where the envelop theorem has been applied. The second order condition $\partial^2 V_i/\partial s_i \partial s_i < 0$ is satisfied.

$$\frac{\partial V_i}{\partial s_i} = \int_{\underline{z}(s_i,q_1,q_2)}^{\overline{z}} -e_i[R_i(q_1^*,q_2^*,z_i)\text{-}(1+r_i)D_i(R_i(q_1^*,q_2^*,z_i))]+V_i\}dF(z_i) \tag{A5}$$
$$-\frac{\partial z^1(s_i,q_1^*,q_2^*)}{\partial s_i}(1\text{-}s_i e_i)[R_i(q_1^*,q_2^*,z_i)\text{-}(1+r_i)D_i(R_i(q_1^*,q_2^*,z_i))]+s_i V_i+D_i(R_i(q_1^*,q_2^*,z_i))\text{-}q_i\}f(z^1(s_i,q_1^*,q_2^*))..$$

To check if the optimal value is zero, suppose first that $\partial V_i/\partial s_i = 0$ for $s_i > 0$. Since the second term is positive, the term $-e_i[R_i(q_1^*,q_2^*,z_i)$-$(1+r_i)D_i(R_i(q_1^*,q_2^*,z_i))]+V_i\}$ must be negative for certain range of z. When we replace s_i by 0 in (A5), this term is increased as the lower bound of integration will be lifted up (since $\frac{\partial z^1(s_i,q_1^*,q_2^*)}{\partial s_i} < 0$), and also the second term is increased. The marginal bank value is still positive at s_i=0. Therefore, the optimal s_i cannot be zero.

For Corollary 6, we need to check how the optimal choice of s_i^* changes with the business status. Consider another distribution $\widehat{F}$ with the property that $\widehat{F}(\underline{z}(s_i,q_1,q_2))<F(\underline{z}(s_i,q_1,q_2))$. It is direct from (A5) that $\partial V_i/\partial s_i$ is greater with $\widehat{F}$. Together with the concavity of V_i ($\partial^2 V_i/\partial s_i \partial s_i < 0$), s_i is greater with distribution is $\widehat{F}$.

Appendix 2

Table A1 Variables Statistics

	ASSET	DEBT	LEVER	STOCK	REVE	REVER	MS	Cost1R	Cost2R	ROE
Mean	3.04E+08	2.78E+08	0.807465	16757291	32756911	0.161243	5.797818	0.754547	0.457958	1.119186
Median	84213654	66283622	0.897846	9927000.	11681121	0.069129	3.378077	0.768309	0.191007	1.002386
Maximum	3.43E+09	3.22E+09	1.402482	1.11E+08	6.66E+08	10.22118	47.60407	2.635814	7.367737	18.38032
Minimum	2069942.	129705.0	0.058683	600000.0	114080.0	-0.983657	0.089815	-0.416461	0.005178	-19.68872
Std. Dev.	5.09E+08	4.78E+08	0.185304	21270005	71568275	0.709629	7.704421	0.266890	0.824870	3.354679
Skewness	2.500116	2.504237	-1.186411	2.369565	5.122620	8.369165	3.082640	0.603139	4.054738	0.020577
Kurtosis	9.616581	9.612603	4.222319	9.039582	34.60837	96.92593	13.38205	8.204292	24.13532	9.184551
Jarque-Bara	1974.601	1975.459	204.5281	1691.951	31695.55	261310.5	4185.605	819.3289	14712.031	098.1048
Sum	2.09E+11	1.92E+11	556.3433	1.15E+10	2.26E+10	111.0962	3994.697	519.8827	315.5330	771.1192
Sum Sq. Dev.	1.79E+20	1.57E+20	23.62436	3.11E+17	3.52E+18	346.4589	40838.37	49.00641	468.1228	742.662
Observation	689	689	689	689	689	689	689	689	689	689
Cross section	72	72	72	72	72	72	72	72	72	72

Table A2 Variables Correlation

	ASSET	DEBT	LEVER	STOCK	REVE	REVER	MS	Cost1R	Cost2R	ROE
ASSET	1.000000	0.999032	0.348190	0.795279	0.728172	-0.014958	0.664564	-0.007970	-0.166886	0.357203
DEBT	0.999032	1.000000	0.362653	0.772002	0.727255	-0.013237	0.652146	0.003969	-0.168796	0.344460
LEVER	0.348190	0.362653	1.000000	0.113127	0.254195	-0.085878	0.137698	0.292913	-0.270694	-0.025073
STOCK	0.795279	0.772002	0.113127	1.000000	0.607394	-0.049496	0.618352	-0.132149	-0.112213	0.362543
REVE	0.728172	0.727255	0.254195	0.607394	1.000000	-0.002151	0.728577	0.101154	-0.172631	0.373949
REVER	-0.014958	-0.013237	-0.085878	-0.049496	-0.002151	1.000000	-0.003875	-0.059689	-0.059470	0.052420
MS	0.664564	0.652146	0.137698	0.618352	0.728577	-0.003875	1.000000	-0.019378	-0.161174	0.538682
Cost1R	-0.007970	0.003969	0.292913	-0.132149	0.101154	-0.059689	-0.007970	1.000000	-0.134039	-0.467412
Cost2R	-0.166886	-0.168796	-0.270694	-0.112213	-0.172631	-0.059470	-0.161174	-0.134039	1.000000	0.0105144
ROE	0.357203	0.344460	-0.025073	0.362543	0.373949	0.052420	0.538682	-0.467412	0.010514	1.00000

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