A Study on Bank Risk-Taking Behaviors under the Capital Regulation and Constraints of Bank Asset Allocation Strategies

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***Abstract*— It is controversial that whether capital regulation can really reduce the risk of banks. This paper studied the assets allocation behaviors of banks under supervision and explores the effectiveness of capital regulation based on bank asset allocation strategies. We built a linear programming model to find a certain bank's asset allocation strategies under regulation. Then we established relationship between bank's profit and risk to study bank's risk taking behavior. We found that profit and risk are not exactly positively related and that banks need to make strategies based on its goal—maximum profit or minimum risk. The innovation of this paper lies in asset allocation strategies and linear programming solution.**

Keywords-capital regulation; asset allocation; commercial bank

I. INTRODUCTION

The minimum capital requirements established by the new "Basel Agreement", market disciplines and government supervision have become three pillars for banking supervision. The minimum capital requirements require commercial banks to meet the standard of minimum capital adequacy ratio with the aim of restraining the overexpansion of bank risk assets, so as to ensure that the bank can undertake asset losses of depositors and other creditors with its own capital and avoid bank run crisis and even bankruptcy.

The traditional theory believes that implementing the supervision of capital adequacy ratio can enhance banks' ability to resist risks, however, after increasing the requirements of capital regulation, in order to make up the extra cost of capital for increasing capital adequacy ratio, commercial banks will change a part of the assets from low risk to high risk, this may make them face a greater risk of bankruptcy. Keeley and Furlong (1990) [1] pointed out that higher capital requirements will reduce the value of deposit insurance option and reduce the risk of assets portfolio for banks. However, capital regulation is also likely to increase the risk of bank assets and cause low efficiency in capital regulation. Gennotte and Pyle (1991) [2], and Rochet (1992) [3] believed that the financial leverage ratio and the risk of banks will replace by each other, when the leverage ratio is forced to be lower, they will choose to increase asset risk. Li Ying (2011) argued that when there is an asset substitution effect, the increase in capital will lead to an increased risk of asset allocation. Song Qin and Zheng Zhenlong (2010) found that the supervision of bank capital adequacy ratio is effective when the market concentration is low, but when the market concentration is high, its effect is undetermined. Therefore, whether the capital regulation and constraint can inhibit the risk-taking behaviors of commercial banks, so as to improve the stability of the banking industry, is worth deep studying. In the perspective of bank asset allocation strategies, constructing a linear programming model and studying the risk of bank asset allocation under capital regulation will contribute to the understanding of the function mechanism of capital regulation on risk-taking behaviors of banks; it has the important theoretical significance.

II. THE OBJECTIVE FUNCTION OF BANKS' ASSETS ALLOCATION UNDER CAPITAL REGULATION AND CONSTRAINTS

Capital adequacy ratio (CAR,), also called as asset ratio of capital risk, is used to measure the ratio of a bank's capital to its weighted risk. The formula is expressed as the percentage of the sum of core capital and subsidiary capital to risk-weighted assets. "Basel Agreement III requires CAR >8%", greatly increases the percentage of the core capital and requires the ratio of the core capital to risk-weighted assets ratio>4.5%.

Assuming the total assets of a listed bank is V, banks hold three of assets, which are X_1, X_2, X_3, X1 is risk-free asset, and the risk of X3 is higher than that of X2. The proportion of X1 in total assets is α, then The proportion of X2 in total assets is $(1-\alpha)*\alpha_2$, and that of X3 is $(1-\alpha)*\alpha_3$, the proportion of deposits in total assets is β deposits D= βV, equity capital is C, the profit of total assets is R, the bank's risk is ε .Take a brief look at the following principles, steps and purposes.

There is $X_1 + X_2 + X_3 = D + C = V$ .Using R_1, R_2, R_3 respectively to represent the yield rate of three assets, and $R_1 < R_2 < R_3$.

According to the theory of CAPM, we can get the following formulas after describing the connotation of this theory:

$$R_2 = R_1 + \theta\varepsilon_2 \quad (1)$$

$$R_3 = R_1 + \theta\varepsilon_3 \quad (2)$$

θ is a constant, ε_i is an indicator reflecting the risk, $\theta\varepsilon_i$ represents the risk premium, and the cost of deposit capital is R_D.

Assuming the goal of risk-neutral banks is profit maximization, that is to say, the decision-making goal of banks is

$$\max\{R_1X_1 + R_2X_X + R_3X_3 - R_DD\} \quad (3)$$

Putting (1) and (2) into (3), the decision-making goal of banks can be written as:

$$\max\{\theta(\varepsilon_2 x_2 + \varepsilon_3 x_3) + R_1V - R_DD\} \quad (4)$$

Assuming that the asset risks of banks is ranked from large to small and can be divided unlimitedly, thus the asset risk of banks are not the same, not the same as required in Basel Agreement, then, according to risk-weighted ratio $h_i = f(\varepsilon_i)$ and $f'(\varepsilon_i) > 0$, assuming K represents the requirement for capital adequacy ratio, then the constraint conditions for bank behaviors are:

$$\frac{V-D}{f(\varepsilon_2)X_2 + f(\varepsilon_3)X_3} \geq k \quad (5)$$

At this moment, supposing that the market is effective, the government is executing supervisory mechanisms, however, if the bank capital is lower than the requirement for capital adequacy ratio, the market will have low confidence in the banks, then runs on banks will occur, causing the bank to go bankrupt.

III. THE LINEAR PROGRAMMING SOLUTION OF BANK ASSETS ALLOCATION UNDER CAPITAL REGULATION AND CONSTRAINT

Simplified as:

$$X_3 = \frac{V-D}{kf(\varepsilon_3)} - \frac{f(\varepsilon_2)}{f(\varepsilon_3)}X_2 \quad (6)$$

According to formula (6), the number of assets with high yield and that of assets with low yield is negatively related, and it is unrelated to the proportion of risk-free assets. The number of assets with high yield is determined by bank capital, capital adequacy ratio, the number of assets with low yield and the respective risk weighted ratio of these two assets together.

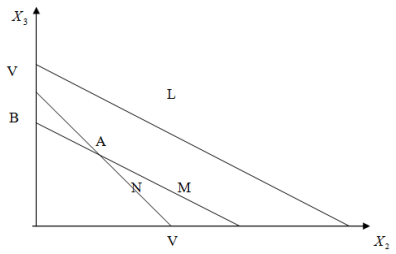
To maximize（4）is maximizing

$$Y = \varepsilon_2 X_2 + \varepsilon_3 X_3 \quad (7)$$

That is $X_3 = \frac{Y}{\varepsilon_3} - \frac{\varepsilon_2}{\varepsilon_3}X_2$ （8）

and $X_2 + X_3 \leq V$

Using the method of linear programming:



Line N represents $X_2 + X_3 = V$, Line M and L represent $X_3 = \frac{V-D}{kf(\varepsilon_3)} - \frac{f(\varepsilon_2)}{f(\varepsilon_3)}X_2$, wherein, $-\frac{f(\varepsilon_2)}{f(\varepsilon_3)} > -1$.

When $\frac{V-D}{kf(\varepsilon_3)} \geq V$, we can get $\frac{C}{V} > kf(\varepsilon_3)$, that is, when the risk weight ratio is greater than the product of the minimum capital and the risk weight of high risk assets, L is always greater than N, the feasible region is below N, the objective function Y is unrelated to L, that is to say, the minimum capital requirement cannot limit the risk taking of banks.

Therefore, when the equity capital of banks is very abundant, banks have enough capital to withstand the unknown risks and possible future costs, and the ratio of equity capital is greater than the minimum capital, at this moment, the minimum capital has no effect on the risk taking behaviors of banks, banks will increase the ratio of high risk assets and take an excessive risk.

When $\frac{V-D}{kf(\varepsilon_3)} < V$, that is, the risk weight ratio is smaller than the product of the minimum capital and the risk weight of high risk assets:

1. If $\frac{f(\varepsilon_2)}{f(\varepsilon_3)} > \frac{\varepsilon_2}{\varepsilon_3}$, namely, the target line slope is greater than that of Line M, that is to say, the growth rate of the risk weight is greater than the growth rate of risks.

According to the linear programming, Y gets the maximum at point B, $X_3 = \frac{V-D}{kf(\varepsilon_3)}, X_2 = 0, X_1 = \frac{D-[1-kf(\varepsilon_3)]V}{kf(\varepsilon_3)}$

$Y = \frac{\varepsilon_3(V-D)}{kf(\varepsilon_3)}$

Conclusion 1: when strengthening the capital regulation, in order to meet regulatory requirements, at this moment, banks will not choose to hold low-risk assets, because holding low risk assets will increase the risk of banks, and the profit obtained is not enough to offset losses brought by the risk, banks will have to transfer high risk assets to risk-free assets, such as National Bonds, the effect of capital regulation is obvious, and the risk of banks reduces; when the capital regulation is weakened, banks will transfer risk-free assets to high risk assets, and will not choose to hold low risk assets, because holding high risk assets will gain more revenue, and is enough to cover losses brought by the risk.

2. If $\frac{f(\varepsilon_2)}{f(\varepsilon_3)} < \frac{\varepsilon_2}{\varepsilon_3}$, namely, the target line slope is smaller than that of Line M, that is to say, the growth rate of the risk weight is smaller than the growth rate of risks.

According to the linear programming, Y gets the maximum at point A, thus

$$X_3 = \frac{[1-kf(\varepsilon_2)]V - D}{k[f(\varepsilon_3) - f(\varepsilon_2)]}, X_2 = \frac{D-[1-kf(\varepsilon_3)]V}{k[f(\varepsilon_3) - f(\varepsilon_2)}, X_1 = 0$$

$$Y = \frac{(\varepsilon_3 - \varepsilon_2)(V - D)}{k[f(\varepsilon_3) - f(\varepsilon_2)]} + V$$

Conclusion 2: when strengthening the capital regulation, high risk assets will be reduced, and low risk assets will be increased, banks will not hold risk-free assets, because the profit gained by holding risk assets at this moment can cover losses brought by the increased risk, banks will transfer high risk assets to low risk assets, the effect of capital regulation is obvious and the risk taken by banks is reduced.

IV. RISKS OF CAPITAL ADJUSTMENT AND ASSET ALLOCATION OF BANKS

The total revenue of banks

$$R = \alpha R_1 + (1-\alpha)\ \alpha_2 R_2 + (1-\alpha)\ \alpha_3 R_3 \qquad (9)$$

The total risk of banks

$$\varepsilon = (1-\alpha)^2 \alpha_2^2 \varepsilon_2^2 + (1-\alpha)^2 \alpha_3^2 \varepsilon_3^2 + 2(1-\alpha)^2 \rho \alpha_2 \alpha_3 \varepsilon_2 \varepsilon_3 \qquad (10)$$

Wherein, ρ is a correlation coefficient, and

$$\alpha_2 + \alpha_3 = 1 \qquad (11)$$

Putting (11) into (9) and (10), we can get:

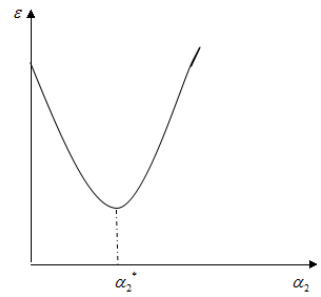
$$R = -\theta(\varepsilon_3 - \varepsilon_2) * (1-\alpha) * \alpha_2 + \theta\ (1-\alpha) * \varepsilon_3 + R_1 \qquad (12)$$

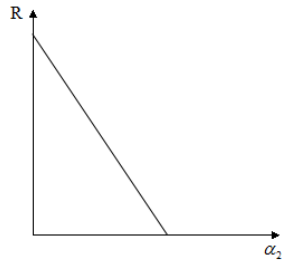
$$\varepsilon = (1-\alpha)^2 \left[(\varepsilon_2^2 + \varepsilon_3^2 - 2\rho\varepsilon_2\varepsilon_3) * \alpha_2^2 + (2\rho\varepsilon_2\varepsilon_3 - 2\varepsilon_3^2) * \alpha_2 + \varepsilon_3^2 \right] \qquad (13)$$

Assuming when the risk is the smallest, $\alpha_2 = \alpha_2^*$

$$\alpha_2^* = \frac{\varepsilon_3^2 - \rho\varepsilon_2\varepsilon_3}{\varepsilon_2^2 + \varepsilon_3^2 - 2\rho\varepsilon_2\varepsilon_3} \qquad (14)$$

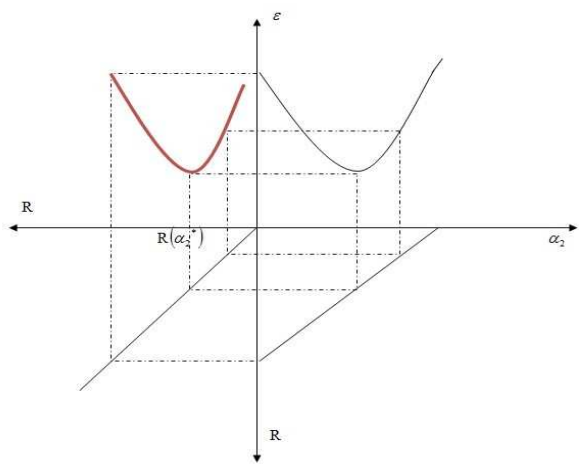
The relationship between ε and α_2





The relationship between R and α_2

We can get from two charts above:



From (5) and (11), we can get

$$\alpha_2 \geq \frac{f(\varepsilon_3)}{f(\varepsilon_3) - f(\varepsilon_2)} - \frac{1-\beta}{k[f(\varepsilon_3) - f(\varepsilon_2)]} \qquad (15)$$

Putting (12) into (15), we get:

$$R \le \frac{\theta(\varepsilon_3 - \varepsilon_2) * (1-\alpha)[1-\beta - kf(\varepsilon_3)]}{k[f(\varepsilon_3) - f(\varepsilon_2)]} + \theta(1-\alpha)\ \varepsilon_3 + R_1 = R^*$$

（16）

R^* is the highest yield which banks can gain under the requirement of the minimum capital, assuming the profit of banks is w.

$$w = R - R_D \beta$$

（17）

When $R^* \le R(\alpha_2^*)$ and $R = R^*$ the profit is the biggest, and the risk is the smallest, at this moment, banks will hold relatively more low risk assets, which is enough to meet the requirement of minimum capital adequacy ratio, banks will choose to hold high risk assets, and because there is a correlation between two assets, it can reduce risk and increase the profit of banks until to the maximum profit, that is, banks holds the corresponding assets portfolio of R^*; when the deposit interest rate increases, the assets portfolio is the optimal one, so the profit rate will decrease.

When $R^* > R(\alpha_2^*)$, taking $(R(\alpha_2^*), R^*)$, as compared with the right part of $R(\alpha_2^*)$, the yield is high in the same risk level, this is because the covariance of two assets makes banks correspond to two different profit asset portfolio under the same risk level. If the goal of banks is pursuing profit maximization, then taking the corresponding asset portfolio of R^*, the profit is the biggest at this moment, but the risk is also the greatest, banks are easy to go bankruptcy; if the goal of banks is to minimize the risk, then taking the corresponding asset portfolio of $R(\alpha_2^*)$, the risk of banks is the smallest, but the profit is not the optimal, shareholders are likely to intervene to increase the profit rate; when the deposit interest rate rises, in order to maintain their profit margin, banks will tend to increase the total profit, that is approach to the highest yield which they can get under the requirement of minimum capital, then the holding rate of low risk decreases, while that of high risk asset rate increases, banks will increase their high risk assets.

Generally speaking, profit and risk is positively correlated; from the above analysis, the existence of the covariance makes the assets portfolio with low total risk, here the total profit of banks is not the lowest, that is to say, profit and risk is positively correlated. Different assets portfolios can make the same risk and profit, namely, the same risk must correspond to two assets portfolios with different profit, banks will choose suitable assets portfolio instead of holding too much low risk assets to avoid risks.

V. CONCLUSIONS AND RELEVANT POLICY RECOMMENDATIONS

The part of conclusion is added. Summing up the above conclusions, we can get:

Based on comprehensive analysis, we proposed three suggestions: (1) developing inter-bank bond market and the inter-bank market to facilitate the financing of commercial banks, when the market is low in confidence, it easy to occur runs on banks, relatively free financing can reduce the risk of bankruptcy. (2) The rational allocation of bank assets. Commercial banks should take their business objectives as their guides, balance the liquidity and profitability under capital regulation and constraints. (3) Strengthening the punishment of financial crime, enhance the information disclosure and evaluation on banks, making the behaviors of decision-makers in banks tend to be normative and reducing financial accidents. In addition, we should exert the effectiveness of prudential supervision of the CBRC; strengthen the transparency of banking information disclosure, cultivate and maintain the market confidence for the market confidence steady management of banks so as to improve the efficiency of financial supervision.

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