The Effects of Sunshine-Induced Mood on Bank Lending Decisions and Default Risk: An Option-Pricing Model

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Abstract: Even though psychological evidence and casual intuition predict that weather may lead to changes in equity returns, little attention has been paid to these changes through asset pricing mechanisms. This paper fills this gap by examining the effects of sunny weather enhanced upbeat mood on bank spread management and default risk. An option-based model of bank spread behavior is developed to study these closely related phenomena. The model is designed to indicate the fat tails of loan repayments caused by mood effects induced by good weather. With the good mood influences on bank lending, this paper shows that sunshine is negatively correlated with the default risk in equity returns.

Key-Words: Default Risk, Sunny Weather, Upbeat Mood, Fat Tails.

I Introduction

It is argued that mood fluctuations induced by variations in the weather, partially influence equity returns. Numerous studies focus on the misattribution of weather-induced mood in influencing equity returns. Examples include Saunders (1993), Hirshleifer and Shumway (2003), and Dowling and Lucey (2008). However, little is known about weather-induced pricing. If equity returns are driven by decision makers' actions based on weather-induced mood rather than on reason, it suggests two things about the price formation process: first, that mood affects individual investment decisions, and second, and more importantly, mood affects the actions of the marginal decision maker, i.e. the decision maker setting prices (Goetzmann and Zhu, 2002). Such pricing behavior is known as the "weather-induced managerial discretion". What are the effects of such behavior on lending decisions that are made in banks?

The answer to this question is largely depended on an understanding of mood-influencing characteristics of bank intermediaries. The perspective of how bank managers make decisions involving conditions assumes what Leoewenstein, Weber, Hsee and Welch (2001) describe as a consequentialist perspective. This perspective can be seen in the finance theories of the Markowitz portfolio theory (Markowitz, 1952). The principal advantage of this traditional approach is the explicit treatment of uncertainty which has long played a prominent role in discussions of intermediary behavior. This approach, however, omits two key aspects of mood and behavior of bank intermediaries: first, the approach does not consider sunshine-induced mood fluctuations, which can capture the fat tails of asset returns; second, the approach assumes that asset markets are perfectly competitive so that quantity setting is the relevant behavioral mode in the markets. This assumption is not applicable to loan markets since such markets are highly concentrated where banks set loan rates and face random loan levels in the banking deregulation environment (Kole and Lehn, 1997).

Integrating bank lending mode with psychological evidence suggests that weather-induced mood is a behavior since sunlight influences mood, and is also a lending decision process since mood affects lending decision making. The purpose of this paper is to develop an option-based model of bank behavior that integrates the weather-induced managerial discretion of the portfolio-theoretic approach with the bank lending considerations of the firm-theoretic approach. The results of this paper show how weather and risk conditions jointly affect the optimal loan rate, and the resulting default risk in equity returns. It proves that a positive weather-induced mood in the loan-repayment expectation and volatility, expressed by the loan repayments distributing fatter tails, results in a lower

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default risk in the bank's equity return.

The remainder of this paper is organized as follows: Section II introduces the basic model, Section III describes the solution of this model; Section VI develops the comparative static properties of the model and Section V presents the conclusions.

II The Basic Model

In a banking firm, which makes decisions in a single-period horizon, at the start of the period, the bank accepts D dollars of deposits and provides depositors with a rate of return equal to the market rate, R_D. The bank's equity capital, K, is assumed to be fixed over the planning horizon and tied by regulations to be a fixed proportion q of its 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 the beginning of the period, $\partial q / \partial L > 0$.

When the capital constraint is binding, the bank's balance sheet constraint at the beginning of the period is given by

$$L + B = K + D = K(1 + \frac{1}{q}) \qquad (1)$$

where B is a composite variable denoting the bank's net position in the liquid asset market. The bank lends or borrows in the market at a known rate R.

The bank makes term loans L at the start of the period, which mature and are paid off at the end of the period. The loan market faced by the bank is imperfectly competitive in the sense that the bank is a loan-rate setter which has some market power in lending (Hancock (1986)). Loan demand is a downward-sloping function of the loan rate, $L(R_L)$, that is $\partial L / \partial R_L < 0$. We further argue that the loan rate determination may be difficult to reconcile with complete rationality since human judgment and behavior are subject to biases. In particular, compared to the judgments of decision makers in a neutral mood, decision makers in a good mood, due to good weather are, arguably, able to make more optimistic judgments about assets (Dowling and Lucey, 2003). Sunshine-induced mood changes may be expected to influence the fat tails of asset returns. Specifically, distributions of asset returns have flatter tails and higher centers due to sunshine-induced moods when compared to a normal distribution, meaning that more of the outcomes are located in the tails rather than toward the center of the distribution.[1]

The initial lending funds are invested in risky lending assets and default-free liquid assets maturing at the end of the period. At any time during the period horizon, the value of the bank's risky assets is:

[1] Fat tails are of course influenced by the customer acceptance (see Asosheha, Bagherpour, and Yahyapour, 2008). For simplicity, this particular case is ignored.

$$V(R_L)\begin{cases} = (1+R_L)L(R_L) = V^0, \text{if no loan losses} \\ < V^0 \qquad\qquad\qquad\quad , \text{if loan losses} \end{cases} \tag{2}$$

Given the constraint in equation (1), the value of the bank's earning-asset portfolio is:[2]

$$A = V(R_L) + (1+R)[K(1+\frac{1}{q}) - L(R_L)] \tag{3}$$

The value of the bank's equity return at the end of the period is the residual value of the bank after meeting all of the obligations, $S = \max\{0, A-Z\}$, where $Z = (1+R_D)K/q$. The bank's total costs Z in this model are considered as only the deposit payment costs.

The bank's objective is to set R_L to maximize the equity return, S. The selection of this model's objective function is based on Mullins and Pyle (1994). We specify the bank's objective function that the equity return is viewed as a call option on its loan repayments. The strike price of the call option is the book value of the bank's liabilities net of default-free liquid assets. When the value of the bank's loan repayments is less than the strike price, the value of equity is equal to zero.

With this approach, the effect of sunshine-induced mood changes is further divided into two parts: 1) its effect on the mean of loan repayments; 2) how it affects loan-repayment volatilities. The dynamic processes of loan repayments V and the book value of the net obligations M follow as below, respectively:

$$dV = (\mu+\alpha)Vdt + (\sigma+\beta)VdW \tag{4}$$

$$dM = \delta M dt \tag{5}$$

where

$\delta = R - R_D$,

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

μ and σ are the instantaneous drift and volatility of loan repayments, respectively.
α and β are the constant differences between with and without sunshine-induced mood changes in the mean and volatility of loan repayments, respectively.[3]
W is a standard Wiener process.
δ is the spread, which is the difference between the liquid fund market rate and the promised market deposit rate to initial depositors.

Let sunshine-induced mood changes exist in the mean and volatility of loan repayments as: $\alpha \neq 0$ and $\beta \neq 0$. This model can tractably disclose the impact of

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[2] Results to be derived from our model do not extend to the case where bond is not Treasury bond, but high-yield bond (Lee and Cheng, 2008).

[3] α and β can be treated as structural equation modeling (see Shih, Lin, Hsiao, Huang, Chiu, and Chen, 2009). Adding this complexity affects none of the qualitative results.

the mood on contingent claim pricing. Specifically, the market value of the bank's equity S is expressed by the Black and Scholes' (1973) formula for call options:

$$S = VN(d_1) - Me^{-\delta} N(d_2) \qquad (6)$$

where

$$d_1 = \frac{1}{\sigma+\beta}[\ln\frac{V}{M} + \delta + \frac{1}{2}(\sigma+\beta)^2]$$

$$d_2 = d_1 - (\sigma+\beta)$$

$N(\cdot)$ is the cumulative density function of the standard normal distribution.

Because loan rate-setting affects profitability, the bank's equity return and its default risk in the equity return should be related. Given equation (6), we follow Vassalou and Xing (2004) and define the probability of default or default risk in the bank's equity return as:

$$P_{def} = N(-d_3) \qquad (7)$$

where

$$d_3 = \frac{1}{\sigma+\beta}[\ln\frac{V}{M} + (\mu+\alpha) - \frac{1}{2}(\sigma+\beta)^2]$$

In equation (7), $\mu+\alpha$ is defined as the mean of the change associated with weather-induced mood in $\ln V$. d_3 demonstrates how many standard deviations the log of this ratio needs to deviate from its mean in order for default to occur. It is noted that although the value of the call option in equation (6) does not depend on $\mu+\alpha$, equation (7) does. This is because d_3 depends on the future value of loan repayments, which is given in d_1.

III Equilibrium

In the partially differentiating equation (6) with respect to R_L, the first-order condition is given by:

$$\frac{\partial V}{\partial R_L} N(d_1) - \frac{\partial M}{\partial R_L} e^{-\delta} N(d_2) = 0 \qquad (8)$$

where

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

$$\frac{\partial M}{\partial R_L} = [\frac{(R-R_D)}{q^2}\frac{\partial q}{\partial L} + (1+R)]\frac{\partial L}{\partial R_L} < 0$$

It is noted that there are two additional terms in equation (8), $V(\partial N/\partial d_1)(\partial d_1/\partial R_L)$ and $Me^{-\delta}(\partial N/\partial d_2)(\partial d_2/\partial R_L)$. Since these two terms are equal, the result of equation (8) is obtained. A sufficient condition for an optimum is: $\partial^2 S/\partial {R_L}^2 < 0$.

The term associated with $N(d_1)$ in equation (8) represents the bank's risk-adjusted value for marginal risky-asset repayment of loan rate. Since the bank operates on the elastic portion of its loan demand curve, just as a monopolistic firm does, the value of the loan repayment decreases when the bank increases its loan rate. The term associated with $N(d_1)$ represents the marginal risk-adjusted net obligation of its loan rate. Equation (8) describes the equilibrium loan rate set by the bank where its risk-adjusted present value of marginal risk-asset repayment equals that value of marginal net obligation. The equilibrium condition demonstrates that the bank maximizes the market value of its equity return anticipating resolution in the loan rate determination. We further substitute in the optimal loan rate to obtain the default risk of the bank's equity return in equation (7) staying on the equity maximization.

VI Comparative Static Results

Having examined the solution to the bank's optimization problem, this section will discuss the effects on the default risk in the bank's equity return from sunshine-induced mood changes in the mean and volatility of the loan repayments. Relatively speaking, $\Delta\alpha > 0$ and $\Delta\beta > 0$ represent the positive mood effects of good weather in the loan-repayment mean and volatility, respectively. Differentiation of equation (7) evaluated at the optimal loan rate R_L^* with respect to α and β yields:

$$\frac{dP_{def}}{d\alpha} = \frac{\partial P_{def}}{\partial \alpha} + \frac{\partial P_{def}}{\partial R_L}\frac{\partial R_L}{\partial \alpha} \tag{9}$$

$$\frac{dP_{def}}{d\beta} = \frac{\partial P_{def}}{\partial \beta} + \frac{\partial P_{def}}{\partial R_L}\frac{\partial R_L}{\partial \beta} \tag{10}$$

where

$$\frac{\partial P_{def}}{\partial \alpha} = -\frac{\partial N}{\partial d_3}\frac{1}{\sigma+\beta} < 0$$

$$\frac{\partial P_{def}}{\partial R_L} = \frac{1}{\sigma+\beta}\left(\frac{1}{V}\frac{\partial V}{\partial R_L} - \frac{1}{M}\frac{\partial M}{\partial R_L}\right)$$

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

$$\frac{\partial P_{def}}{\partial \beta} = -\frac{1}{(\sigma+\beta)^2}\left[\ln\frac{V}{M} + (\mu+\alpha) + \frac{1}{2}(\sigma+\beta)^2\right] < 0$$

$$\frac{\partial R_L}{\partial \beta} = -\frac{\partial^2 S}{\partial R_L \partial \beta} \Big/ \frac{\partial^2 S}{\partial R_L^2}$$

$$\frac{\partial^2 S}{\partial R_L \partial \beta} = \frac{\partial V}{\partial R_L}\left(\frac{\partial N}{\partial d_1} - \frac{N(d_1)}{N(d_2)}\frac{\partial N}{\partial d_2}\right)\frac{\partial d_1}{\partial \beta} + \frac{\partial V}{\partial R_L}\frac{N(d_1)}{N(d_2)}\frac{\partial N}{\partial d_2}$$

The results of equations (9) and (10) are stated in the following propositions.

Proposition 1: The positive mood effect of good weather in the loan-repayment expectation is negatively related to the lower default risk in the bank's equity return.

The first term on the right-hand side of equation (9) can be explained as the direct effect, which demonstrates the change in P_{def} due to $\Delta\alpha > 0$, holding R_L^* constant. This direct effect is negative since the positive mood effect of good weather makes the expectation of loan repayments to be higher, resulting in the lower default risk in the bank's call option equity value. The second term can be explained as the indirect effect, which represents the optimal loan rate effect on P_{def} from $\Delta\alpha > 0$. The sign of this term is determined by how $\Delta\alpha > 0$ affects R_L^*, as well as by the relationship between P_{def} and R_L^*. As mentioned earlier, the value of the call option in equation (6) evaluated at R_L^* does not depend on α so that the indirect effect vanishes since $\partial R_L / \partial\alpha = 0$. Thus, the change in P_{def} due to $\Delta\alpha > 0$ is explained by the negative direct effect only.

Proposition 2: With strategic complements, the positive mood effect of good weather in the loan-repayment volatility is negatively related to the lower default risk in the bank's equity return.

The first term on the right-hand side of equation (9) can be interpreted as the direct effect, while the second term can be interpreted as the indirect effect. The direct effect captures the change in P_{def} due to $\Delta\beta > 0$, holding R_L^* constant. This negative direct effect stands for the positive mood effect of good weather which can reduce the default risk in the bank's call option equity value.

In addition, the sign of the indirect effect is determined by how $\Delta\beta > 0$ affects R_L^*, as well as by the relationship between P_{def} and R_L^*. First, the sign of the term $(1/V)(\partial V / \partial R_L) - (1/M)(\partial M / \partial R_L)$ is the same as the term: $(R_L / V)(\partial V / \partial R_L) - (R_L / M)(\partial M / \partial R_L)$, which can be explained as the loan rate elasticity effect. This elasticity effect represents the difference between the loan rate elasticity of loan repayments and the loan rate elasticity of net obligations. Based on general assumptions, changes in the loan rate have a more significant impact on the loan repayments than on the net obligations, since banks frequently encounter situations in which loan rate decisions are made in the presence of fixed deposits. This behavioral mode has been modeled by Hyman (1972). Thus, the loan rate elasticity effect is negative and then $\partial P_{def} / \partial R_L < 0$. Second, the sign of $\partial R_L / \partial\beta$ depends on $\partial^2 S / \partial R_L \partial\beta$. The concept of Bulow, Geanakoplos, and Klemperer (1985) is used to define the term as strategic substitutes or complements to $\Delta\beta$. The bank regards its marginal equity return of loan rate as a strategic substitute (complement) to the positive mood effect of good weather in the loan-repayment volatility when $\partial^2 S / \partial R_L \partial\beta$ is negative (positive). As a result, the indirect effect is negative with strategic complements since $\partial P_{def} / \partial R_L < 0$ and $\partial R_L / \partial\beta > 0$.

As the indirect effect reinforces the direct effect, the total positive mood effect of good weather in the loan-repayment volatility on the default risk in the bank's equity return is negative. This is because sunshine is one of the most significant weather-based influences on mood and behavior. In particular, as sunshine increases, general good mood increases. With regard to such behavior in our model, an increase in good mood decreases the bank's lending amount at an increased loan rate (interest margin) and hence decreases the default risk in the bank's equity value.

While it is convincing that mood plays a role in the individual decision-making process, it is striking, in light of the efficient market theory that valuation by rational decision makers does not compensate for the irrationality of others. In particular, if the bank manager is the one whose outlook for the loan market depends on the weather, then the market in the "return to retail" environment is plainly not efficient and other factors prevent the profitable exploitation of irrational behavior.[4]

V Conclusion

This paper proposes a microeconomic model of a banking firm, and focuses on lending determination when sunshine induces upbeat moods. The results suggest that when a bank manager has positive moods, more upbeat-mood optimistic lending results in lower default risk in equity returns. One implication of this result is to understand the dual upbeat moods of lending determinants proposed as alternatives for lending decisions. It is suggested that more or over-optimistic lending may cause lower risks. This paper provides one explanation why this should be expected.

However, the amount of expected sunshine occurring today may be not highly correlated with the amount that will prevail for one week or for one month from today. Is it the case that the results of this paper also apply to the unexpected sunshine case? In a very simple, uniform way regarding sunny weather and its resultant upbeat mood, the answer is expected to be yes. Specifically, if the amount of sunshine having occurred one week or one month from today is averagely uniform, the optimal loan rate set here is a loan rate that exists in a uniform way. In such way, the optimal loan rate influenced by sunny weather associated with upbeat mood remains the same each day. Of course, in a world without such a uniform way, other factors would affect the optimal loan rate determination. For example, preference may play a very important role, as would more extreme problem of information asymmetries. Such concerns are beyond the scope of this paper and so are not addressed here. This paper has demonstrated the important role played by sunshine in affecting the optimal loan rate determination, and hence bank risks.

[4] This "return to retail" contrasts with the 1990s, when banks sought to diversify revenues, deemphasize branch networks, and target financial services to a broader range of customers (Clark, Dick, Hirtle, Strioh, and Williams, 2007).

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