International Journal of Information and Management Sciences

International Journal of Information and Management Sciences
30 (2019), 169-184. DOI:10.6186/IJIMS.201906_30(2).0005

Optimal Bank Interest Margin Under Capital Regulation: Regret Aversion and Shadow Banking

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Abstract

This paper takes a contingent claim approach to the market valuation of a banking firm's equity. A model is presented that explicitly takes into account the following: (i) the bank is regret-averse; (ii) the earning-asset portfolio of the bank includes regular banking loans, default-free liquid assets, and shadow banking wealth management products; and (iii) imposing heightened capital requirements on the bank emerges. We argue that it may not be regretful for the bank to conduct the WMPs, implying that these activities have been increasing over time. Increases in WMPs or capital requirements decrease the bank interest margin, which makes the bank more prone to loan risk-taking, thereby adversely affecting banking stability.

Keywords: Regret, shadow banking, bank interest margin, capital regulation.

1. Introduction

The bank interest margin, commonly defined as the spread between the loan rate and the deposit rate, conveys vital information for the efficiency of the banking system (see Saunders and Schumacher [25]). In the past decades, banks in many developed countries have experienced a gradual decline in interest margins (see Arnold and Ewijk [2]). In explanation of deteriorating bank interest margins, Berger et al. [3], and De Guevara et al. [6] show a strong focus on competitive conditions, and Lepetit et al. [15], and Albertazzi and Gambacorta [1] show a strong focus on diversification into non-interest income businesses in response to heightened competition and disintermediation in regular retail markets. Although considerable research effort has been put toward modeling bank interest margin for the purpose of evaluating explanatory variables written on it, little attention has been paid to the effects of shadow banking on bank interest margin (see, for instance, Kasman et al. [14] for literature review of papers that model bank interest margin). The effect that shadow banking may have on bank interest margin is not obvious, since shadow banking is a form of off-balance-sheet bank lending intended to skirt the regulatory loan-to-deposit rules (see Jiang [13]).

In the present paper, we construct a contingent claim model along the line of Tsai [27] for the valuation of a bank's equity. The author's main contribution is to explicitly consider default risk in a contingent claim model to value the equity of a bank based on a regret aversion argument in the spirit of Braun and Muermann [4]. Specifically, the author examines the optimal bank interest margin when the bank is regret-averse under capital regulation. Regret aversion is common and supported by a large body of experimental literature and our life experience (see Starmer and Sugden [26]). Wong [31] argues that banks may have a desire to avoid consequences wherein banks appear to have made ex-post suboptimal decisions, even though those decisions are ex-ante optimal based on the information available at that time. Taking this consequence of decision making under uncertainty seriously, Quiggin [23], and Wong [31] propose regret-averse preferences among banks. The recent financial crisis provides one opportunity for assessing how risk-based capital regulation influences choices that a risk-averse and regret-averse CEO makes on the margin. To this end, Tsai [27] incorporate risk-averse and regret averse preferences into the firm-theoretical model of a regulated bank facing credit risk. However, Tsai [27] is silent on the shadow banking issue. Knowing how shadow banking affects bank interest margin when the bank is regret-averse is of paramount importance for bank managers and regulators contemplating prudential banking regulation.

In light of previous work, the purpose of this paper is to incorporate regret theory into the contingent claim model of a bank operating shadow banking wealth management products (WMPs). These products attract investors who want a higher return than is available on deposits at banks, whose interest rates are set by the government (see Lu et al. [18]). To this end, we characterize the bank's regret aversion by the equity function viewed as a call option on the bank's assets that includes a reduced value from operating only the regular banking activities. Our paper's main conclusion is to document that it is not regretful for banks to conduct the WMPs, demonstrating that these shadow banking activities have been increasing over the past decade (see Copeland [5]). It also implies a financial mechanism that the WMPs can complement regular banking loans by expanding access to credit or by supporting market liquidity, and risk sharing (see Ghosh [9]). Our finding that bank interest margin decreases is explained by increasing the WMPs. Accordingly, we suggest that increases in shadow banking activities make the bank more prone to loan risk-taking, thereby adversely affecting banking stability.

The rest of this paper is organized as follows. Section 2 discusses related literature. Section 3 delineates a contingent claim approach to the market valuation of a banking firm's equity when the bank is regret-averse. Section 4 derives the optimal bank interest margin and examines the effects of WMPs, and capital regulation on the optimal margin. Section 5 presents a numerical analysis to explain the intuition of the comparative static results. The final section concludes the paper.

2. Related Literature

Our theory of bank interest margin is related to two main strands of the literature. The first strand is the recent literature on the optimal bank interest margin determination with regret theory. Wong [31] follows Braun and Muermann [4] to characterize a bank's regret-averse preferences by a utility function that includes a loss from having chosen ex-post suboptimal alternatives. The key assumption of the model is that the bank is not only risk-averse but also regret-averse based on the standard von Neumann-Morgenstern expected utility function. The author documents that the presence of regret aversion raises or lowers the optimal bank interest margin than the one chosen by the purely risk-averse bank, depending on whether the default risk is below or above a threshold value, respectively. Specifically, regret aversion as such makes the bank more prone to risk-taking when the default risk is high, thereby adversely affecting the banking stability.

However, Braun and Muermann's [4] approach to modeling default risk, the risk that the firm's assets will be less than the book value of the firm's liabilities, is ignored. Rahman et al. [24] find robust evidence that more efficient banks hold higher capital and charge lower financial intermediation costs (and hence lower bank margins). Tsai [27] also follows Braun and Muermann [4] to characterize a bank's regret-averse preferences by a call-option utility function that includes disutility from the dislike of bank equity risk in the argument of Hermalin [11]. The author demonstrates that an increase in bank capital requirement increases the optimal bank interest margin when the risk aversion dominates the regret aversion, but decreases the margin when the regret aversion dominates the risk aversion capital regulation as such makes the bank more prone to risk-taking when the regret aversion relative to the risk aversion is significant, thereby adversely affecting the banking stability.

While we also examine bank interest margin, our focus on the shadow banking activities under capital regulation takes our analysis in a different regulatory direction. Our paper applies the model of Braun and Muermann [4] as its point of departure. Specifically, the bank's regret-averse preference is characterized by a call option theory of corporate security valuation that includes the loss from conducting only the regular banking activities. The primary difference between our model and these papers above is that we consider the effects of shadow banking under capital regulation where the objective function is expressed by a call-option function. A main conclusion in the paper is that increases in the shadow banking activities decrease the bank interest margin, that makes the bank more prone to loan risk-taking, thereby adversely affecting bank stability.

This paper also relates to the recent strand of the literature on the interaction between regular banking and shadow banking. Ordonez [21] shows that unregulated banking can be superior to regulated banking when (i) regulation inefficiently restricts risk taking by bank, and (ii) reputational concerns are an effective disciplining device in the shadow banking sector. Overall, if regulation is inefficient, then a shadow banking sector might be desirable. Li and Lin [16] suggest that relaxing capital requirements may lead to superior performance and greater safety for the bank carrying on shadow banking activities. Gennaioli et al. [8] present a model of shadow banking and securitization in which banks originate and trade loans, assemble them into diversified portfolios, and finance portfolios externally with riskless debt. The authors conclude that the shadow banking system is stable and welfare improving under rational expectations, but vulnerable to crises and liquidity dry-ups when investors neglect tail risks. Harris et al. [10] also develop a shadow banking model in which capital requirements for banks may be counterproductive. The authors argue that tightening capital requirements reduce the funding capacity of banks. This may spur entry by nonbanks in the business of lending to good borrowers. This induces banks to focus on lending to bad borrowers for which their profits are generated by the government put, rather than by the intrinsic value of the projects that they fund. Lin et al. [17] develop a contingent claim model to evaluate a bank's equity and liabilities that integrates the premature default risk conditions with loan rate-setting behavioral mode and multiple shadow banking activities under capital regulation and demonstrate that financial disturbance may be created because of the potential for shadow banking activities to spill over to regular banking activities and damage the real economy. Plantin [22] develops a framework to study the optimal prudential regulation of banks in the presence of a shadow banking sector. The author concludes that tightening capital requirements may spur a surge in shadow banking activity that may lead to an overall larger risk on the money-like liabilities of the regulated and shadow banking institutions.

The fundamental insight shared by the previous papers is that conformity is generated by a desire to distinguish oneself from the type with which one wishes not to be identified. This insight is an important aspect of bank interest margin management as well since the analyst agrees with bank managers to avoid being identified as untalented in determining bank interest margins. What distinguishes our work from this literature is our focus on the commingling of the bank interest margin determination with the assessment of regret aversion and, in particular, the emphasis we put on the interaction between regular and shadow banking under capital regulation. In the following section, we develop a basic model of the bank interest margin when the bank is risk-neutral and regret-averse. The standard call option of corporate security valuation assuming risk-neutral valuation and lognormal asset values is applied to the contingent claims of a regulated bank with shadow banking activities. Regret-averse preferences are characterized by a call-option function. Since changes in shadow banking activities may affect bank spread behavior under capital regulation, we focus on the bank interest margin determination with considering shadow banking and capital regulation. Accordingly, we consider a contingent claim model framework for a banking firm based on a model proposed by Merton [20], and inspired by the model of Braun and Muermann [4] whose description we partially adopt.

3. The Model

The bank that makes decisions in a single period horizon with two dates, 0 and 1, $t \in [0, 1]$. The initial businesses at $t = 0$ are given in Table 1.

Time $t = 1$ can be considered as the time to maturity of a single cohort of deposits and WMPs. At $t = 0$ the bank has the following balance sheet in the regular banking activities:

$$L + B = D + K \tag{3.1}$$

Table 1: Simplified business model of a bank at $t = 0$.

Assets		liabilities and equity	
balance-sheet components:			
risky loan	L	Deposits	$D = K/q$
risk-free liquid assets	B	Equity	K
Total	$L + B$	Total	$D + K = (1/q + 1)K$
shadow banking components:			
risk assets funded by WMPs	αM	WMPs	M
risk-free assets funded by WMPs	$(1 - \alpha)M$		
Total	M	Total	M

Note: q is a capital-to-deposits ratio, and $0 < \alpha < 1$.

where $L > 0$ is the amount of loans, $B > 0$ is the quantity of liquid assets, such as bonds, $D > 0$ 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 faced by the bank is governed by a downward-sloping demand function, $L(R_L)$, where $R_L > 0$ is the loan rate set by the bank. Loans are risky in that they are subject to non-performance. The liquid assets held by the bank during the period earn the security-market interest rate of $R > 0$. The supply of deposits faced by the bank is perfectly elastic at a deposit market rate of $R_D > 0$. Equity capital held by the bank is tied by regulation to be a fixed proportion q of the bank's deposits, $K \geq qD$ (see VanHoose [28]). When the capital constraint is binding where the security market interest rate is sufficiently larger than the deposit market interest rate (see Wong [30]), the bank's liquidity constraint of Eq. (3.1) can be restated as $L + B = K(1/q + 1)$ because the bank would like to rely on deposits rather than on equity capital to finance loans. This model focuses on the binding case. In addition to regular banking, the bank can also create WMPs $M > 0$ by offering investors the chance to pong up short-term money against a single large loan, or a package of loans and other credit instruments, including bonds and interbank placements (see Jiang [13]). As pointed out by Jiang [13], in China, shadow banking instruments largely fall into the following categories: wealth management products, entrusted loans, undiscounted bankers' acceptance, trust loans, informal lending and loans by finance companies. In the year of 2014, the total worth of the wealth management products held by banks in China is approximately RMB 15 trillion, which equals 25% of GDP, 13.2% of all outstanding bank deposits, and 28% of total shadow products. This is a reason why we focus on the wealth management products in our model. The bank cannot invest funds in non-standard assets that exceed of the value of its outstanding WMPs by regulation (see Lu et al. [18]).

By applying the option pricing framework (see Merton [20]), the equity of the bank is viewed as a call option on the bank's assets. The reason is that equity holders are residual claimants on the bank's assets after all other payments have been met. The strike price of the call is the book value of the bank's liabilities. When the value of the bank's assets is less than the strike price, the equity value of the bank is equal to zero. The market value of the bank's underlying assets follows a geometric Brownian motion of the form:

$$dV = \mu V dt + \sigma V dW \tag{3.2}$$

where

$$\begin{aligned} V &= (1 + R_L)L + \alpha(1 + R_M)M \\ \mu dt &= \Big(\frac{L}{L + \alpha M}\mu_L + \frac{\alpha M}{L + \alpha M}\mu_M\Big)dt \\ \sigma dW &= \frac{L}{L + \alpha M}\sigma_L dW_L + \frac{\alpha M}{L + \alpha M}\sigma_M dW_M. \end{aligned}$$

In this equation, V includes (i) the loan repayments $(1+R_L)L$ with the expected rate of return, μ_L, and the expected volatility of σ_L, and (ii) the repayments from the WMPs $\alpha(1 + R_M)M$ with the expected rate of return, μ_M, and the expected volatility of σ_M where $R_M > 0$ is a constant interest rate of WMPs. μ is the expected return from V, which is a function of the weighted-average return from the loans μ_L and the weighted-average return from the WMPs μ_M. σdW is the expected volatility of V, which is a function of the weighted-average volatility of the loans σ_L and the weighted-average volatility of the WMPs σ_M where dW, dW_L, and dW_M are Wiener processes, respectively. Both μ and σ in the weighted-average forms reveal different states of expected return and volatility of the WMPs related to the loans of the bank. We verify that modifying the weighted-average form of the volatility to other common form does not change the qualitative results of the model. Note that we do not assume a covariance between the repayment from loans and the repayment from the WMPs for the following reason. Changes in L and M will affect the weights, which in turn may affect μ or/and σ. All decision variables of the model are affected by μ and σ. Therefore, it is not assumed that there is a covariance between the repayments from loans and WMPs, which does not necessarily mean that the repayments of loans and WMPs are independent.

The market value of the bank's equity, S, will then be given by the Merton [19] formula for call options:

$$S = VN(d_1) - Ze^{-\delta}N(d_2) \tag{3.3}$$

where

$$Z = \frac{(1 + R_D)K}{q} - (1 + R)[K(\frac{1}{q} + 1) - L] + (1 + R_P)M - (1 - \alpha)(1 + R)M$$

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

and where $Z \equiv$ the payments to depositors (the first term on the right-hand side) net of the repayments from the liquid-asset investments (the second term), and the payments to investors of the WMPs (the third term) net of the repayments from a portion of the products $(1 - \alpha)M$ invested in the liquid-asset market (the last term), $\delta \equiv$ the difference between the liquid-asset market rate and the deposit market rate, the compounded riskless spread rate, and $N(\cdot) \equiv$ the cumulative distribution function of the standard normal distribution. Z is the strike price of the call. Note that the condition of $R_P > R_D$ attracts investors who want a higher return rate of R_P than is available on deposits in the market (see Lu et al. [18]). As pointed out by Elliott et al. [7], WMPs have grown to be a significant portion of total deposits. Corporate deposit substitutes, usually invested via the inter-bank market, would need to be added as well. However, the great bulk of the funding is still in the form of traditional bank deposits. Accordingly, we assume $D > M$ in our model.

The selection of our model's default risk follows Vassalou and Xing [29]. The default probability is the probability that the bank's assets will be less than the book value of the bank's liabilities. With information about Eq. (3.3), the distance to default d_3 is defined as:

$$d_3 = \frac{1}{\sigma}\Big(\ln\frac{V}{Z} + \mu - \frac{\sigma^2}{2}\Big) \tag{3.4}$$

Default takes place when the ratio of V to Z is less than 1. The d_3 tells us by how many standard deviations the natural log of this ratio needs to deviate from its mean in order for default to occur. Notice that although the value of the call option in Eq. (3.3) does not depend on μ, d_3 does. This is because d_3 depends on the future value of assets which is given in Eq. (3.3). We use the theoretical distribution implied by Merton's [20] model, which is the normal distribution. The theoretical default probability is then given by:

$$P_{def} = 1 - N(d_3). \tag{3.5}$$

The bank's objective is to set R_L to maximize the market value of a regret-averse call option function defined in terms of profits, subject to Eq. (3.1). Following a regret-averse argument in the spirit of Braun and Muermann [4], we assume that the bank's preference is represented by the following modified call option function that includes some compensation for regret:

$$E = U(M > 0) - \beta G(U(M = 0) - U(M > 0)) \tag{3.6}$$

where

$$U(M > 0) = [1 - P_{def}(M > 0)]S(M > 0)$$
$$U(M = 0) = [1 - P_{def}(M = 0)]S(M = 0)$$
$$G(U(M = 0) - U(M > 0)) = U(M = 0) - U(M > 0)$$

and where $U(M > 0) \equiv$ a realized actual equity function defined as the equity value $S(M > 0)$ net of the possible default value $P_{def}(M > 0)S(M > 0)$ when the bank conducts both the regular and shadow banking activities, $U(M = 0) \equiv$ a realized equity function defined as the equity value $S(M = 0)$ net of the possible default value $P_{def}(M = 0)S(M = 0)$ when the bank conducts only the regular banking activities, $\beta > 0 \equiv$ a constant regret coefficient, and $G(\cdot) \equiv$ a regret function. The regret function depends on the difference between (i) the realized equity value of $U(M = 0)$ that the bank's shareholders could have received if the bank had made the decisions based on conducting only the regular banking activities and (ii) the realized actual equity value of $U(M > 0)$.

The reasons that the regret function $G(\cdot)$ is assumed to be linear are as follows. In general, if the assumption of perfect capital markets is made, then the bank's objective is to maximize its market value. In this case, a linear objective function would be appropriate (Zarruk and Madura [32]). Tsai [27] adopts a similar objective function for the valuation of a bank's equity. Under the assumed form of the regret function, if the value of G is positive, i.e., $U(M = 0) > U(M > 0)$, the bank experiences loss from undertaking the shadow banking decision. If the value of G is negative, the bank experiences loss from not taking the shadow banking decision or benefit from having taken the decision with some compensation. Eq. (3.6) posits that learning about the outcome of foregone WMPs investment creates the possibility of experiencing regret.

4. Solution and Results

With the equity value function well described, one can now move on to considering the optimal loan rate determination. Partially differentiating Eq. (3.6) with respect to R_L, the first-order condition is given by:

$$\frac{\partial E}{\partial R_L} = \frac{\partial U(M>0)}{\partial R_L} - \beta\Big(\frac{\partial U(M=0}{\partial R_L} - \frac{\partial U(M>0)}{\partial R_L}\Big) = 0 \qquad (4.1)$$

where

$$\frac{\partial U(M>0)}{\partial R_L} = -\frac{\partial P_{def}(M>0)}{\partial R_L}S(M>0) + [1+P_{def}(M>0)]\frac{\partial S(M>0)}{\partial R_L}$$

$$\frac{\partial U(M=0)}{\partial R_L} = -\frac{\partial P_{def}(M=0)}{\partial R_L}S(M=0) + [1+P_{def}(M>0)]\frac{\partial S(M=0)}{\partial R_L}.$$

We require that the second-order condition be satisfied, $\partial^2 E/\partial R_L^2 < 0$. The term $\partial U(M > 0)/\partial R_L$ in Eq. (4.1) can be interpreted as the marginal realized equity value, while the term $\beta(\cdot)$ can be interpreted as the marginal realized regret value. The optimal loan rate is determined where both the marginal values are equal.

Consider next the impact on the bank's loan rate (and thus on the bank's interest margin since the deposit market rate is not a choice variable) from changes in the WMPs and the capital-to-deposits ratio. Implicit differentiation of Eq. (4.1) with respect to α and q yields:

$$\frac{\partial R_L}{\partial \alpha} = -\frac{\partial^2 E}{\partial R_L \partial \alpha}\Big/\frac{\partial^2 E}{\partial R_L^2} \qquad (4.2)$$

$$\frac{\partial R_L}{\partial q} = -\frac{\partial^2 E}{\partial R_L \partial q}\Big/\frac{\partial^2 E}{\partial R_L^2} \qquad (4.3)$$

where

$$\frac{\partial^2 E}{\partial R_L \partial \alpha} = (1+\beta)\frac{\partial^2 U(M>0)}{\partial R_L \partial \alpha}$$

$$\frac{\partial^2 E}{\partial R_L \partial q} = \frac{\partial^2 U(M>0)}{\partial R_L \partial q} - \beta\Big(\frac{\partial^2 U(M=0)}{\partial R_L \partial q} - \frac{\partial^2 U(M>0)}{\partial R_L \partial q}\Big).$$

In general, the added complexity of call options in the comparative static analysis does not always lead to clear-cut results, but we can certainly speak of tendencies for reasonable parameters levels corresponding roughly to Eqs. (4.2) and (4.3). Exactly, we conduct a numerical analysis along the lines of the relevant literature of option pricing framework (see Tsai [27]). Another reason for the numerical analysis is that we have assumed the form of regret function in Eq. (3.6). Toward that end, we assume that the parameters are $R = 3.5\%$, $R_D = 2.5\%$, $R_M = 4.0\%$, $R_P = 3.0\%$, $M = 30$, $K = 16$, $q = 8.0\%$ and $\beta = 0.2$. Let $(R_L\%, L)$ change from (4.5, 200) to (5.1, 179) due to the downward-sloping condition. The intuition of the parameters levels is explained as follows. $R_L > R$ indicates the scope for earning-asset portfolio substitution. $R > R_D$ implies the capital binding condition. $R_L > R_M > R$ demonstrates that WMPs are risky and thus $R_M > R$, and a large share of WMPs has a short-term maturity and thus $R_L > R_M$. $R > R_P > R_D$ explains the attraction to investors who want a higher return than is available on deposits at the bank (see Lu et al. [18]). The specification of capital-to-deposits ratio is set by $q = K/D = 16/D = 8.0\%$, which meets the capital adequacy requirement (see VanHoose [28]).

First of all, we observe the realized equity value of the bank, represented by E in the third panel of Table 2. It is interesting that, as the WMPs increase, E and $U(M > 0)$ are increased but $U(M = 0)$ is invariant. The result is understood because both the realized actual equity value with regular and shadow banking activities and the negative regret value with incremental shadow banking activities are more likely to come into effect, as the WMPs increase. Our argument is largely supported by Copeland [5] that shadow banking activities have been increasing over time and represent a quantitatively important share of bank earnings. This suggests that, from a viewpoint of bank equity return, it is not regretful for the bank to conduct the shadow banking activities of the WMPs.

In addition, the condition of $\partial^2 E/\partial R_L^2 < 0$ presented in the fourth panel confirms the validness of the second-order condition required by Eq. (4.1). From the last panel, we have the result of $\partial R_L/\partial \alpha < 0$. Intuitively, as the bank increases the WMPs, it must now provide a return to a larger shadow banking product base. One way the bank may attempt to augment its total returns is by shifting its investments to its loan portfolio and away from the liquid-asset market. If loan demand is relatively rate-elastic, a larger loan portfolio is possible at a reduced margin. Shadow banking activities as such make the bank less prudent and more prone to loan risk-taking, thereby adversely affecting the stability of the banking system. Our result is consistent with a finding of Jeffers and Baicu [12]: the financial crisis reveals the negative consequences that the interconnections between banks and shadow banking entities have on financial stability. Accordingly, the solvency of regular banking at a reduced bank interest margin then may be offset by such growth in shadow banking. To summarize, we have the following proposition.

Proposition 1. *Increases in the WMPs decrease the optimal bank interest margin.*

The two relevant distinctions for our argument are whether the expected return of regular banking loans is relatively higher than the expected return of shadow banking

Table 2: Responsiveness of bank interest margin to α.

α \ $(R_L\%, L)$	(4.5, 200)	(4.6, 199)	(4.7, 197)	(4.8, 194)	(4.9, 190)	(5.0, 185)	(5.1, 179)
	$U(M > 0)$						
0.10	32.6159	32.6603	32.6013	32.4374	32.1674	31.7905	31.3061
0.15	32.7628	32.8070	32.7476	32.5831	32.3124	31.9346	31.4491
0.20	32.9100	32.9539	32.8940	32.7289	32.4576	32.0789	31.5924
0.25	33.0573	33.1009	33.0406	32.8750	32.6029	32.2235	31.7359
0.30	33.2048	33.2480	33.1873	33.0212	32.7485	32.3682	31.8797
0.35	33.3524	33.3953	33.3342	33.1676	32.8943	32.5132	32.0237
0.40	33.5001	33.5428	33.4813	33.3142	33.0402	32.6583	32.1679
	$U(M = 0)$, invariant to α						
	32.2259	32.2707	32.2121	32.0488	31.7795	31.4035	30.9204
	E						
0.10	32.6938	32.7383	32.6792	32.5151	32.2450	31.8678	31.3832
0.15	32.8702	32.9143	32.8546	32.6899	32.4190	32.0408	31.5549
0.20	33.0468	33.0905	33.0303	32.8650	32.5932	32.2140	31.7268
0.25	33.2236	33.2669	33.2063	33.0403	32.7676	32.3875	31.8991
0.30	33.4005	33.4435	33.3824	33.2157	32.9423	32.5612	32.0716
0.35	33.5777	33.6203	33.5587	33.3914	33.1172	32.7351	32.2443
0.40	33.7550	33.7972	33.7352	33.5673	33.2924	32.9093	32.4174
	$\partial^2 E/\partial R_L^2$						
0.10	-	-10.3534	-10.4935	-10.6098	-10.6974	-10.7484	-
0.15	-	-10.3672	-10.5086	-10.6271	-10.7178	-10.7731	-
0.20	-	-10.3807	-10.5235	-10.6441	-10.7378	-10.7973	-
0.25	-	-10.3938	-10.5380	-10.6606	-10.7572	-10.8208	-
0.30	-	-10.4067	-10.5522	-10.6767	-10.7762	-10.8437	-
0.35	-	-10.4193	-10.5660	-10.6925	-10.7947	-10.8661	-
0.40	-	-10.4316	-10.5796	-10.7080	-10.8128	-10.8879	-
	$\partial R_L/\partial\alpha(\%)$						
0.10→0.15	-	-0.7269	-0.9793	-1.2547	-1.5684	-1.9408	-
0.15→0.20	-	-0.7143	-0.9608	-1.2293	-1.5347	-1.8966	-
0.20→0.25	-	-0.7021	-0.9427	-1.2046	-1.5021	-1.8539	-
0.25→0.30	-	-0.6901	-0.9251	-1.1806	-1.4704	-1.8125	-
0.30→0.35	-	-0.6785	-0.9080	-1.1573	-1.4397	-1.7724	-
0.35→0.40	-	-0.6671	-0.8914	-1.1347	-1.4099	-1.7335	-

Note: Unless otherwise indicated, $R = 3.5\%$, $R_D = 2.5\%$, $R_M = 4.0\%$, $R_P = 3.0\%$, $M = 30$, $K = 16$, $q = 8.0\%$, $\mu_L = \mu_M = 0.3$, $\sigma_L = \sigma_M = 0.3$, and $\beta = 0.2$. Shaded areas represent the corresponding values with an approximate optimal loan rate of 4.6%.

WMPs, and whether the expected risk of loans is relatively higher than the expected risk of WMPs. Together they lead to the following five scenarios: a benchmark call where $\mu_L = \mu_M = 0.3$ and $\sigma_L = \sigma_M = 0.3$; a low return case of wealth management products where $\mu_L = 0.3$, $\mu_M = 0.1$, and $\sigma_L = \sigma_M = 0.3$; a high return case of wealth management products where $\mu_L = 0.3$, $\mu_M = 0.5$, and $\sigma_L = \sigma_M = 0.3$; a high risk case of wealth management products where $\mu_L = \mu_M = 0.3$, $\sigma_L = 0.3$, and $\sigma_M = 0.5$; a low risk case of wealth management products where $\mu_L = \mu_M = 0.3$, $\sigma_L = 0.3$, and $\sigma_M = 0.1$. These five cases will be compared in the following analysis.

Table 3: Responsiveness of bank interest margin to α at various levels of instantaneous drifts and variances.

α	(i)	(ii)	(iii)	(iv)	(v)
	$\partial R_L/\partial\alpha(\%)$				
0.10→0.15	-0.7147	-0.7559	-0.7269	-1.0923	-0.3744
0.15→0.20	-0.7101	-0.7417	-0.7143	-1.0698	-0.3764
0.20→0.25	-0.7054	-0.7278	-0.7021	-1.0479	-0.3783
0.25→0.30	-0.7007	-0.7144	-0.6901	-1.0266	-0.3801
0.30→0.35	-0.6960	-0.7013	-0.6785	-1.0059	-0.3818
0.35→0.40	-0.6912	-0.6886	-0.6671	-0.9858	-0.3834

Notes: Unless otherwise indicated, $R = 3.5\%$, $R_D = 2.5\%$, $R_M = 4.0\%$, $R_P = 3.0\%$, $M = 30$, $K = 16$, $q = 8.0\%$, and $\beta = 0.2$. The computed results of $\partial^2 E/\partial R_L^2$ at various levels of α, μ_L, μ_M, σ_L, and σ_M are consistently negative, which confirm the required second-order condition of Eq. (4.1). Benchmark $\equiv$ case (iii) where $\mu_L = \mu_M = 0.3$, and $\sigma_L = \sigma_M = 0.3$. Low return of shadow banking investment $\equiv$ case (i) where $\mu_L = 0.3$, $\mu_M = 0.1$, and $\sigma_L = \sigma_M = 0.3$. High return of shadow banking investment $\equiv$ case (ii) where $\mu_L = 0.3$, $\mu_M = 0.5$ and $\sigma_L = \sigma_M = 0.3$. High risk of shadow banking investment $\equiv$ case (iv) where $\mu_L = \mu_M = 0.3$, $\sigma_L = 0.3$, and $\sigma_M = 0.5$. Low risk of shadow banking investment $\equiv$ case (v) where $\mu_L = \mu_M = 0.3$, $\sigma_L = 0.3$, and $\sigma_M = 0.1$.

Table 3 presents comparative static results of the impacts on bank interest margin from changes in the WMPs at various levels of instantaneous drifts and variances when ranges between 0.10 and 0.40. We find that an increase in the WMPs consistently decreases the optimal bank interest margin in the alternative five cases, yielding negative consequences on banking stability. Further the negative effect of WMPs on bank interest margin is reinforced when the expected return or risk from the WMPs is high, yielding much more significant negative consequences on banking stability. Our results demonstrate the spill-over effect between the regular banking and the shadow banking. Although the bank is not regretful for getting involved in shadow banking business, the regular banking lending activities are exposed to risks in the shadow banking. As a result, strengthening regulation of WMPs is recommended. Our result is implicitly supported by Plantin [22]: the higher solvency of the regular banking may be more than offset by the growth in shadow banking. Accordingly, we establish the following proposition.

Proposition 2. *The negative effect of WMPs on bank interest margin is more significant when the expected return on risk of the products is high than when that is low.*

Table 4: Responsiveness of bank interest margin to q.

$q\%$ \ $(R_L\%, L)$	(4.5, 200)	(4.6, 199)	(4.7, 197)	(4.8, 194)	(4.9, 190)	(5.0, 185)	(5.1, 179)
	$U(M>0)$						
8.0	32.6159	32.6603	32.6013	32.4374	32.1674	31.7905	31.3061
8.2	32.5846	32.6290	32.5698	32.4057	32.1355	31.7583	31.2736
8.4	32.5548	32.5991	32.5398	32.3755	32.1051	31.7276	31.2426
8.6	32.5264	32.5706	32.5112	32.3467	32.0761	31.6984	31.2131
8.8	32.4994	32.5434	32.4839	32.3193	32.0485	31.6705	31.1850
9.0	32.4735	32.5175	32.4578	32.2931	32.0221	31.6439	31.1581
	$U(M=0)$						
8.0	32.2259	32.2707	32.2121	32.0488	31.7795	31.4035	30.9204
8.2	32.1946	32.2393	32.1805	32.0170	31.7475	31.3713	30.8878
8.4	32.1647	32.2093	32.1505	31.9867	31.7170	31.3405	30.8567
8.6	32.1363	32.1808	32.1218	31.9579	31.6880	31.3113	30.8272
8.8	32.1092	32.1536	32.0945	31.9304	31.6603	31.2833	30.7990
9.0	32.0833	32.1276	32.0684	31.9042	31.6339	31.2567	30.7720
	E						
8.0	32.6938	32.7383	32.6792	32.5151	32.2450	31.8678	31.3832
8.2	32.6626	32.7069	32.6476	32.4834	32.2130	31.8357	31.3507
8.4	32.6328	32.6770	32.6176	32.4532	32.1827	31.8050	31.3198
8.6	32.6044	32.6486	32.5890	32.4245	32.1537	31.7758	31.2903
8.8	32.5774	32.6214	32.5618	32.3971	32.1261	31.7480	31.2622
9.0	32.5515	32.5955	32.5357	32.3709	32.0997	31.7214	31.2353
	$\partial R_L/\partial q(\%)$						
8.0→8.2	-	-5.0855	-6.7442	-8.4666	-10.3235	-12.4024	-
8.2→8.4	-	-4.8393	-6.4146	-8.0503	-9.8137	-11.7876	-
8.4→8.6	-	-4.6105	-6.1085	-7.6640	-9.3406	-11.2174	-
8.6→8.8	-	-4.3976	-5.8238	-7.3047	-8.9010	-10.6876	-
8.8→9.0	-	-4.1991	-5.5586	-6.9702	-8.4916	-10.1943	-

Note: As Table 2, except that $\alpha = 0.10$, and $8.0\% \leq q \leq 9.0\%$. The computed results of $\partial^2 E/\partial R_L^2$ at various levels of q are consistently negative, which confirm the required second-order condition of Eq. (4.1).

Based on the computed results observed from the first three panels of Table 4, we conclude that, from a viewpoint of bank equity return, it is not regretful for the bank to additionally conduct the WMPs. The computed result observed from the last panel indicates that an increase in the capital-to-deposits ratio decreases the bank interest margin. Basically, increases in the capital-to-deposits ratio encourage the bank to shift investments to its loan portfolio from other earning assets such as Federal funds (liquid assets). In an imperfect loan market, the bank must reduce the size of its margin in order to increase the amount of loans. As mentioned previously, banks have experienced a gradual decline in interest margins (see Arnold and Ewijk [2]). In explanation of deteriorating bank interest margins, this paper shows a strong focus on capital regulation conditions. Accordingly, we have the following proposition.

Proposition 3. *An increase in the capital-to-deposits rate will decrease the optimal bank interest margin.*

Table 5: Responsiveness of bank interest margin to q at various levels of instantaneous drifts and variances.

$q\%$	(i)	(ii)	(iii)	(iv)	(v)
	$\partial R_L/\partial q(\%)$				
8.0→8.2	-5.1122	-5.0587	-5.0855	-5.0428	-5.1281
8.2→8.4	-4.8647	-4.8138	-4.8393	-4.7986	-4.8798
8.4→8.6	-4.6347	-4.5862	-4.6105	-4.5718	-4.6491
8.6→8.8	-4.4206	-4.3744	-4.3976	-4.3606	-4.4344
8.8→9.0	-4.2210	-4.1770	-4.1991	-4.1637	-4.2343

Note: As Table 2, except that $\alpha = 0.10$, and $8.0\% \leq q \leq 9.0\%$.

It is of interest to discuss the effects of capital regulation on the optimal bank interest margin of the previous specified five scenarios. The results are summarized in Table 5. First, we show that an increase in the capital-to-deposits ratio consistently decreases the optimal bank interest margin, increasing bank risk-taking substantially. In addition, the results also document that the negative effect of capital regulation on the optimal bank interest margin is deducted when the expected return (case (ii)) or the expected risk (case (iv)) of the WMPs is relatively high, yield less significant negative consequences on banking stability. An explanation of low bank interest margins, this paper shows a strong focus on shadow banking activity conditions. To summarize, we establish the following proposition.

Proposition 4. *The negative effect of the capital requirements on the optimal bank interest margin is reduced when the expected return or the expected risk of the WMPs is relatively high.*

There are two locally optimal regulatory responses to such regulatory arbitrage. First, the regulator can tighten capital requirements, triggering an insignificant increase in the regular banking loan activity at a reduced margin when the expected risk of the WMPs involved by the bank is high, thereby adversely affecting the banking stability insignificantly. Second, the regulator may also prefer to relax regulatory capital requirements so as to significantly bring the regular banking loan activity back in the spotlight of regulation when the expected risk of the WMPs is low (case (v)), thereby significantly affecting the banking stability. Current regulatory reforms seem to trend towards the former solution. The later one may yet be preferable, particularly so if the shadow banking active activity does not lead to an overall high risk on the money-like liabilities of banks.

5. Conclusion

This paper examines the effects of WMPs and capital regulation on the optimal bank interest margin. Our main contribution is to propose a regret-theoretic contingent claim approach to corporate security valuation view equity as a call option on the assets of the bank when regret is explicitly relevant to incremental wealth management product investment choices. Several results are derived that should be of interest to investors, analysts, and policy makers. For example, from a viewpoint of bank equity performance, it may not be regretful for the bank to conduct WMPs. However, shadow banking activities and capital regulation may lead to decrease the optimal bank interest margin, yielding the negative consequences on banking stability. In conclusion, it is shown that the regret-theoretic call model is intimately relevant to shadow banking and bank capital regulation. The framework presented here should open at least two further avenues of research. First, a weakness of the regret-theoretic call option approach developed in the paper is that we are silent on introducing the risk of a premature default (barrier option structure) to the valuation of the bank's equity. Banks involved in shadow banking activities, especially under severe regulation, are likely to exhibit a higher probability of hitting the barrier before the maturity date than banks without such characteristics. Further research will involve an extension of our model to include the premature default structure to value the equity of a regulated bank. Second, according to relevant literature and research results of this paper, it is obvious that the relationship between bank interest margin and shadow banking activities are likely to depend on the level of the regret aversion. The issues of how bank shadow banking activities are optimally determined under regret-averse preference, and how the impact of shadow banking activities on bank interest margin varies with the level of regret aversion, deserve closer scrutiny.

Acknowledgements

We would like to thank Prof. Ruey-Chyn Tsaur (Managing Editor) and two anonymous referees for their helpful comments and suggestions. The usual disclaimer applies. This paper was supported by National Natural Science Foundation of China (No. 71503205) and Fundamental Research Funds for the Central Universities (JBK1902036, JBK1805006).

References

[1] Albertazzi, U. and Gambacorta, L. (2009). *Bank profitability and the business cycle*, Journal of Financial Stability, Vol.5, 393-409.

[2] Arnold, I. J. M. and Ewijk, S. E. V. (2012). *The quest for growth: The impact of bank strategy on interest margins*, International Review of Financial Analysis, Vol.25, 18-27.

[3] Berger, A. N., Demirgüç-Kunt, A., Levine, R. and Haubrich, J. G. (2004). *Introduction: Bank concentration and competition: An evolution in the making*, Journal of Money, Credit, and Banking, Vol.36, 433-451.

[4] Braun, M. and Muermann, A. (2004). *The impact of regret on the demand for insurance*, Journal of Risk and Insurance, Vol.71, 737-767.

[5] Copeland, A. (2012). *Evolution and heterogeneity among larger bank holding companies: 1994 to 2010, Federal Reserve Bank of New York*, Economic Policy Review, Vol.18, 83-93.

[6] De Guevara, J. F., Maudos, J. and Prez, F. (2005). *Market power in European banking sectors*, Journal of Financial Services Research, Vol.27, 109-137.

[7] Elliott, D., Kroeber, A. and Yu, Q. (2015). *Shadow banking in China: A primer*, Economic Studies at Brookings, April, available at: http://www.brookings.edu/research/papers/2015/04/01-shadow-banking-china-primer-elliott-kroeber-yu

[8] Gennaioli, N., Shleifer, A. and Vishny, R. (2013). *A model of shadow banking*, Journal of Finance, Vol.68, 1331-1363.

[9] Ghosh, S., del Mazo, I. G. and Ötker-Robe, İ. (2012). *Chasing the shadows: How significant is shadow banking in emerging markets?* Economic Review, World Bank Note Series 88, 1-7.

[10] Harris, M., Opp, C. C. and Opp, M. M. (2014). *Higher capital requirements, safer banks? Macro-prudential regulation in a competitive financial system*, University of California, Berkeley (Haas), March, available at SSRN: http://ssrn.com/abstract=2181436.

[11] Hermalin, B. E. (2005). *Trends in corporate governance*, Journal of Finance, Vol.60, 2351-2384.

[12] Jeffers, E. and Baicu, C. (2013). *The interconnections between the shadow banking system and the regular banking system: Evidence from the Euro area*, CITYPERC Working Paper Series, No. 2013/07.

[13] Jiang, W. (2015). *The future of shadow banking in China*, Columbia Business School, White Paper, 1-12.

[14] Kasman, A., Tunc, G., Vardar, G. and Okan, B. (2010). *Consolidation and commercial bank net interest margins: Evidence from the old and new European Union members and candidate countries*, Economic Modelling, Vol.27, 648-655.

[15] Lepetit, L., Nys, E., Rous, P. and Tarazi, A. (2008). *The expansion of services in European banking: Implications for loan pricing and interest margins*, Journal of Banking & Finance, Vol.32, 2325-2335.

[16] Li, X. and Lin, J. H. (2016). *Shadow-banking entrusted loan management, deposit insurance premium, and capital regulation*, International Review of Economics & Finance, Vol.41, 98-109.

[17] Lin, J. H., Chen, S. and Huang, F. W. (2018). *Bank interest margin, multiple shadow banking activities, and capital regulation*, International Journal of Financial Studies, Vol.6, 63-82.

[18] Lu, Y. L., Guo, H. F., Kao, E. H. and Fung, H. G. (2015). *Shadow banking and firm financing in China*, International Review of Economics & Finance, Vol.36, 40-53.

[19] Merton, R. C. (1973). *Theory of rational option pricing*, Bell Journal of Economics and Management, Vol.4, 141-183.

[20] Merton, R. C. (1974). *On the pricing of corporate debt: The risk structure of interest rates*, Journal of Finance, Vol.29, 449-470.

[21] Ordonez, G. (2013). *Sustainable shadow banking*, NBER Working Paper No. 19022.

[22] Plantin, G. (2015). *Shadow banking and bank capital regulation*, Review of Financial Studies, Vol.1, 146-175.

[23] Quiggin, J. (1994). *Regret theory with general choice sets*, Journal of Risk and Uncertainty, Vol.8, 153-165.

[24] Rahman, M. M., Ashraf, B. N., Zheng, C. and Begum, M. (2017). *Impact of cost efficiency on bank capital and the cost of financial intermediation: Evidence from BRICS countries*, International Journal of Financial Studies, Vol.5, 32-49.

[25] Saunders, A. and Schumacher, L. (2000). *The determinants of bank interest rate margins: An international study*, Journal of International Money and Finance, Vol.19, 813-832.

[26] Starmer, C. and Sugden, R. (1993). *Testing for juxtaposition and event-splitting effects*, Journal of Risk and Uncertainty, Vol.6, 235-254.

[27] Tsai, J. Y. (2012). *Risk and regret aversions on optimal bank interest margin under capital regulation*, Economic Modelling, Vol.29, 2190-2197.

[28] VanHoose, D. (2007). *Theories of bank behavior under capital regulation*, Journal of Banking & Finance, Vol.31, 3680-3697.

[29] Vassalou, M. and Xing, Y. (2004). *Default risk in equity returns*, Journal of Finance, Vol.59, 831-868.

[30] Wong, K. P. (1997). *On the determinants of bank interest margins under credit and interest rate risks*, Journal of Banking & Finance, Vol.21, 251-271.

[31] Wong, K. P. (2011). *Regret theory and the banking firm: The optimal bank interest margin*, Economic Modelling, Vol.28, 2483-2487.

[32] Zarruk, E. R. and Madura, J. (1992). *Optimal bank interest margin under capital regulation and deposit insurance*, Journal of Financial and Quantitative Analysis, Vol.27, 143-149

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(Received September 2017; accepted March 2019)