

## Review

# Optimal bank interest margin under capital regulation: Equity return maximization vs. equity risk minimization

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**This paper examines the effects of capital regulation on the optimal bank interest margin with two related bank objectives of option-based equity return maximization and equity risk minimization. We find that an increase in the capital-to-deposits ratio decreases the optimal interest margin under the equity return maximization, but increases the margin under the equity risk minimization. The proposed Basel system as such enables the bank to be more prone to loan risk when the objective is the equity return maximization, thereby adversely affecting the stability of the banking system, but to be less prone to loan when the objective is the equity risk minimization, thereby substantially contributing the stability. As a consequence, we argue that the effect of capital requirements on the safety of the banking system depends on the selection of the alternative objectives by banks, contributing to the literature's conflicting conclusions about capital regulation's effects on bank behavior.**

**Key words:** Bank interest margin, capital regulation, equity return maximization, equity risk minimization.

## INTRODUCTION

The first Basel accord was adopted in 1998 and is credited with providing stability to the international banking system. Banking authorities in the United States and other countries developed Basel II in 2004 because Basel I was not sufficiently sensitive in measuring risk exposures. By 2006, the European Union implemented Basel II. United States banking authorities issued the final rules for the implementation of the Basel II on December 7, 2007, and published the final regulation for implementing Basel II on April 1, 2008. At the time, the United States was in the most severe economic recession. Federal regulatory authorities turned their attention to stabilizing the financial system (Eubanks, 2010). If stability-oriented policies for the banking sector are effective, more stringent prudential capital regulation should, in principle, lead to more cautious bank operations management, in particular, as bankruptcy looms. The impacts on bank lending management related to the incentives to manage margin and risk from the imposition of the Basel II system of risk-based capital requirements provide one obvious opportunity for assessing whether

this holds.

It is widely recognized that the theoretical banking literature is divided about the effects of capital requirements on bank behavior and, hence, on the risks faced by individual institutions and the banking. Some work argues that capital requirements unambiguously contribute to various possible measures of bank stability. In contrast, other work indicated that capital requirements make banks riskier institutions than they would be in the absence of such requirements (VanHoose, 2007).<sup>1</sup> However, this paper aims to direct a more critical focus on the reasons for the literature's conflicting conclusions about capital regulation's effects on bank behavior. Particularly, the effect that capital regulation has on equity returns and/or equity risks may be not obvious since the choice of an appropriate goal in modeling the bank optimization problem remains a controversial issue.

This paper makes an attempt to examine the effects of capital regulation on bank lending under two alternatives, but related objectives of the equity return maximization versus the equity risk minimization. Since capital

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<sup>1</sup>For recent reviews of evidence and of broader implications of capital regulation for economic stability (VanHoose, (2007).

adequacy measures are tied to bank credit risk, the adoption of the Basel Accord allows regulators to control the risk behavior of banks. For bank credit risk management, it is bank obligation to ensure that capital and liquidity are allocated to different business lines at prices that reflect the risk-adequate costs of capital, aligned to the objective of maintaining the equity return maximization (Ackermann, 2008). Alternatively, the grip of nationalism in 2008 to 2009 is tightest in banking, and this widespread nationalization has generated large reports concerning the effect of ownership on bank performance (Economist, 2009a).<sup>2</sup> Under the circumstances, we argue that a nationalized or state-owned bank's objective may be to minimize its equity risk rather than to maximize its equity return, regarding the effects of capital regulation on bank behavior and overall safety and soundness for the banking system as a whole.

We develop a simple option-based model of bank behavior under capital regulation that integrates the risk considerations of portfolio-theoretic approach with the market conditions and loan rate-setting behavioral mode of the firm-theoretic approach. The principal advantage of this integrated approach is the explicit treatments of credit risk, market discipline and lending operation which have played the prominent roles in discussions of the Basel II.

The results of this paper show how regulation and credit risk conditions jointly determine the optimal bank interest margin decision under the equity return maximization and under the equity risk minimization. We find that if the bank's objective is to set loan rate to maximize the value of its equity return, then the negative impact on the bank's margin from more stringent capital regulation results in decreasing its loan portfolio. Alternatively, if the bank's objective is to set loan rate to minimize the value of its equity risk, then the positive impact on the bank's margin from more stringent capital regulation results in increasing its loan portfolio.

One immediate application of this research is to evaluate the objective choices proposed as alternatives for future loans under bank capital regulation. This paper produces mixed predictions regarding the effects of capital regulation on bank interest margin and overall bank safety. In particular, the proposed Basel II system with more stringent bank capital regulation makes the bank more prone to risk-taking when the objective is the equity return maximization, thereby adversely affecting the stability of the banking system. In contrast, if the objective is the equity risk minimization chosen by an individual bank, capital regulation as such makes the bank less prone to risk-taking, t stability of the banking system. Our paper contributes to direct a more critical focus on the reasons for current literature's conflicting conclusions about capital regulation's effects on bank spread behavior.

The rest of this paper is organized as follows.

Subsequently, we present the studies that form the background to our paper. Thereafter, we lay out the basic model of a banking firm under the two related objectives either to maximize equity return or to minimize equity risk. Then we derive the solutions of the model and the comparative static analysis. Afterwards, we provide numerical examples of capital regulation effects. Finally, the paper is concluded.

## LITERATURE REVIEW

The following sketch is somewhat selectively culled from the existing literature and provides the broad motivations for our paper. Our theory of bank behavior under capital regulation is related to three strands of the literature.

The first is the literature on bank interest margins. The pioneering study by Ho and Saunders (1981) has been the reference framework by many of the contemporary studies of determinants of bank interest margins. In this model, a bank is assumed to be a risk-averse dealer in the credit market, acting as an intermediary between the demanders and suppliers of funds. This dealership model analyzed the determinants of bank margins and concludes that the interest margin depend on both the degree of market competition and the interest rate risk. This model is further extended to account for cross-elasticities of demand between bank products (Allen, 1988), for operating cost related to direct measurement of market power (Maudos and de Guevara, 2004), and for managerial efficiency (Hawtrey and Liang, 2008). By contrast, Zarruk and Madura (1992), Wong (1997, 2011), and Hakenes and Schnabel (2011) viewed the banking firm in a setting where the supply and demand of deposits and loans clear both markets by employing the micro-model of the banking firm approach. While we also examine bank interest margin, our focus on the regulatory aspects of financial intermediation efficiency using the firm-theoretical approach takes our analysis in a different direction.

The second strand is the literature on the choice of an appropriate valuation in modeling the bank's optimization problem. Kahane (1977) and Koehn and Santomero (1980) use a mean-variance portfolio-selection model to analyze the portfolio impacts of binding capital regulation. Their findings indicate that the effect of capital requirements on the overall safety and soundness of the banking system as a whole depends on the distribution of risk aversion across banks. Kim and Santomero (1988), Cordell and King (1995), and Cuoco and Liu (2006) extend the portfolio-selection approach to analysis of an asset-risk-weighted system and provide support for this approach. Alternatively, using a firm-theoretical approach, Zarruk and Madura (1992), Broll and Wong (2010), and Wong (1997, 2011) examine how the bank interest margin under capital regulation is determined when the bank's preferences admit the von Neumann-Morgenstern expected utility representation. This is understood that

<sup>2</sup>For example, Northern Rock, a British bank, was nationalized in early 2008 (Economist, 2009b).

bank managers may have incentives to make decisions that maximize their own expected utility (Jensen and Meckling, 1976) due to a substantial amount of human capital invested in the bank. Besides, the broader contingent claims approach has found a natural application in bank regulation (Crouhy and Galai, 1991; Bhattacharya et al., 1998; Episopos, 2008). The primary difference between our model and these papers is that we modify that contingent claims approach by adding related valuation forms, allowing bank to choose the bank interest margin and the equity riskiness under capital regulation.

The third strand is the literature on the riskiness and stability effects of capital requirements. Zarruk and Madura (1992) show that an increase in bank capital requirement results in increasing the loan amount held by the bank at a reduced bank interest margin under non-increasing risk aversion. Milne (2002) suggests seeking to reduce banks' risk-taking behavior by toughening regulatory penalties rather than assessing more stringent or more requirements tied to asset risks. Hellmann et al. (2000) demonstrate that combining a deposit rate ceiling with capital regulation can unambiguously induce all banks to reduce investment in risky assets. Repullo and Suarez (2004) and Hakenes and Schnabel (2011) indicate that capital requirements are effective in controlling bank risk-taking incentives.

In particular, capital regulations intended to discourage banks from selecting high-risk portfolio are more likely to be successful when banks' market power is greatest, so that banks have less incentive to gamble. What distinguishes our work from this literature is our focus on bank spread behavior under capital regulation utilizing numerous diverse theoretical bank modeling approaches and, in particular, contemplating capital regulation in terms of required capital-to-deposits ratio.

## TWO RELATED OBJECTIVES

Consider a bank that makes decisions in a single horizon with two dates, 0 and 1,  $t \in [0, 1]$ . At  $t = 0$ , the bank has the following balance sheet:

$$L + B = D + K \quad (1)$$

where  $L > 0$  is the amount of loans,  $B > 0$  is the quantity of liquid assets,  $D > 0$  is the amount of deposits, and  $K > 0$  is the stock of equity capital.

The bank's loans belong to a single homogeneous class of fixed-rate claims that mature at  $t = 1$ . The demand for loans is governed by a downward-sloping demand function,  $L(R_L)$ , where  $R_L > 0$  is the loan rate chosen by the bank. This assumption implies that the bank exercises some market power in its loan market

(Wong, 2011). Loans are risky in that they are subject to non-performance. In addition to loans, the bank can also hold a quantity  $B$  of liquid assets at  $t = 0$ . These assets earn the security-market interest rate of  $R$  at  $t = 1$ . The total assets to be financed at  $t = 0$  are  $L + B$ . They are financed partly by demandable deposits,  $D$ . The bank provides depositors with a deposit market rate of return equal to the interest rate  $R_D$ . Capital  $K$  held by the bank is tied by capital regulation to be a fixed proportion  $q$  of the bank's deposits,  $K \geq qD$ . The required capital-to-deposits ratio  $q$  is assumed to be an increasing function of the amount of the loans  $L$  held by the bank at  $t = 0$ ,  $\partial q / \partial L = q' > 0$ . The ratio is designed to force the bank's capital positions to reflect its asset portfolio risks (VanHoose, 2007). When the capital constraint is binding, the bank's balance-sheet constraint is given by  $L + B = K(1/q + 1)$ .

The equity of the bank is viewed as a call option on its assets (Merton, 1974). This is because equity holders are residual claimants on the bank's assets after all other obligations have been met. The strike price of the call option is the book value of the bank's liabilities. When the value of the bank's asset is less than the strike price, the value of equity equals zero. In our model, the market value of the bank's assets is specified as the market value of the bank's loan repayments  $V = (1 + R_L)L$ . This value varies continuously over the time interval according to the stochastic process of  $dV = \mu V dt + \sigma V dW$  where  $\mu$  is the instantaneous expected rate of return on  $V$ ,  $\sigma$  is the instantaneous standard deviation of the return, and  $W$  is a Wiener process. The stochastic process implies that the value of  $V$  will follow a lognormal distribution of the geometric Brownian motion. The market value of the bank's equity  $S$  is a call option on the underlying asset of  $V$ , that is:

$$S = VN(d_1) - Ze^{-\delta}N(d_2) \quad (2)$$

where,  $Z = (1 + R_D)\frac{K}{q} - (1 + R)[K(\frac{1}{q} + 1) - L]$ ,

$$d_1 = \frac{1}{\sigma} \left( \ln \frac{V}{Z} + \delta + \frac{1}{2} \sigma^2 \right), \quad d_2 = d_1 - \sigma, \quad \delta = R - R_D$$

is the risk-free spread rate, and  $N(\cdot)$  = the cumulative probability distribution function for a standard normal variable.

Equation (2) demonstrates the ability to buy  $V$  at a strike price  $Z$ . Based on the balance-sheet constraint, the strike price is specified as the book value of the net-obligation payments, the difference value between the deposit payments and the liquid-asset repayment

at  $t = 1$ .<sup>3</sup> Using information about  $S$  in Eq. (2), let  $\sigma_s$  stand for the standard deviation of the rate of return on  $S$  (Ronn and Verma, 1986):

$$\sigma_s = \frac{V}{S} \frac{\partial S}{\partial V} \sigma = \frac{VN(d_1)\sigma}{S} \quad (3)$$

where,  $\frac{\partial S}{\partial V} = N(d_1) + V \frac{\partial N(d_1)}{\partial d_1} \frac{\partial d_1}{\partial V} - \frac{\partial Z}{\partial V} e^{-\delta} N(d_2) - Ze^{-\delta} \frac{\partial N(d_2)}{\partial d_2} \frac{\partial d_2}{\partial V}$

$$\frac{\partial Z}{\partial V} = 0, \quad V \frac{\partial N(d_1)}{\partial d_1} \frac{\partial d_1}{\partial V} = Ze^{-\delta} \frac{\partial N(d_2)}{\partial d_2} \frac{\partial d_2}{\partial V}$$

**SOLUTIONS AND RESULTS**

With all the assumptions in place, the bank’s objective is to set  $R_L$  to maximize  $S$  or to minimize  $\sigma_s$ . First, partially differentiating Equation (2) with respect to  $R_L$ , the first-order condition in the equity return maximization is given by:

$$\frac{\partial S}{\partial R_L} = \frac{\partial V}{\partial R_L} N(d_1) + V \frac{\partial N(d_1)}{\partial d_1} \frac{\partial d_1}{\partial R_L} - \frac{\partial Z}{\partial R_L} e^{-\delta} N(d_2) - Ze^{-\delta} \frac{\partial N(d_2)}{\partial d_2} \frac{\partial d_2}{\partial R_L} = 0 \quad (4)$$

where,  $\frac{\partial V}{\partial R_L} = L + (1 + R_L) \frac{\partial L}{\partial R_L} < 0$ ,

$$\frac{\partial Z}{\partial R_L} = \left[ \frac{(R - R_D)Kq'}{q^2} + (1 + R) \right] \frac{\partial L}{\partial R_L} < 0$$

$$V \frac{\partial N(d_1)}{\partial d_1} \frac{\partial d_1}{\partial R_L} = Ze^{-\delta} \frac{\partial N(d_2)}{\partial d_2} \frac{\partial d_2}{\partial R_L}$$

$$\frac{\partial d_2}{\partial R_L} = \frac{\partial d_1}{\partial R_L} = \frac{1}{\sigma} \left( \frac{1}{V} \frac{\partial V}{\partial R_L} - \frac{1}{Z} \frac{\partial Z}{\partial R_L} \right)$$

The second-order condition of Equation (4) is  $\partial^2 S / \partial R_L^2 < 0$ . The term  $\partial V / \partial R_L$  can be expressed as  $L(1 + \eta)$ , where  $\eta = [(1 + R_L) / L] \partial L / \partial (1 + R_L)$ , that is the interest rate elasticity of loan demand evaluated at the optimal loan rate. The sign of  $\partial V / \partial R_L$  is negative since the bank faces a downward-sloping loan demand curve. Thus, the term  $\partial Z / \partial R_L$  is negative in sign.

Equation (4) indicates that the bank sets optimal equity-maximizing loan rate at the point where the marginal risk-adjusted loan repayments of loan rate equals the marginal risk-adjusted net-obligation payments denoted by  $(\partial V / \partial R_L)N(d_1) = (\partial Z / \partial R_L)e^{-\delta} N(d_2)$ .

The optimal bank interest margin is given by the difference between the optimal loan rate and the fixed deposit rate. Since the deposit rate is not a choice variable of the bank, examining the impact of capital regulation on the optimal bank interest margin is tantamount to examining that on the optimal loan rate. Consider next the impact on the bank’s margin from changes in the capital-to-deposits ratio under the objective of equity return maximization. Implicit differentiation of Equation (4) with respect to  $q$  yields:

$$\left. \frac{\partial R_L}{\partial q} \right|_{\max S} = - \frac{\partial^2 S}{\partial R_L \partial q} / \frac{\partial^2 S}{\partial R_L^2} \quad (5)$$

where,

$$\frac{\partial^2 S}{\partial R_L \partial q} = \left( \frac{\partial^2 V}{\partial R_L \partial q} N(d_1) - \frac{\partial^2 Z}{\partial R_L \partial q} e^{-\delta} N(d_2) \right) - \frac{\partial V}{\partial R_L} \left( 1 - \frac{VN(d_1)}{Ze^{-\delta} N(d_2)} \right) \frac{\partial N(d_1)}{\partial d_1} \frac{\partial d_1}{\partial q}$$

$$\frac{\partial^2 V}{\partial R_L \partial q} = 0, \quad \frac{\partial^2 Z}{\partial R_L \partial q} = - \frac{2(R - R_D)Kq'}{q^3} \frac{\partial L}{\partial R_L} > 0,$$

$$\frac{\partial d_1}{\partial q} = - \frac{1}{\sigma Z} \frac{(R - R_D)K}{q^2} < 0$$

The sign of Equation (5) is governed by  $\partial^2 S / \partial R_L \partial q$  since the second-order condition of  $\partial^2 S / \partial R_L^2$  is assumed to be negative. The first term on the right-hand side of  $\partial^2 S / \partial R_L \partial q$  can be interpreted as the mean profit effect on  $\partial S / \partial R_L$  from a change in  $q$ , while the second term can be interpreted as the variance or “risk” effect. Both the terms are negative, and the difference between these two terms is thus indeterminate. This ambiguous result will be further investigated in a later section when a numerical example is provided.

Second, partially differentiating Equation (3) with respect to  $R_L$ , the first-order condition in the equity risk minimization is given by:

$$\frac{\partial \sigma_s}{\partial R_L} = \left( \frac{1}{S} \frac{\partial V}{\partial R_L} - \frac{V}{S^2} \frac{\partial S}{\partial R_L} \right) N(d_1)\sigma + \frac{V}{S} \frac{\partial N(d_1)}{\partial d_1} \frac{\partial d_1}{\partial R_L} \sigma + \frac{VN(d_1)}{S} \frac{\partial \sigma}{\partial R_L} = 0 \quad (6)$$

where,

$$\frac{\partial S}{\partial R_L} = \frac{\partial V}{\partial R_L} N(d_1) + V \frac{\partial N(d_1)}{\partial d_1} \frac{\partial d_1}{\partial R_L} - \frac{\partial Z}{\partial R_L} e^{-\delta} N(d_2) - Ze^{-\delta} \frac{\partial N(d_2)}{\partial d_2} \frac{\partial d_2}{\partial R_L}$$

$$\frac{\partial \sigma}{\partial R_L} = 0$$

As a result, Equation (6) implies that the bank sets its optimal equity-risk-minimizing loan rate. Further, implicit differentiation of Equation (6) with respect to  $q$  yields:

$$\left. \frac{\partial R_L}{\partial q} \right|_{\min \sigma_s} = - \frac{\partial^2 \sigma_s}{\partial R_L \partial q} / \frac{\partial^2 \sigma_s}{\partial R_L^2} \quad (7)$$

<sup>3</sup>Siddiqui (2012) argues that an increase in the administrative costs increases the bank’s interest margin. In this model, the administrative costs and the fixed costs are omitted for simplicity.

$$\text{where, } \frac{\partial^2 \sigma_s}{\partial R_L \partial q} = \left[ \frac{\partial^2 V}{\partial R_L \partial q} N(d_1) + \frac{\partial V}{\partial R_L} \frac{\partial N(d_1)}{\partial d_1} \frac{\partial d_1}{\partial q} \right] + \frac{\partial V}{\partial q} \frac{\partial N(d_1)}{\partial d_1} \frac{\partial d_1}{\partial R_L} \\ - \left[ \left( \frac{1}{S} \frac{\partial V}{\partial q} - \frac{V}{S^2} \frac{\partial S}{\partial q} \right) \frac{\partial S}{\partial R_L} N(d_1) + \frac{VN(d_1)}{S} \frac{\partial^2 S}{\partial R_L \partial q} + \frac{V}{S} \frac{\partial S}{\partial R_L} \frac{\partial N(d_1)}{\partial d_1} \frac{\partial d_1}{\partial q} \right] \\ \frac{\partial V}{\partial q} = 0, \quad \frac{\partial S}{\partial q} = -\frac{\partial Z}{\partial q} e^{-\delta} N(d_2) < 0$$

The sign of Equation (7) is governed by the numerator term  $\partial^2 \sigma_s / \partial R_L \partial q$  since the second-order condition of  $\partial^2 \sigma_s / \partial R_L^2$  is assumed to be positive in sign. We can rearrange the numerator term as

$$\frac{\partial^2 \sigma_s}{\partial R_L \partial q} = \frac{VN(d_1)}{S} \left( \frac{1}{S} \frac{\partial S}{\partial q} \frac{\partial S}{\partial R_L} - \frac{\partial^2 S}{\partial R_L \partial q} \right) + \left( \frac{\partial V}{\partial R_L} - \frac{V}{S} \frac{\partial S}{\partial R_L} \right) \frac{\partial N(d_1)}{\partial d_1} \frac{\partial d_1}{\partial q} \quad (8)$$

The first term on the right-hand side of Equation (8) can be interpreted as the mean equity effect on  $\partial \sigma_s / \partial R_L$  from changes in  $q$ , while the second term can be interpreted as the risk effect. The mean equity effect captures the change in  $\partial \sigma_s / \partial R_L$  due to an increase in  $q$ , holding the risk-adjusted factor  $N(d_1)$  constant. It is unambiguously positive because an increase in  $q$  forces the bank to provide a return to a larger equity base and thus makes loans more costly to grant. The risk effect arises because an increase in  $q$  increases  $\partial \sigma_s / \partial R_L$  in every possible risk-adjusted state. As usual, the sign of this risk effect is indeterminate. In general, the added complexity of call option does not always lead to clear-cut results. But we can certainly speak of tendencies for reasonable parameter levels that roughly correspond to the comparative static results. Subsequently, we use numerical exercises to examine the results of Equations (5) and (7).

## NUMERICAL EXERCISES

Starting from a set of assumptions on  $R = 3.50\%$ ,  $R_D = 3.00\%$ ,  $K = 20$ , and  $\sigma = 0.10$ , we calculate the market value of bank equity and the standard deviation of its return which are consistent with Equations (2) and (3). In a second step, let  $(R_L\%, L)$  change from (4.00, 250) to (5.25, 240), and let  $q\%$  increase from 7.6 to 8.8. Note that (i) the specification of capital adequacy requirements is consistent with the standard approach of Basel II, which is contemplated by changes in the capital-to-deposits ratio to capture the state of more stringent capital requirements, (ii)  $R_L > R$  indicates fund reserves as liquidity and the asset substitution in the earning-asset portfolio, and (iii)  $R_L > R_D$  demonstrates the bank interest margin as a proxy for the efficiency of financial

intermediation. The numerical parameters presented previously can be given an intuitive interpretation roughly approaching a real state of a hypothetical bank.

In Table 1, we have the results of  $S > 0$ ,  $\partial^2 S / \partial R_L \partial q < 0$ , and  $\partial^2 S / \partial R_L^2 < 0$  observed from the first three panels.  $\partial^2 S / \partial R_L^2 < 0$  demonstrates the condition of the equity return maximization. Accordingly, we can have the result of  $\partial R_L / \partial q < 0$ . It is interesting that an increase in the capital-to-deposits ratio decreases the bank interest margin under the equity return maximization. Intuitively, as the bank is forced to increase its capital relative to its deposit level, it must now provide a return to a large equity base. One way the bank may attempt to augment its total returns is by shifting its investment to its loan portfolio and away from the liquid assets. If loan demand faced by the bank is relatively rate-elastic, a larger loan portfolio is possible at a reduced margin.

Capital regulation as such makes the bank less prudent and more prone to risk-taking when the bank's objective is the equity return maximization, thereby adversely affecting the stability of the banking system. Kim and Sentomero (1988), Zarruk and Madura (1992), Boyd and De Nicolò (2005), and VanHoose (2007), for example, argue that more stringent capital requirements may not improve bank safety. Our finding under the equity maximization is consistent with this argument.

Alternatively, we analyze the impact on the bank's interest margin from changes in the capital-to-deposits ratio under the equity risk minimization by using the computed results observed from Table 2. The findings are  $\sigma_s > 0$ ,  $\partial^2 \sigma_s / \partial R_L \partial q < 0$ , and  $\partial^2 \sigma_s / \partial R_L^2 > 0$ . Note that the condition of  $\partial^2 \sigma_s / \partial R_L^2 > 0$  indicates the validness of the equity risk minimization optimization. As a result, we have  $\partial R_L / \partial q > 0$  calculated from the second and third panels in Table 2.

An interesting result is that, as the capital requirement becomes more stringent, the bank interest margin is increased under the equity risk minimization. The intuition is very straightforward. As the bank is forced to increase its capital relative to its deposit level, it shifts its investments to liquid assets from its loan portfolio at an increased margin to meet the objective of the equity risk minimization. Capital regulation as such enables the bank more prudent and less prone to risk taking, thereby contributing the stability of the banking system. Keeley and Furlong (1990), VanHoose (2007), and Hakenes and Schnabel (2011), argue that more stringent capital regulation may improve bank safety. Our finding under the equity risk minimization is consistent with this argument.

## CONCLUSION

In this paper, we have developed a simple option-based

**Table 1.** Values of  $S$  and  $\partial R_L / \partial q$ \*

$q\%$	$(R_L\%, L)$					
	(4.00, 250)	(4.25, 248)	(4.50, 246)	(4.75, 244)	(5.00, 242)	(5.25, 240)
	$\sigma_s\%$					
7.6	83.2417	82.0487	80.8722	79.7122	78.5686	77.4413
7.8	83.2961	82.1027	80.9258	79.7654	78.6214	77.4937
8.0	83.3478	82.1540	80.9768	79.8160	78.6716	77.5435
8.2	83.3970	82.2029	81.0253	79.8641	78.7193	77.5908
8.4	83.4439	82.2494	81.0715	79.9100	78.7648	77.6360
8.6	83.4887	82.2938	81.1156	79.9537	78.8083	77.6791
8.8	83.5314	82.3363	81.1577	79.9955	78.8497	77.7202
$\partial^2 \sigma_s / \partial R_L \partial q$						
7.6~7.8	-0.0004	-0.0004	-0.0004	-0.0004	-0.0004	-0.0004
7.8~8.0	-0.0004	-0.0003	-0.0004	-0.0004	-0.0004	-0.0004
8.0~8.2	-0.0003	-0.0004	-0.0004	-0.0004	-0.0004	-0.0004
8.2~8.4	-0.0004	-0.0003	-0.0003	-0.0004	-0.0004	-0.0003
8.4~8.6	-0.0004	-0.0003	-0.0004	-0.0002	-0.0004	-0.0004
8.6~8.8	-0.0002	-0.0004	-0.0003	-0.0004	-0.0004	-0.0003
$\partial^2 \sigma_s / \partial R_L^2$						
7.6		0.0165	0.0165	0.0164	0.0163	
7.8		0.0165	0.0165	0.0164	0.0163	
8.0		0.0166	0.0164	0.0164	0.0163	
8.2		0.0165	0.0164	0.0164	0.0163	
8.4		0.0166	0.0164	0.0163	0.0164	
8.6		0.0167	0.0163	0.0165	0.0162	
8.8		0.0165	0.0164	0.0164	0.0163	
$\partial R_L / \partial q = -(\partial^2 \sigma_s / \partial R_L \partial q) / (\partial^2 \sigma_s / \partial R_L^2)$						
7.6~7.8		0.0242	0.0242	0.0244	0.0245	
7.8~8.0		0.0181	0.0244	0.0244	0.0245	
8.0~8.2		0.0242	0.0244	0.0244	0.0245	
8.2~8.4		0.0181	0.0183	0.0245	0.0183	
8.4~8.6		0.0180	0.0245	0.0121	0.0247	
8.6~8.8		0.0242	0.0183	0.0244	0.0184	

\*Parameter values, unless stated otherwise:  $R = 3.50\%$ ,  $R_D = 3.00\%$ ,  $K = 20$ , and  $\sigma = 0.10$ .

firm-theoretical model to study the optimal bank interest margin (that is, the spread between the loan rate and the deposit rate) for a bank under the equity return maximization and the equity risk minimization. We utilize the model to show how credit risk and capital regulation of the Basel system, especially denoted by the capital-to-deposits ratio, determine the optimal spread decision.

Specifically, we find that, as capital requirements become more stringent, the loan portfolio held by the

bank is increased at a reduced margin under the objective of the equity return maximization and is decreased at an increased margin when the objective of the equity risk minimization. The result in the maximization objective is largely supported by Zarruk and Madura (1992), Boyd and De Nicolò (2005), and VanHoose (2007) concerning bank risk-taking spread behavior, while the result in the minimization objective is largely supported by Keeley and Furlong (1990),

**Table 2.** Values of  $\sigma_s$  % and  $\partial R_L / \partial q$  \*.

$q\%$	$(R_L\%, L)$					
	(4.00, 250)	(4.25, 248)	(4.50, 246)	(4.75, 244)	(5.00, 242)	(5.25, 240)
	$\sigma_s$ %					
7.6	83.2417	82.0487	80.8722	79.7122	78.5686	77.4413
7.8	83.2961	82.1027	80.9258	79.7654	78.6214	77.4937
8.0	83.3478	82.1540	80.9768	79.8160	78.6716	77.5435
8.2	83.3970	82.2029	81.0253	79.8641	78.7193	77.5908
8.4	83.4439	82.2494	81.0715	79.9100	78.7648	77.6360
8.6	83.4887	82.2938	81.1156	79.9537	78.8083	77.6791
8.8	83.5314	82.3363	81.1577	79.9955	78.8497	77.7202
	$\partial^2 \sigma_s / \partial R_L \partial q$					
7.6~7.8	-0.0004	-0.0004	-0.0004	-0.0004	-0.0004	-0.0004
7.8~8.0	-0.0004	-0.0003	-0.0004	-0.0004	-0.0004	-0.0004
8.0~8.2	-0.0003	-0.0004	-0.0004	-0.0004	-0.0004	-0.0004
8.2~8.4	-0.0004	-0.0003	-0.0003	-0.0004	-0.0004	-0.0003
8.4~8.6	-0.0004	-0.0003	-0.0004	-0.0004	-0.0002	-0.0004
8.6~8.8	-0.0002	-0.0004	-0.0003	-0.0004	-0.0004	-0.0003
	$\partial^2 \sigma_s / \partial R_L^2$					
7.6		0.0165	0.0165	0.0164	0.0163	
7.8		0.0165	0.0165	0.0164	0.0163	
8.0		0.0166	0.0164	0.0164	0.0163	
8.2		0.0165	0.0164	0.0164	0.0163	
8.4		0.0166	0.0164	0.0163	0.0164	
8.6		0.0167	0.0163	0.0165	0.0162	
8.8		0.0165	0.0164	0.0164	0.0163	
	$\partial R_L / \partial q = -(\partial^2 \sigma_s / \partial R_L \partial q) / (\partial^2 \sigma_s / \partial R_L^2)$					
7.6~7.8		0.0242	0.0242	0.0244	0.0245	
7.8~8.0		0.0181	0.0244	0.0244	0.0245	
8.0~8.2		0.0242	0.0244	0.0244	0.0245	
8.2~8.4		0.0181	0.0183	0.0245	0.0183	
8.4~8.6		0.0180	0.0245	0.0121	0.0247	
8.6~8.8		0.0242	0.0183	0.0244	0.0184	

\*Parameter values, unless stated otherwise:  $R = 3.50\%$ ,  $R_D = 3.00\%$ ,  $K = 20$ , and  $\sigma = 0.10$ .

VanHoose (2007), and Hakenes and Schnabel (2011) concerning bank spread behavior related to bank safety.

What effects do banking-firm models indicate that capital regulation has on bank operations? The predicted effects of capital regulation on marginal decision-making depend on which aspects of bank operations a researcher chooses to emphasize in an analytical banking framework. Specifically, our model provides alternative explanations for bank spread behavior under capital regulation based on equity return maximization and equity risk minimization frameworks. Central to evaluating

whether risk-based capital regulation truly makes individual banks safer.

This paper argues that an individual bank may attempt more stringent capital regulation by making more risky loan choices under the bank equity return maximization; however by making less risky loan choices under the bank equity risk minimization. Thus, a future research may direct a more critical focus that capital requirements complementing other forms of regulation may necessarily produce a regulator's preferred outcome, indicating that the intellectual underpinning for the proposed Basel II

system may not be particularly strong.

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## REFERENCES

- Ackermann J (2008). The subprime crisis and its consequences. *J. Financ. Stab.* 4(4):329-337.
- Allen L (1988). The determinants of bank interest margins: a note. *J. Financ. Quant. Anal.* 23(2):231-235.
- Bhattacharya S, Boot A, Thakor A (1998). The economics of bank regulation. *J. Money. Credit. Bank.* 30(4):745-769.
- Boyd JH, De Nicolò G (2005). The theory of bank risk taking and competition revisited. *J. Financ.* 60(3):1329-1343.
- Broll U, Wong KP (2010). Banking firm and hedging over the business cycle. *Port. Econ. J.* 9(1):29-33.
- Cordell LR, King KK (1995). A market evaluation of the risk-based capital standards for the U.S. financial system. *J. Bank. Financ.* 19(3):531-562.
- Crouhy M, Galai D (1991). A contingent claim analysis of a regulation depository institution. *J. Bank. Financ.* 15(1):73-90.
- Cuoco D, Liu H (2006). An analysis of var-based capital requirements. *J. Financ. Intermed.* 15(3):362-394.
- Economist (2009a). The return of economic nationalism. *Economist.* February 7<sup>th</sup>: pp.9-10.
- Eubanks WW (2010). The status of the Basel III Capital Adequacy Accord. Congressional Res. Service 7-5700, www.crs.gov, R41467.
- Hakenes H, Schnabel I (2011). Bank size and risk-taking under Basel II. *J. Bank. Financ.* 35(6):1436-1449.
- Hawtrey K, Liang H (2008). Bank interest margins in OECD countries. *N. Am. J. Econ. Financ.* 19(3):249-260.
- Hellmann KCM, Thomas F, Joseph ES (2000). Liberalization, moral hazard in banking, and prudential regulation: are capital requirements enough? *Am. Econ. Rev.* 90(1):147-165.
- Ho T, Saunders A (1981). The determinants of bank interest margins: theory and empirical evidence. *J. Financ. Quant. Anal.* 16(4):581-600.
- Jensen M, Meckling W (1976). Theory of the firm: managerial behavior, agency cost, and ownership structure. *J. Financ. Econ.* 3(4):305-360.
- Kahane Y (1977). Capital adequacy and the regulation of financial intermediaries. *J. Bank. Financ.* 1(2):207-218.
- Keeley MC, Furlong FT (1990). A re-examining of mean-variance analysis of bank capital regulation. *J. Bank. Financ.* 14(1): 69-84.
- Kim D, Santomero AM (1988). Risk in banking and capital regulation. *J. Financ.* 43(5):1219-1233.
- Koehn M, Santomero M (1980). Regulation of bank capital and portfolio risk. *J. Financ.* 35(5):1235-1244.
- Maudos J, de Guevara JF (2004). Factors explaining the interest margin in the banking sectors of the European Union. *J. Bank. Financ.* 28(9):2259-2281.
- Merton RC (1974). On the pricing of corporate debt: the risk structure of interest rates. *J. Financ.* 29(2):449-470.
- Milne A (2002). Bank capital regulation as an incentive mechanism: implications for portfolio choices. *J. Bank. Financ.* 26(1):1-23.
- Repullo R, Suarez J (2004). Loan pricing under Basel capital requirements. *J. Financ. Intermed.* 13(4):496-521.
- Ronn E, Verma A (1986). Pricing risk-adjusted deposit insurance: an option-based model. *J. Financ.* 41(4):871-895.
- VanHoose D (2007). Theories of bank behavior under capital regulation. *J. Bank. Financ.* 31(12):3680-3697.
- Wong KP (1997). On the determinants of bank interest margins under credit and interest rate risks. *J. Bank. Financ.* 21(2):251-271.
- Wong KP (2011). Regret theory and the banking firm: the optimal bank interest margin. *Econ. Model.* 28(6):2483-2487.
- Zarruk E, Madura J (1992). Optimal bank interest margin under capital regulation and deposit insurance. *J. Financ. Quant. Anal.* 27(1):143-149.