# bank capital regulation model

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paris 1

12 March 2014

# Bank Capital Regulation (BCR) Model

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March 11, 2014

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How we can induce the moral hazard problem?

# 1.Motivation - Special concerns for financial crisis...

Banking sector: Need to cooperate for the financial stability )
Basel 3, accord by the financial regulation,

1. Raising the quality, consistency and transparency of the *capital base*
2. Enhancing *risk coverage*
3. Supplementing the risk-based capital requirement with a *leverage ratio*
4. Reducing procyclicality (to the financial shocks) and promoting *countercyclical buffers*.
5. Addressing *systemic risk* and *interconnectedness*

# 2.Literature

*Economic approach for capital adequacy regulation*
Michaelsen-Goshay (1967), Krouse (1970), Parkin (1970), Haugen and Kroncke (1970), Pyle (1971), Hart and Jaffee (1974), Kahane and Nye (1975)

*Bank's problem approach (commercial, reserve bank)* Cost of Deposit Insurance, Merton (1978) Dynamic banking model, deposit as uncertainty variable, OHARA (1983) Reserve management modeling, Santomero (1984) Capital regulation on bank asset portfolio risk, Furlong-Keeley (1989) Financial intermediaries and Liquidity trader, Gorton-Pennachi (1990)

# 2.Literature

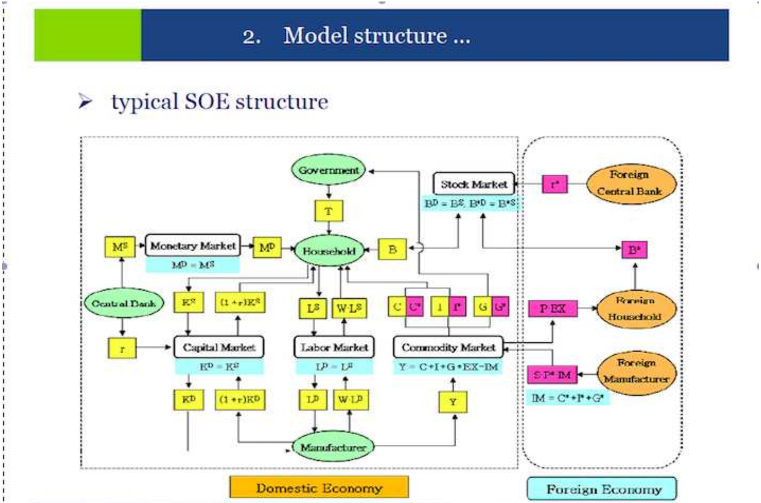
*Financial Market approach* Regulatory capital requirement, Berger-Herring-Szego (1995) Bank lending and money supply, Thakor (1996) Bank shareholder value and market risk, Kupiec-Obrien (1997)

*Macruprudential approach* One bank model at the bank capital and risk-taking, Milne-Whalley (1998) Dynamics of variables in the general equilibrium, Diaz (2005) Procyclicality of Capital requirement in a general equilibrium and equity issuance cost, Covas-Fujita (2010) Financial Regulation in General Equilibrium, Goodhart-Kashrap-Tsomocos (2011) Macroprudential capital regulation in general equilibrium, Nelson-Pinter (2012)

# 3.Risks recognized in the General Equilibrium

In the systemic risk, we can measure the risk impacting on other factors like firms, households and federal reserve banks, not on commercial banks.
Easily, **monetary policy** on banking considers the **systemic risk**.
We need to consider different measures to analyse systemic risk of banks with **domino effects, contagions**. Systemic risk of banks can be explained in the "**static model within the general equilibrium**". Otherwise, domino effects or contagions should be described as movements having the future tendency. "**Scope of regulation**" should be detected by categorization of on balance sheet and off balance sheet factors.
Risks on the balance sheet of bank are divided into **credit risk, market risk, liquidity risk and systemic risk**.

# SOE(Structure of Equilibrium) of BOK (Bank of Korea)



# Vanhoose 2008 - Asset/Liability of banks

**Table 2.1** Assets of U.S. commercial banks

| Asset category | $ Billions | % |
|---|---|---|
| Commercial and industrial loans | 1,197.9 | 12.3 |
| Consumer loans | 847.4 | 9.0 |
| Real estate loans | 3,573.9 | 36.7 |
| Interbank loans | 364.6 | 3.6 |
| Other loans | 269.0 | 2.7 |
| Total loans | 6,252.8 | 64.3 |
| Securities | 2,017.7 | 20.7 |
| Cash assets | 247.1 | 2.5 |
| Other assets | 1,220.4 | 12.5 |
| Total assets | 9,738.0 | 100.0 |

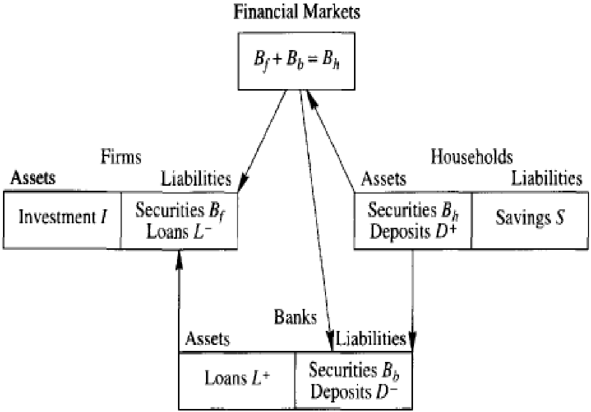
(Source: Board of Governors of the Federal Reserve System, August 2008)

**Table 2.2** U.S. commercial bank liabilities and equity capital

| Category | $ Billions | % |
|---|---|---|
| Transactions deposits | 579.1 | 6.0 |
| Large time deposits | 1,016.4 | 10.4 |
| Savings and Small Time Deposits | 4,171.6 | 42.8 |
| Total deposits | 5,767.1 | 59.2 |
| Borrowings | 1,744.8 | 17.9 |
| Other liabilities | 1,051.4 | 10.8 |
| Total liabilities | 8,563.3 | 87.9 |
| Equity capital | 1,174.7 | 12.1 |
| Total liabilities and equity capital | 9,738.0 | 100.0 |

(Source: Board of Governors of the Federal Reserve System, August 2008)

# Freixas-Rochet (1999)



# Structure of Equilibrium

Each Market Clearing

I=S (Good Market)
$D_h$ (Firm)-$D_h$ (Firm)+$D_h$ (Household)-$D_h$ (Household)+$D_h$ (Bank)-$D_h$ (Bank)(Deposit market)
$L_{fr}$ (Firm)-$L_{fr}$ (Firm)-$L_{fr}$(Bank)+$L_{fr}$(Bank)+$L_{fr}$(FR)-$L_{fr}$(FR) (Credit Market)
$B_h$(Firm)-$B_h$(Firm)+$B_h$(Household)-$B_h$(Household)+$B_{fr}$ (Bank)-$B_{fr}$ (Bank) +$B_{fr}$ (FB)-$B_{fr}$ (FB) (Financial Market)

Firms

| Assets | Liabilities |
|---|---|
| Real Asset $D_h$+$B_h$ (=Investment I) | Liabilities to banks $D_h$+$B_h$ -$L_{fr}$ Liabilities to central bank $L_{fr}$ |

Households

| Assets | Liabilities |
|---|---|
| Securities $B_h$ Deposits $D_h$ Real Asset $S_h$-($B_h$+$D_h$) | Savings $S_h$ |

Banks: domestically chartered commercial banks, country branches and agencies of foreign banks, Edge Act corporation

| Assets | Liabilities |
|---|---|
| Claims to corporate $D_h$+$B_{fr}$ -$L_{fr}$ | Deposits $D_h$ Borrowing $B_{fr}$ −$L_{fr}$ |

Federal Reserve Banks

| Assets | Liabilities |
|---|---|
| Claims to corporate $L_{fr}$ Currency $C_r$ Borrowing to banks $B_{fr}$ -$L_{fr}$ | Securities $B_{fr}$ |

# Saving preference of Consumers

The two-period model $(t = 0, 1, 2,)$ with a unique physical good initially owned by the consumers in the economy in which a continuum of ex-ante identical agents is each endowed with one unit of good at period $t = 0$, and this good is to be consumed at periods $t = 1$ and $t = 2$. The consumer chooses her consumption profile $(C_1,\ C_2)$, and the allocation of her savings S between bank deposits $D_h$ and securities $\sum_{s\in\Omega} P_s B_s^h$, in a way that maximize her utility function $u$ under her budget constraints:

Max $u(C_1, C_2)$
$C_1 + \sum_{s\in\Omega} P_s B_s^h + D^h + S_h - \sum_{s\in\Omega} P_s B_s^h - D^h = \omega_1$
$C_2 = \Pi_f + \Pi_b + (1+r)\sum_{s\in\Omega} P_s B_s^h + (1+r_D)D^h + (1+r_h)S_h -$
$(1+r)\sum_{s\in\Omega} P_s B_s^h$
$-(1+r_D)D^h$

# Borrowing composition of Firms

The firm chooses its investment level $I$ and its financing (through real asset $D_h + \sum_{s\in\Omega} P_s B_h$, liabilities to bank $D_h + \sum_{s\in\Omega} P_s B_h - L_{fr}$ (or Liabilities to central bank $L_{fr}$) in a way that maximizes its profit:

Max $\Pi_f \ (P_f)$

$\Pi_f = f(I) + r_f(D_h + \sum_{s\in\Omega} P_s B_s^h) - r_{L^{Bank}}(D_h + \sum_{s\in\Omega} P_s B_s^h - L_{fr}) - r_{L^{fr}} L_{fr}$

$I = S_h = D_h + \sum_{s\in\Omega} P_s B_s^h$

Where $r_f$ is the premium of firm real asset. $r_{L^{Bank}}$, $r_{L^{fr}}$ is the interest rate on bank loans and federal reserve bank loan. $D_h$ denotes for bank deposits. $B_h$ denotes for securities. Especially $B_{fr}$ denotes for securities of federal reserve banks. $L_{fr}$ is loan claimed by the firm to the federal reserve bank.

# Demand Deposit of Bank

The bank chooses its supply of loans to firms $D_h + B_{fr} - L_{fr}$, its demand for deposits $D_h$, and the borrowing $B_{fr} - L_{fr}$ in a way that maximized its profit:

Max $\Pi_b \ (P_b)$

$\Pi_b = r_{L^{Bank}}(D_h + \sum_{s \in \Omega} P_s B_s^h - L_{fr}) - r_{L^f r}(\sum_{s \in \Omega} P_s B_s^{fr} - L_{fr}) - r_D D^h$

Where $r_{L^{Bank}}$, $r_{L^{fr}}$ is the interest rate on bank loans and federal reserve bank loan. $D_h$ denotes for bank deposits. $r_D$ is the interest rate paid by deposits $B_s^h$ denotes for securities. Especially $B_s^{fr}$ denotes for securities of federal reserve banks. $L_{fr}$ is loan claimed by the firm to the federal reserve bank.

# Federal Reserve Banks and general equilibrium

The Federal Reserve Banks chooses its investment level $I$ and its financing (through real asset $D_h + \sum_{s\in\Omega} P_s B_s^h$, liabilities to bank $D_h + \sum_{s\in\Omega} P_s B_s^h - L_{fr}$ (or Liabilities to central bank $L_{fr}$) in a way that maximizes its profit:

Max $\Pi_f \ (P_f)$
$\Pi_f = f(I) + r_f(D_h + \sum_{s\in\Omega} P_s B_s^h) - r_{L^{Bank}}(D_h + \sum_{s\in\Omega} P_s B_h - L_{fr}) - r_{L^{fr}} L_{fr}$
$I = S_h$

# description about the BCR model

(result) Arrow (1953) If firms and households have unrestricted access to perfect financial markets, then at the competitive equilibrium
(result) Cho (2014) If the sum accumulated variables is not negative, for example, the components Investment I, Savings $S_h$, $L_{fr}$ are not negative, there is the equilibrium in the economy and the existence of each factors like firms, Households, Banks, Federal Reserve Banks is fulfilled. **The size of banks is affecting on each agent because equity capitals depend on previous deposits.** Depending the change of bank size influencing on total deposit $D_h$, the liability of firms is affected by liabilities to banks $D_h + \sum_{s \in \Omega} P_s B_s^h - L_{fr}$, deposit of household $D_h$ and real asset of household and firms.

# Autarky concerns

The simplest case, in which there is no trade between agents, is called "autarky".
$C_1 = 1 - I + LI = 1 - I(1 - L)$ is equivalent or less than 1
Consumer can liquidate investment $I$ and re-invest $LI$.
On the contrary, if he has to consume late, he obtains profit $R$ about Investment $I$. Hence, he get $RI$
$C_2 = 1 - I + RI = 1 + I(R - 1)$ is equivalent or less than R
With equality only when $I = 1$. In autarky, each consumer will select the consumption profile that maximizes his ex-ante utility u under the constrains $C_1$ and $C_2$

## Market Economy - With trade

If agents are allowed to trade, welfare improves. By investing I at $t = 0$, an agent can now obtain

$$C_1 = 1 - I + pRI$$

If she needs to consume early (in which case she will sell RI bonds). If, on the contrary, she needs to consume late, she will obtain $C_2 = \frac{p}{1-I} + RI = \frac{p}{1}(1 - I + pRI)$

# Market Economy - With trade

Since she can then buy $\dfrac{1-I}{p}$ bonds at $t=1$

I can be freely chosen by agents, the only possible equilibrium price is $p=\dfrac{1}{R}$.

Otherwise either an excess supply or an excess demand of bonds will occur $(I=+\infty)$ if $p>\frac{1}{R}$

The equilibrium allocation of the market economy is therefore $C_1^M=1$, $C_2^M=R$ and the corresponding investment level is $I^M=\Pi_2$.

Notice that this market allocation Pareto dominates the autarky allocation. Since there is no liquidation. In addition, it is not ex-ante Pareto optimal.

# Optimal allocation

$$\max \Pi_1 u(C_1) + \rho \Pi_2 u(C_2)$$
$$\Pi_1 C_1 + \Pi_2 \frac{C_2}{R} = 1$$
$$\text{L}{=}\Pi_1 u(C_1) + \rho \Pi_2 u(C_2) - \lambda(1 - \Pi_1 C_1 + \Pi_2 \frac{C_2}{R})$$
$$\frac{\partial L}{\partial C_1} = 0$$
$$\frac{\partial L}{\partial C_2} = 0$$
$$\Pi_1 u'(C_1) + \lambda[Pi_1 C_1] = 0$$
$$\rho \Pi_2 u'(C_2) + \lambda[\frac{Pi_2}{C_1}] = 0$$

# Optimal allocation

This optimal allocation satisfies in particular the first-order condition: u'($C_1^*$)= $\rho$Ru'$C_2^*$
Therefore, except in the very peculiar case in which u'(1)=$\rho$Ru'(R), The market allocation ($C_1^M$=1, $C_2^M$=R ) is not Pareto optimal. In particular, Diamond and Dybvig (1983) assume that C $\longrightarrow$ Cu'(C) is decreasing. In that case, since R>1, $\rho R u'(R) < \rho u'(1) < u'(1)$, and the market allocation can be Pareto improved by increasing $C_1^M$ and decreasing $C_2^M$: $C_1^M = 1 < C_1^*$ ; $C_2^M = R > C_2^*$ The market economy does not provide perfect insurance against liquidity shocks, and therefore does not lead to an efficient allocation of resources.

# Financial Intermediation ("FI" as below)

Provided the possibility of strategic behavior of depositors is ruled out, the Pareto optimal allocation $(C_1^*, C_2^*)$ can be implemented very easily by a financial intermediary who offers a demand deposit contract stipulated as follows:
In exchange for a deposit of one unit at $t = 0$, individuals can get either $C_1^*$ at $t = 1$ or $C_2^*$ at $t = 2$. In order to fulfill its obligation, the FI stores $\Pi_1 C_1^*$ and invests the rest in the illiquid techonology.
Thus we have established the following:

(result) In an economy in which agents are individually subject to independent liquidity shocks, the market allocation can be improved by a deposit contract offered by a financial intermediary.

# Financial Intermediation ("FI" as below)

The reason why the market allocation is not Pareto optimal is that complete contingent markets cannot exist: the state of economy (i.e., the complete list of the consumers who need to consume early) is not observable by anyone. The only (noncontingent) financial market that can be opened (namely the bond market) is not sufficient to obtain efficient risk sharing.
(point) Notice that a crucial assumption is that no individual withdraw at $t = 1$ if he or she does not have to. Provided $\rho R > 1$, this assumption is not unreasonable, since it corresponds to a Nash equilibrium behavior. The first-order condition of the optimal allocation implies ( since $\rho R \geq 1$ ) that $C_1^* < C_2^*$:

# Financial Intermediation ("FI" as below)

in other words, a deviation by a single late consumer (withdraw at $t = 1$ and store the good until $t = 2$) is never in that consumer's own interest.
Also, another Pareto-dominated Nash equilibrium exists in which deviations of all late consumers occur simultaneously.
(point) In this simple setup, an FI cannot coexist with a financial market. Indeed if there is a bond market at $t = 1$, the equilibrium price is necessarily p=$\frac{1}{R}$. then the optimal allocation $(C_1^*, C_2^*)$ is not a Nash equilibrium anymore:
$RC_1^* > R > C_2^*$

# The Moral Hazard Issue

| Assets ($t = 0$) | Liabilities ($t = 0$) |
|---|---|
| Loans L | Deposits D |
| Insurance premium P | Equity F |

| Assets ($t = 1$) | Liabilities ($t = 1$) |
|---|---|
| Loan Repayments $\tilde{L}$ | Deposits D |
| Insurance Payment $\tilde{S}$ | Liquidation Value $\tilde{V}$ |

# The Moral Hazard Issue

At date 1, the stockholders receive the liquidation value of the bank:
$\tilde{V} = BankAsset - Deposits + RecoveredDeposits = \tilde{L} - D + \tilde{S}$
The expected profit for the bank's stockholders will be
$\pi := E(\tilde{V} - F = (\theta X - L) + ((1-\theta)D - P)$,
If deposit insurance is fairly priced, this term is nil $(P = (1-\theta)D)$, and the strong form of the Modigliani-Miller result obtains: the market value of firm, $E(\tilde{V}) + D$, is independent of its liability structure.

# The Moral Hazard Issue

The moral hazard problem is easily captured from this formula. Suppose that P is fixed and that banks are free to determine the characteristic ($\theta$, X) of the projects they finance in a given feasible set. Then, within a class of projects with the same NPV ($\theta$X-L $=$ constant),the banks will choose those with the lowest probability of success $\theta$ (or the highest risk). This comes from the fact that the premium rate $\dfrac{P}{D}$ is given, and does not depend on the risk taken by the bank.

# The portfolio composition effected by the minimum equity capital regulation

In the model of Kahane (1977), the minimum capital requirement causes an unintended result: it worsened, rather than improved the intermediary's condition and increases its probability of ruin. He check this calculation with the ruin constraint and given standard deviation of rate of return at the portfolio composition of liability, stock and bonds.

In this paper, with the portfolio of risky portfolio and stable portfolio, explanation will be easier to be understood why minimum equity regulation induces for banks to operate riskier portfolio.

# The portfolio composition effected by the minimum equity capital regulation

If we assume that the bank manages a risky portfolio with an expected rate of return of 17% and a standard deviation of 27%. The expected rate of return on equity is 7%. and even though, there is pressure to raise the required equity every period, liability is same every period. The bank try to meet the bank capital condition regulated by the financial intermediaries, the bank should operate much more riskier portfolio comparing to the previous period as following.

# The portfolio composition effected by the minimum equity capital regulation

Effects of increasing the equity at the portfolio composition

| Period | Required Equity, Liability | Portfolio composition (risky portfolio, stable portfolio) |
|---|---|---|
| 1 | 12 (12%), 88(88%) | (-61.6%, 161.6%) |
| 2 | 13 (13%), 88(87.12%) | (-61 %, 161 %) |
| 3 | 14 (14%), 88(86.72%) | (-60.4 %, 160.4 %) |

# The portfolio composition effected by the minimum equity capital regulation

Thus, in order to obtain a mean return of 0.84%, 0.90%, 0.96%, the bank must invest -61.6%, -61%, -60.4 of total funds in the risky portfolio and 161.6%, 161%, 160.4% in stable portfolio.

Standard deviation which implies the probability to get mean return, is also increasing.

Standard Deviation
$0.12 \times 0.27 = 0.0324$
$0.13 \times 0.27 = 0.0351$
$0.14 \times 0.27 = 0.0378$

# Deposit affects optimized equity capital

| $n$ | *Deposits* | *Borrowings* | *OptimizedEquityCapital* |
|---|---|---|---|
| $n = 0$ | $D_0 = 1$ | - | - |
| $n = 1$ | $D_1 = (1 - \beta - K)$ | $B_1 = (1 - \beta)$ | $OEC_1 = K$ |
| $n = 2$ | $D_2 = (1 - \beta - K)^2$ | $B_2 = (1 - \beta)(1 - \beta - K)$ | $OEC_2 = K(1 - \beta - K)$ |
| $n = 3$ | $D_3 = (1 - \beta - K)^3$ | $B_3 = (1 - \beta)(1 - \beta - K)^2$ | $OEC_3 = K(1 - \beta - K)^2$ |
| ... | ... | ... | ... |
| $n = k$ | $D_k = (1 - \beta - K)^k$ | $B_k = (1 - \beta)(1 - \beta - K)^{k-1}$ | $OEC_k = K(1 - \beta - K)^{k-1}$ |
| ... | ... | ... | ... |
| $n \to \infty$ | $D_\infty = 0$ | $B_\infty = 0$ | $OEC_\infty = 0$ |
| | total deposits | total borrowings | total optimized equity capital |
| | $D = \frac{1}{K + \beta}$ | $B = \frac{1 - \beta}{K + \beta}$ | $OEC = \frac{K}{K + \beta}$ |

# Deposit affects optimized equity capital

[$\beta =$ restriction of borrowing] Then, Borrowings can be executed between Deposit 1 and Restriction $\beta$

[balance sheet equality constraint] $D_n = B_n - OEC_n$

Hart and Jaffee(1974) analyzed the properties of the feasible and efficient set with the assumption that the initial equity capital is zero (i.e. K=0) in the substantial degrees of leverage. In the paper, following the KAHANE (1977), we assume the equity is positive ($K > 0$) so that the opportunity set does not pass through the origin (i.e. the vector of Deposit D, Borrowing B, Optimized Equity Capital = 0 give an infeasible solution).

# Deposit affects optimized equity capital

Then the theoretical superior limit for deposits is defined by the following:

$$Deposits = \sum_{n=0}^{\infty}[(1-K-\beta)] = \frac{1}{K+\beta}$$

Theoretically, superior limit for the equity capital by the firm is defined by the following:

$$OptimizedEquityCapital = K \times Deposits = \frac{K}{K+\beta}$$

and the theoretical superior limit for total borrowings in banks is defined by the following:

$$Borrowings = (1-\beta) \times Deposits = \frac{1-\beta}{K+\beta}$$

# Deposit affects optimized equity capital

Borrowings at stage $k$ are a function of the deposits at the precedent stage: $B_k = (1 - \beta - K) \times D_{k-1}$

Optimized Equity Capital at stage $k$ is a function of the deposits at the precedent stage: $OEC_k = K \times D_{k-1}$
Hence, if the optimized equity capital depends on the initial deposit and assume the terminal condition of bank is liquidation of bank deposits,

(result) Hence, Optimized Equity Capital depends on the previous deposit. In addition, deposit insurance cost also increases because deposit insurance depends on the number of household.

# $k$ index for the indicator of risk taking

Define the equity capital ratio with respect to total liabilities and equity capital, $\frac{EquityCapital}{D_h + B_{fr} - L_{fr}}$, $K \in (0,1)$, the borrowing (from the federal banks) ratio $\frac{B_{fr} - L_{fr}}{D_h + B_{fr} - L_{fr}}$, $\beta \in (0,1)$; suppose the demand for funds is unlimited;

By summing up two quantities, the theoretical equity capital multiplier is defined as

$$k = \frac{Deposits + OptimizedEquityCapital}{Borrowings + OptimizedEquityCapital} = \frac{1+K}{K+\beta}$$

# $k$ index for the indicator of risk taking

$k$ is the index to decline to increase the risk at the portfolio of commercial banks. The deposit is fixed at total 1 and borrowings have the constraint can not be negative value beyond the minimum borrowings $\beta$. For example, if deposit=1, the minimum of required equity = 10%, borrowings = 0.3

$$\frac{1+0.1}{0.3+0.1} = \frac{1.1}{0.4} = 2.75$$

If the minimum of required equity is raised from 10%, to 15%, $k$ index was downed as below.

$$\frac{1+0.15}{0.3+0.15} = \frac{1.15}{0.45} = 2.55$$

To increase the $k$ index, the bank should increase the deposit beyond the initial deposit level (1 in this simulation) or allocate the borrowing portfolio.

# Conclusion

(Conclusion) The combination of **portfolio composition test, deposit-equity optimization and k index** enables bounding the bank capital regulation problems.

The **minimum capital requirement** is a necessary condition for banking sector stability to raise the quality, consistency and transparency of the capital base. However, it has **friction with the portfolio management.** By using effects of increasing the equity at the portfolio composition, *reducing procyclicality (to the financial shocks) and promoting the countercyclical buffer* are pursued.

# Conclusion

In the **Basel 3** system, The **risk coverage** framework intends to capture all material risks by using **counterparty credit risk formula** weighted on the external rating of the counter party. Exposure measures contain on-balance sheet, repurchase agreements and securities finance, derivatives and off-balance sheet (OBS) items. *In the paper, rather than enlarging the risk contagion, related factors and risk affection scope are detected without overstatement by using the general equilibrium model and deposit affection to the optimized equity capital.*

# Conclusion

Basel 3 introduced a minimum leverage ratio. the **leverage ratio** was calculated by **dividing Tier1 capital by the bank's average total consolidated assets**. In the paper, **k index** is suggested as the **indicator of risk taking.** Within the liability, three major fractions like deposits, borrowings and optimized equity capital are considered as the complementary of minimum capital requirement. Assets of commercial banks are mainly consisted with loans and securities. Because the optimized equity capital grows and deposits is restricted by change, *borrowings which is the difference between asset and deposit+equity capital should be checked whether borrowings can cover the optimized equity by k index.*

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# Further concerns

**Stress testing with the k index**
**empirical analysis**
**Debt sustainability**

Thank you.