Regulators, capital adequacy models

16th May 2019

Why do we need to regulate the banks at all?

Banks play special roles:

- Operating settlement/payment systems
- Enhancing the growth of the economy

High social cost of bank crisis

Prudential regulation

The beginnings- establishing the Basel Committee on Banking Supervision

- Competition in making the regulation less strict
- First banking crisis in the 70's
- 1975: G10 countries established BCBS

Goal: formulating standards and recommendations, but not regulations enforceable by the law

The beginnings- direct causes leading to Basel I regulation

1987:

- Stock market crash
- Portfolio Crisis
- Savings and Loans Crisis

1988:

Basel I was published

The potential toolkit of prudential regulation

- Restrictions on holding certain assets
- Separating different activities
- Control of competition
- ***Rules of capital adequacy***
- Risk-based pricing of debit insurances
- Regulations of disclosure
- Authorization
- Continuous monitoring

Special role of capital rules in the prudential regulation framework

- Protection against insolvency, enhancing risk-orientation
- Need for uniform, international rules
- Basel I. – 1988
  - Uniform definition of regulatory capital
  - Role of the off-balance transactions
  - The magical 8%

- Basel II. –2007-2013 (2006 parallel usage)
- Basel III. –2013-2018

Capital rules in Basel I (1988)

- Capital needs to be set aside only for credit risks
- 0, 20, 50, 100% risk weights
- Also off-balance items: with credit equivalent
- Requirement: 8%, at least the half of it must be Tier 1:

$$\frac{\text{Capital}}{\text{Risk weighted assets}} \geq 8\%$$

Causes leading to Market Risk Amendment of Basel I

1994:

- Bond Market Crash
- Increasing volume of exotic derivatives

1995

- Nick Leeson – Barings Collapse

1997:

- Asia market Crash

Innovation of Basel I: introduction of market risk capital adequacy -1996

Components:

- Equities and bonds in trading book
- FX risk in banking and trading book

$$\frac{\text{Capital}}{\text{Risk weighted assets} + \text{market risk components} * 12.5} \geq 8\%$$

- Standard approach vs VaR-based capital modeling

Capital requirement for market risk – standardized approach

- Risk of individual bonds (based on net position 0-12%)
- General risk of bonds (as function of the expiration/maturity, mapping specified in a table form)
- Risk of individual equities (2 or 4%)
- General risk of equities (net 8%)
- Capital requirements for counterparty risk and concentrated risks

Capital requirement for market risk – VaR based approach

- level of confidence 99%
- 10-day holding period
- observations based on (at least) 1-year long data window
- Strict conditions of application
- max(VaR on the previous day, average VaR figure of the last consecutive 60 days * correction factor) is the formula of the figure, which needs to be disclosed

What was the problem with the Basel I rules?

- Did not differentiate appropriately
- Did not take into account the portfolio effects (diversification benefits)
- Did not take into consideration the risk mitigating effects (hedges)

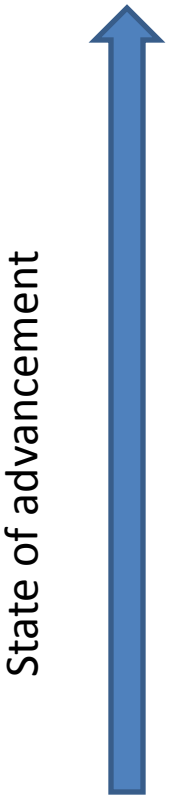
Basel II capital rules

Pillar I	Pillar II	Pillar III
Minimum capital requirements for: • credit risk • market risk • operational risk	Supervisory review process	Disclosure requirements– market discipline

$$\frac{\text{Capital}}{\text{Risk weighted assets} + (\text{market} + \text{operational risk components}) * 12.5} \geq 8\%$$

- 1999 first version
- 2005 final rules
- 2007 possibility for applying
- 2008 mandatory application

Application of Pillar I



Credit risk	Market risk	Operational risk
Advanced internal rating based model	Internal VaR models	Advanced Measurement Approaches
Foundation internal rating based approach	---	Standardized approach
Standardized approach	Standardized approach	Basic Indicator Approach

Standardized approach for credit risk requirement

- It does take account not only the type of the counterparty, but also its riskiness
- Usage of external ratings (like Moody's, S&P)

IRB approach for credit risks

- Simplified regulatory model for calculation of the capital requirement
- Base IRB: bank does estimate the PD, LGD and EAD are fixed
- Advanced IRB: all parameters are estimated by the bank
- Real risk weights: calculating by pre-specified risk function
- Capital requirement: 8% of the risk weighted assets has been kept

Capital requirement for operational risk

- Basic Indicator Approach: 15% of the average of the gross profits in the last 3 years

- Standardized approach: 12, 15 or 18 % of different profit indicators assigned to branches

- Advanced Measurement Approaches: modelling of the potential loss

Problems with Basel II regulation

2007:

- Subprime Crisis (Bear Stearns, Lehman, AIG, Wachovia, Merrill Lynch, Morgan Stanley, etc)

2008

- Financial Crisis (Societe Generale Rouge Trading, Credit Suisse Mispricing, etc)

2009

- Basel II.5 was published
- Basel III was published

On the way towards Basel III (2013-2018 continuous implementation)

- ***Re-regulation of capital items***
- Introduction of leverage ratio (3% for the Tier 1 capital)
- Capital conservation buffer (2,5% above the minimum level)
- Introducing of stressed liquidity rate
- Introducing of liquidity rate for 1 year time horizon

Basel 2.5 capital requirement for market risk

Sum of the following items:

- 10-day 99%-os VaR x backtest multiplier
- 10-day 99%-os stressed VaR x multiplier
- Incremental Risk Charge (IRC) – for products in Trading Book potentially affected by credit risk (bonds, default swaps, etc)
- Comprehensive Risk Measure (CRM) – for correlation products (indices, bespoke tranches, etc)
- capital calculated by the standardized approach for those products, where the above mentioned models have not been approved yet

Base idea of VaR calculation

Current value of the portfolio:

$$f(x_1, x_2, x_3 \dots x_k)$$

Where x_i 's are different risk factors.
We would like to measure the effect of change in these factors on our portfolio somehow:

$$PnL = f(x_1 + \Delta x_1, x_2 + \Delta x_2, x_3 + \Delta x_3 \dots x_k + \Delta x_k) - f(x_1, x_2, x_3 \dots x_k)$$

where the changes are random numbers (variables), hence the PnL as well, whose quantile we are interested in.

Methods for VaR calculation:

$$PnL = f(x_1 + \Delta x_1, x_2 + \Delta x_2, x_3 + \Delta x_3 \dots x_k + \Delta x_k) - f(x_1, x_2, x_3 \dots x_k)$$

1. Full revaluation:
   a. Usage of parametric (mostly Gaussian) distributions. To be able to apply it appropriately the distribution of Δx_i 's must fit well, additionally function f need be 'simple' enough (for instance linear)
   b. Monte Carlo simulation: both distribution of Δx_i and f can be arbitrary, but this method is very calculation-intensive!

Methods for VaR calculation:

2. Calculation using approximations:

$$PnL = f(x_1 + \Delta x_1, x_2 + \Delta x_2, x_3 + \Delta x_3 \dots x_k + \Delta x_k) - f(x_1, x_2, x_3 \dots x_k)$$
$$= \sum f'_{x_i}(x_i)\Delta x_i + \frac{1}{2}\sum f''_{x_i x_i}(x_i)(\Delta x_i)^2$$
$$+ \text{ mixed second order components}$$
$$+ \text{ higher order components}$$

Issues at the implementation:

- finding appropriate risk factor
- gappy time series for a risk factor
- effect of the skipped components
- nonlinear products (options, etc)
- alternative models (f functions)

Modelling of default risk

i=1…N issuers (borrowers)

Point of time when they default: τ_i

The (random) loss at the default of the i-th issuer: l_i

Our loss in the [0,T] time period:

$$L = \sum_{i=1}^{N} l_i \, I(\tau_i \leq T)$$

Hence the expected loss:

$$E(L) = \sum_{i=1}^{N} p_i \, E(l_i | \tau_i \leq T)$$

where: $p_i = P(\tau_i \leq T)$

Default risk – value process

Let us assume, that there exist such X_i continuous random variables (asset values) and fixed c_i thresholds (liquidation values), that:

$$\{\tau_i \leq T\} \equiv \{X_i \leq c_i\}$$

This means, if F_i^X denotes the cumulative distribution function of X_i :

$$c_i = \left(F_i^X\right)^{-1}(p_i)$$

Default risk – systematic factors

Additionally, let us assume that there exists a d-dimensional Z random vector (with 0 means and with unit variance components), that (X_1, X_2… X_N, I_1, I_2… I_N) is conditionally independent from Z.

Typical interpretation of components of Z:

- general state of economy
- situation of one single industry, etc.

Default risk – systematic factors 2.

From the conditional independency:

$$E(L) = E\left(\sum_{i=1}^{N} p_i(Z) l_i(Z)\right)$$

Where:

$$p_i(Z) = P(X_i \leq c_i | Z)$$

$$l_i(Z) = E(l_i | Z)$$

Default risk – simplest Gaussian copula model

$$\left.\begin{aligned} X_i &= a_i Z + \sqrt{1-\|a_i\|^2}\,\varepsilon_i \\ l_i &= l_i^{max}(1-R_i) \end{aligned}\right\} i = 1 \ldots N$$

Where R_i's are non-random values on [0,1] (recovery rates), l_i^{max} denotes the exposure toward the i-th issuer .

ε_i's are iid's, which are independent from Z and have standard normal distribution.

Default risk – random recovery

$$\left.\begin{aligned} X_i &= a_i Z + \sqrt{1-\|a_i\|^2}\,\varepsilon_i \\ l_i &= l_i^{max}\left(1 - C_i(\mu_i + b_i Z + \xi_i)\right) \end{aligned}\right\} i = 1 \ldots N$$

Where ξ_i 's are independent both form Z and ε_i 's, as well as from each other. They have zero means and $\sigma_{\xi_i}^2$ variance.

C_i's are arbitrary functions with [0,1] values.
μ_i 's are constant parameters.

Default risk – random recovery 2.

Statement:

Let us denote the cumulative distribution function of ε_i by F_i^{ε}.

Then:

$$p_i(Z) = F_i^{\varepsilon}\left(\frac{\left(F_i^X\right)^{-1}(p_i) - a_i Z}{\sqrt{1 - \|a_i\|^2}}\right)$$

Proof:

We need only to apply the definitions. (very simple)

Default risk – random recovery 3.

Statement:

Let C_i 's be strictly monotonous increasing functions.

Let us denote: $Y_i = \mu_i + b_i Z + \xi_i$ and $\sigma_i = \sqrt{b_i \cdot b_i + \sigma_{\xi_i}^2}$

If (X_1, X_2… X_N, Y_1, Y_2… Y_N) belongs to the group of continuous elliptical distributions:

$$\tau(X_i, X_j) = 2\pi^{-1}\sin^{-1}(a_i \cdot a_j), i \neq j$$

$$\tau(R_i, R_j) = \tau(Y_i, Y_j)2\pi^{-1}\sin^{-1}\left(b_i \cdot b_j / (\sigma_i \sigma_i)\right), i \neq j$$

$$\tau(R_i, X_j) = \tau(Y_i, X_j)2\pi^{-1}\sin^{-1}\left(b_i \cdot a_j / \sigma_i\right)$$

Where τ denotes the Kendall rank correlation.

Reminder– rank correlation

Let X and Y be arbitrary random variables.
Then:

$$\tau(X,Y) \stackrel{\text{def}}{=} P\left((X-\tilde{X})(Y-\tilde{Y})>0\right) - P\left((X-\tilde{X})(Y-\tilde{Y})<0\right)$$

Where $(\tilde{X},\tilde{Y})$ is an independent copy of (X,Y).

Default risk – random recovery 4.

Statement:

Let $C_i = \Phi$ (std normal cumulative distribution function)

Then:

$$P(R_i < x) = \Phi\left(\frac{\Phi^{-1}(x) - \mu_i}{\sigma_i}\right)$$

$$E(R_i) = \Phi\left(\frac{\mu_i}{\sqrt{1+\sigma_i^2}}\right)$$

$$V(R_i) = \Phi_2\left(\frac{\mu_i}{\sqrt{1+\sigma_i^2}}, \frac{\mu_i}{\sqrt{1+\sigma_i^2}}; \frac{\sigma_i^2}{1+\sigma_i^2}\right) - \Phi\left(\frac{\mu_i}{\sqrt{1+\sigma_i^2}}\right)^2$$

Where $\Phi_2(.,.;\varrho)$ denotes the two-dimensional standard normal cumulative distribution function with ϱ correlation.

Towards Basel ‘4’: Fundamental Review of Trading Book (FRTB)

- Eurozone crisis seems to last for a couple of years
- Big differences between model-based and standardized capital charges
- Trembling reliance on internal models

Towards Basel ‘4’: Fundamental Review of Trading Book (FRTB)

Goals:

- Make the currently used market risk models more standardized
- Decrease the gaps between model-based and standardized capital charges
- Removing the parallelisms in the capital requirements

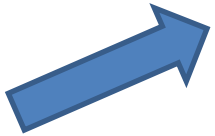
Towards Basel '4': Fundamental Review of Trading Book (FRTB)

VaR

$$\frac{\text{VaR}_{1\text{ day, }99\%} * \sqrt{10} * 3}{8\%}$$

$$\frac{\text{stressed ES}_{\text{varying LH,97.5\%}}}{8\%}$$

Stressed VaR



$$\frac{\text{stressed VaR}_{1\text{ day, }99\%} * \sqrt{10} * 3}{8\%}$$

Towards Basel ‘4’: Fundamental Review of Trading Book (FRTB)

Other risk measures:

- IRC -> DRC (default risk charge)
- CRM -> will be defined at a later stage (disappear?)
- Std charge -> the size of it will be reduced

Towards Basel ‘4’: changes in Credit Risk

According to a paper published by Basel Committee in December 2017 (first appeared in 2016):

- A-IRB model cannot be used at the following exposures:
  - Banks and other financial institutions
  - Corporates (above consolidated annual revenues of 500 m EUR)
  - Equities
- Even if A-IRB remains applicable, certain model parameters will be constrained
- Further specification of parameter estimations

Beyond the Basel regulation – stress tests

Stress testing system has been the key innovation in capital regulation and was found to be the binding capital constraint in many cases.

Pro's:

- It makes other risk measures more effective
- Forward-looking assessment of potential losses
- Might be consistent across banks

Beyond the Basel regulation – stress tests

Con's:

- Inherit need for adaption
- It does not take into account second-round effects

Stress test in US - CCAR

Comprehensive **C**apital **A**nalysis and **R**eview

- Annual exercise from 2009 on
- Capital projections based on several stressed scenarios
- Calculations are done both by the banks and the regulator (Fed) separately
- Dividend and share repurchases will be permitted based on the result of this exercise

Stress test in US - CCAR

Features of this exercise:

- Requirements are not explicitly disclosed in advance
- This stress test must never be static
- It might have 3 outcomes: objection, conditional non-objection, non-objection
- Contains quantitative and qualitative requirements
- Stricter requirements for G-SIB's (banks of global systemic importance)

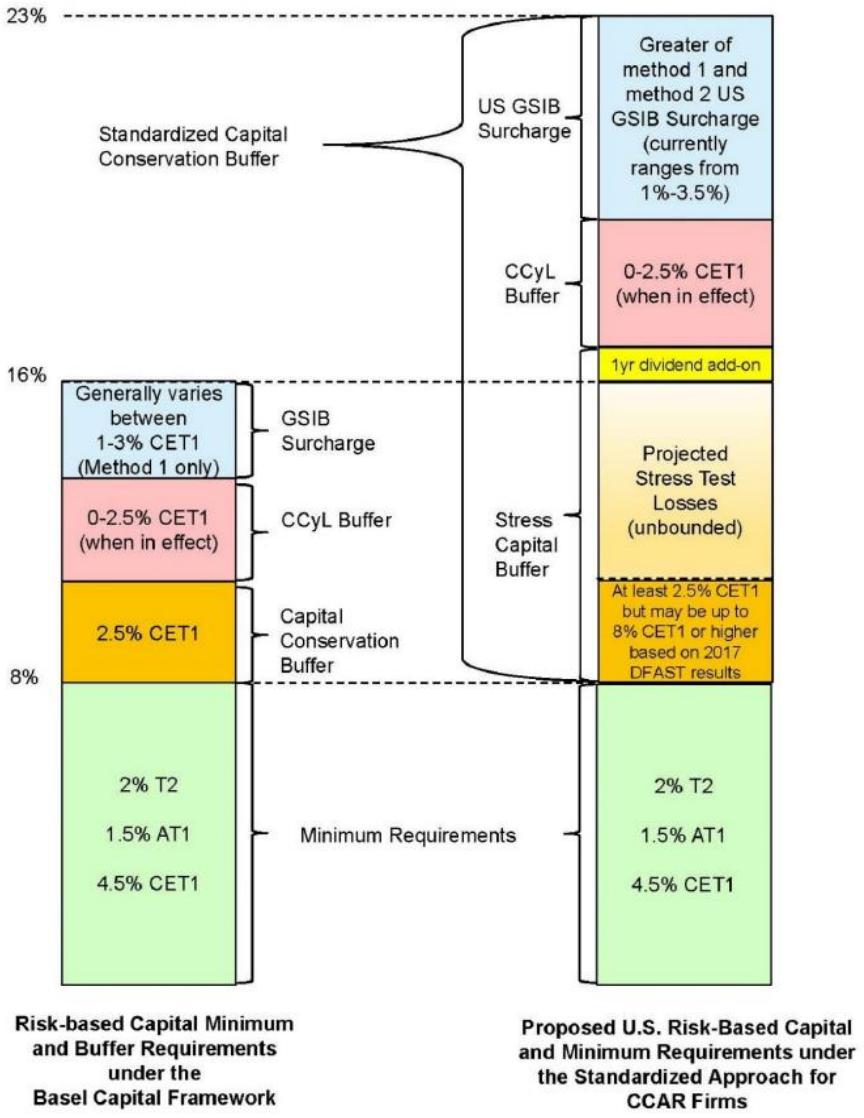
Stress test in US - CCAR

Future plans:

- Qualitative objections will be phased out
- SCB (Stress Capital Buffer): replaces the existing 2.5% fixed capital conservation buffer

It has become a Fed proposal

Stress Capital Buffer in US



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