

# A Counter Cyclical Adjustment on the Economic Capital Measurement of Listed Commercial Banks

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**Abstract:** With the implementation of the "Basel III", banks need more capital to cover comprehensive risks. The changing statutes of capital will be different from the previous. Taking Morgan as an example, a method of economic capital measurement from top to bottom is used to calculate Morgan's economic capital. The result shows Morgan has considered pro-cyclicality and made a great counter cyclical adjustment by comparing with the reported economic capital. In order to provide a reasonable method to grasp the economic capital for the bank supervision department, the top-down economic capital measure model is counter cyclical modified.

## 1. Introduction

"Basel III", the new global regulatory framework requires banks to have higher quality and larger quantity of capital, which greatly increase the banks operating cost, as well as constraint the high-risk behavior in banks. Capital management is always an important composition of the management in banks. Many literatures about the current capital management mainly focus on capital allocation, where the optimal could realize the highest benefit cost, but these capital allocation methods are built on series of assumptions (Zanjani, 2010; Erel et al., 2013; Peng et al., 2013). However, subject to regulatory constraints, the banks can not keep the optimal capital ratio. Unfortunately, due to the fact that the banks cannot keep the optimal capital ratio with the constraints of regulation, literatures on optimal capital under the constraint of bank supervision are proposed (Miles et al., 2013; Repullo and Suarez, 2013). With the implementation of the "Basel III", how to minimize capital will be valued by the bank managers.

Bank's capital is defined as the present value of assets minus the present value of liabilities. Capital is negatively correlated with risk, while being the opposite with the bank's credit quality. Economic capital is such a concept corresponding to risks arising from the course of business. Economic capital management is a cutting-edge and popular capital management mode in commercial banks. Economic capital can be applied in daily management of commercial bank, such as asset allocation and loan pricing. The key to economic capital management is how to measure economic capital. Generally, there are two perspectives in economic capital calculation: bottom-up and top-down. Internal Ratings-Based approach of Basel III suggests bottom-up approach, which calculates economic capital according to amount of various types of risk, including credit risk, operational risk and market risk. However, Schroeck (2002) has introduced a top-down approach for deriving economic capital, this approach calculating economic capital based on listed banks' market data and credit rating that Credit ratings. The economic capital amount in the top-down perspective is similar with the amount reported by bank at the time.

With the development of finance, the Basel committee is gradually realizing that economic capital measurement have strong pro-cyclicality. Some measures such as estimating default rate based on long-term data and using loss given default in a recession have been used to remit pro-cyclicality. This suggests that the economic capital of commercial banks will be great after adjustment in better period while less during weak economy. But the effect of the counter cyclical adjustment can not be measured. The economic capital calculated by using Schroeck's model was close to the economic capital reported by the bank before "Basel II" and "Basel III", consequently,

we assume that the economic capital calculated by using Schroeck's model can reflect the risk of banks. This paper adopts top-down approach to measure economic capital before adjustment, inspects the degree of cycle smoothing in the economic capital measurement, makes counter cyclical adjustment for the economic capital model and finally uses the model to forecast the economic capital next year.

## 2. Model

The top-down approach is based on the theory of option pricing, which regard default as an event that the asset value is less than certain default-triggering level, this level is usually related to the structure of debt in bank. As following formula shows,

$$PD_t = P(V_t < C_t) \tag{1}$$

Here,  $PD_t$  means probability of default at time t,  $C_t$  represent default-triggering level at time t which is determined by asset structure.

Meanwhile, we suppose the asset of bank follows the geometric Brownian motion,

$$\frac{dV_t}{V_t} = \mu dt + \sigma dW(t) \tag{2}$$

Here,  $\mu$  means average return on asset value,  $\sigma$  is the volatility ratio of asset,  $dW(t)$  is standard Brownian motion, the mean of which is zero and the variance is  $dt$ , it is also known as wiener process. Then the value of bank asset is,

$$V_t = V_0 e^{(\mu - \frac{\sigma^2}{2})t + \sigma W(t)} \tag{3}$$

Together with (1) and (3) yields,

$$\begin{aligned} PD_t &= P(V_0 e^{(\mu - \frac{\sigma^2}{2})t + \sigma W(t)} < C_t) \\ &= P((\mu - \frac{\sigma^2}{2})t + \sigma W(t) < \ln \frac{C_t}{V_0}) \end{aligned} \tag{4}$$

Because of  $W(t) = \varepsilon\sqrt{t}$ ,  $\varepsilon \sim N(0,1)$ , formula (4) can be translated to the following formula,

$$PD_t = P(\varepsilon < \frac{\ln \frac{C_t}{V_0} - (\mu - \frac{\sigma^2}{2})t}{\sigma\sqrt{t}}) = \Phi \left( \frac{\ln \frac{C_t}{V_0} - (\mu - \frac{\sigma^2}{2})t}{\sigma\sqrt{t}} \right) \tag{5}$$

On the other hand, Rating agencies have grade commercial banks, a reduction in credit rating will affect competitiveness of commercial banks, reduce public confidence and is not conducive to the development of service. Therefore, we can get the corresponding probability of default according to the relation of credit rating and probability of default. This probability of default is an base line and a target probability of default which commercial bank need maintain to guarantee public confidence, recorded as  $PD_d$ .

According to target probability of default, we get default-triggering level recorded as  $C_T$  through solving formula (6).

$$C_T = V_0 e^{N^{-1}(PD_d)\sigma\sqrt{T} + (\mu - \frac{\sigma^2}{2})T} \tag{6}$$

$C_T$  means the maximum amount of indebtedness that commercial bank can pay so as to maintain

the target probability of default at time  $t$ , if the amount of indebtedness is greater than the  $C_T$ , the probability of default will higher than target level, meanwhile, the bank will have a credit downgrade.

At this time, the economic capital of commercial bank is equivalent to the gap between asset value and default-triggering level as following formula shows,

$$EC = V_0 - C_T \tag{7}$$

### 3. The measurement of economic capital

Selecting asset-liability data and stock data published by JP Morgan, this article calculates the economic capital of Morgan, and then make a comparison with the reported economic capital.

First of all, the asset value and asset volatility have been calculated according to Black-Scholes formula as follows,

$$E = VN(d_1) - e^{-r} DP' N(d_2)$$

$$\sigma_E = \frac{VN(d_1)}{E} \sigma_V \tag{8}$$

Here,  $E$  means owners' equity of Morgan,  $\sigma_E$  is volatility of stock return, which select the fluctuation of weekly stock returns,  $V$  is asset value,  $\sigma_V$  is volatility of asset value, initial default level  $DP' = A_0 - \frac{1}{2}L$ ,  $A_0$ ,  $L$  represents asset and long-term debt, respectively.  $N(d_1)$  is accumulation standard normal distribution function, the parameter is  $d_1, d_2 = d_1 - \sigma_V \sqrt{T}$ ,  $r$  is risk-free interest rate that adopt annual average value of daily treasure long-term rate.

We get asset value and asset volatility through applying MATLAB, shown in the table below.

Table 1 Asset value and asset volatility of Morgan from 2010 to 2012 (in millions)

	E	$A_0$	L	$DP'$	$\sigma_E$	r	$V_0$	$\sigma_V$
2010	165365	2031989	289165	1887407	0.296235692	0.039694	1979320	0.0247
2011	176106	2117605	270653	1982279	0.338230691	0.03880	2082935	0.0286
2012	183573	2265792	256775	2137405	0.302152458	0.035192	2247071	0.0247

Then, by formula (7), we calculate default-triggering level, here the return on assets is the sum of return on asset and risk-free interest rate.

Table 2 Economic capital of Morgan (in millions)

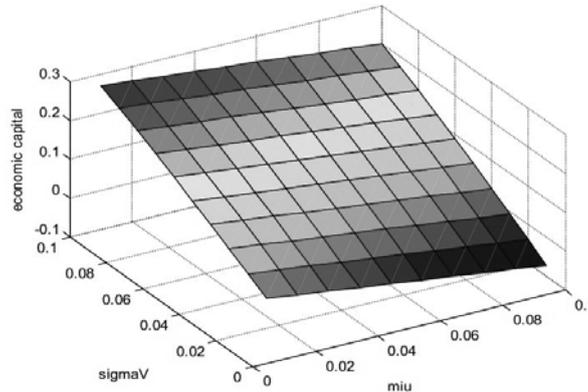
	Credit rating	$PD_d$	$N^{-1}(PD_d)$	$\mu$	$C_T$	$EC$	EC as report( $EC_r$ )	Difference $EC_r - EC$	$\frac{\text{difference}}{EC}$
2010	A+	0.0005	-3.29053	0.048552	1915648	63671.99	78400	14728	0.231311
2011	A	0.0007	-3.19465	0.048003	1995654	87280.82	78100	-9180.819	-0.10519
2012	A	0.0007	-3.19465	0.044979	2174245	72825.73	86000	13174.3	0.180902

Table 2 shows that the differences between economic capital calculated by top-down approach ( $EC$ ) and those published ( $EC_r$ ) are more than 10%. The top-down model is sensitive to the change in the stock market. From Morgan's stock data, we also found the stock price was on the rise in 2010 and 2012 while the  $EC$  is less than  $EC_r$ , then, whereas the stock price declined in 2011, the  $EC$  is more than  $EC_r$ . Morgan has considered pro-cyclicality and made a great counter cyclical adjustment.

#### 4. Modification

We modify the top-down model according to its intrinsic properties.

In the top-down model, there is a certain relationship among return on asset, asset volatility and economic capital, as shown below.



Picture 1 The relationship between  $\mu$ ,  $\sigma_V$  and economic capital

When the average return  $\mu$  is 0.045, the relationship between asset volatility  $\sigma_V$  and economic capital is similar to a straight line with the slope equal to 2.57, thus the economic capital is sensitive to the volatility of asset. Especially for Morgan, it has a large asset scale, even a small change of asset volatility will cause a great change in the amount of economic capital. So we choose the asset volatility as the modified object.

From the table 2, the sign of the difference is opposite to the change of share price. Then we modify the model on the basis of bank stock yield in order to fulfill the need of economic capital calculation at this stage.

As we know, the risk of the bank was influenced by self factors, but also influenced by the whole market. According to capital asset pricing model (CAPM), we calculate the expected return. The expected return can reflect the changes of the market. The economic capital calculated by using this parameters can also reflect the changes of the market.

From 2010 to 2012, the beta coefficients of the CAPM are 1.212, 1.374, 1.3675, those are calculated based on daily return rate of Morgan and NYSE. Since annual returns of NYSE are 0.0834, -0.073, 0.102, we get the returns of Morgan are 0.092671247-0.114934697, 0.126625882.

We modify the asset volatility using expected return in the ways of linear treatment or indexation.

Now suppose

$$\sigma_V' = \begin{cases} (1 + \alpha_l R) \sigma_V \\ \sigma_V \exp(\alpha_e R) \end{cases} \quad (9)$$

By minimizing the residual sum of square of economic capital in three years, we get the correction factor:

$$\begin{cases} \alpha_l = 0.62 \\ \alpha_e = 0.622 \end{cases}$$

Table 3 Economic capital after correction (in millions)

	linear correction	$\frac{\text{difference}}{EC_r}$	Index correction	$\frac{\text{difference}}{EC_r}$
2010	72628.99	-7.36%	72921.27	-6.99%
2011	74271.82	-4.90%	74686.61	-4.37%
2012	86140.66	0.16%	86722.05	0.84%

We get annual  $\sigma_E$  according to the value of  $DP'$  in 2012 as shows in table1 and the stock data of Morgan in 2013. In addition, the ROA is 0.6% in 2013 considering the net income of the first three quarters of Morgan. Then, the commercial bank's return of asset is  $\mu$ , which is equal to ROA plus risk-free rate, here the value of  $\mu$  is 0.0310, the economic capital in 2013 after modification is shown below.

Table 4 Linear estimation result (in millions)

Linear estimation result	$\mu$	$\sigma_E$		$N^{-1}(PD_d)$	$V$	$\sigma_V$	$C_T$	$EC = V - C_T$
	0.0310	0.192	$PD_d=0.007$	-3.19465	2383324.7	0.0164	2318002.0	65322.68
			$PD_d=0.005$	-3.29053			2313924.7	69400.0

Under the condition of linear modification, we estimate the economic capital needs to achieve 69.4 billion when the target probability of default is 0.005. Within range of the error correction the maximum of which is 7.36%, whereas, the economic capital may reach 74.5 billion.

Table 5 Index estimation result (in millions)

Index Estimation result	$\mu$	$\sigma_E$		$N^{-1}(PD_d)$	$V$	$\sigma_V$	$DP$	$EC = V - DP$
	0.03104	0.192	$PD_d=0.007$	-3.19465	2383324.7	0.0164	2317038.4	66286.3
			$PD_d=0.005$	-3.29053			2312934.1	70390.6

When using index estimation, we found that the economic capital needs to achieve 70.39 billion when the target probability of default is 0.005. Within range of the error correction the maximum of which is 6.99%, whereas, the economic capital may reach 75.3 billion.

## 5. Conclusion

The top-down approach adopts the public and transparent data, which is positive for regulatory authority to confirm risks of commercial banks and is conducive to the implement of regulatory authority's measures as well. For example, according to the economic situation, the regulatory authorities can request commercial banks to increase the reverse cycle regulation, where the correction factor may be 0.5. In addition, calculation of the correction factor is not limited to a single bank, so that regulatory authorities can supervise all the listed banks according to their own information.

However, after the financial crisis, with the presenting of new capital management method, the top-down approach has had limitations in a certain sense. After the modification above, drawing the macro factors into the top-down approach, it can better meet the demand of financial regulation in the post-crisis era, and know better about the capital adequacy condition of banks through more accurate estimation of economic capital.

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