

**A forward-looking model
for time-varying capital requirements
and the New Basel Capital Accord**

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Plan of the presentation:

- 1) Overview of credit risk measurement: the NBCA and the business cycle
- 2) A forward-looking model for capital requirements
- 3) Application to US data

The New Basel Capital Accord

Three Pillars:

Pillar 1: minimum capital requirements;

Pillar 2: supervisory review of the capital adequacy;

Pillar 3: market discipline.

Pillar 1 for credit risk: increased risk-sensitivity

A) Standardised Approach

B) Internal Rating Based (IRB) Approach

→ internal estimation of risk components (mainly PD)

Time dimension of credit risk

Dependence on the general economic conditions through systematic risk factors:

Default and migration rates dependent on the state of the business cycle:

Evidence: e.g. Wilson (1997), Nickell et al. (2000),
Carey (2002), Bangia et al. (2002)

In particular:

Bangia et al. (2002): recession and expansion regimes in transition matrices

Business cycle and credit risk models:

Where?

A) Rating Systems:

- Rating Assignment
- Rating Quantification (Probability of Default –PD–)

B) Loss Given Default (LGD)

C) Exposure at Default (EAD)

D) Correlations

Review: Allen and Saunders (2003)

Focusing on (A):

Rating Assignment:

- Point in time –*pit*– (absolute risk)
- Through the cycle –*ttc*– (relative risk – ordinal ranking–)

Rating Quantification:

- Unconditional (constant) PDs
- Time-varying / cycle dependent PDs

Rating systems in current practice

➤ Rating Agencies:

through the cycle ratings;

PDs estimates = long-run averages of default rates

➤ Banks: typically point in time logic (ratings based on accounting or market data)

Crouhy et al. (2001) : *ttc* for lending, *pit* for capital

The NBCA requires:

- through the cycle ratings;
- PDs estimated as long-run averages;

→ neutralization of the business cycle effects

→ time dimension of risk neglected in capital requirement

→ business cycle accounted for under pillar 2 (stress test)

Procyclicality

Def. Amplification of the business cycle due to the **risk-sensitivity** of capital requirements

→ reduction in the capital ratio during recession

$$\frac{RC}{\sum_i w_i A_i} \geq 8\%$$

RC = regulatory capital;

$\sum_i w_i A_i$ = risk-weighted activities.

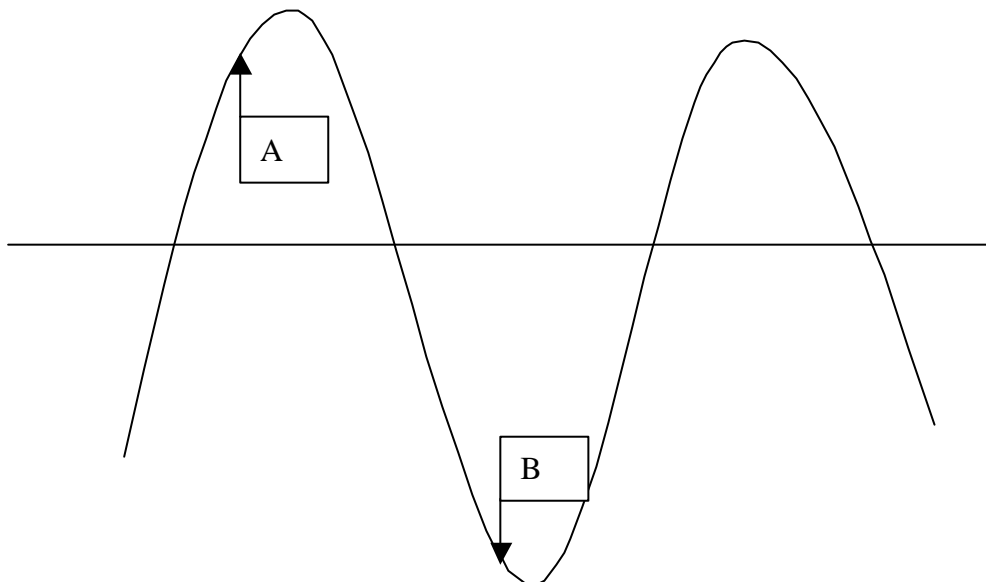
Including the time dimension of risk:

→ economic conditions over the credit horizon (typically one-year)

Two views of the business cycle:

- 1) business cycle too irregular to be predicted → current conditions as the best forecast for future conditions
- 2) business cycle –at least partly- predictable → appropriate forecast over the credit horizon

Severity of the procyclicality depending on (1) or (2):



Objective of the proposed model:

- inclusion business cycle effects;
 - smoothing procyclicality by introducing forecasts.
- *tbc* ratings + time-varying forward-looking PDs

Models for business cycle dependent PDs estimation

➤ Specific macroeconomic variables (e.g. GDP),
continuous values

→ CreditPortfolioView (Wilson (1997)):

PDs estimation: logit regression model (infinite possible values); macroeconomic variables forecast through AR

➤ Business cycle as discrete variable, typically two values
(expansion and recession)

→ Bangia et al. (2002):

PDs estimation: averages over periods of expansion and recession (two possible values) within the Hamilton's regime switching model

Why a discrete binomial model?

- Evidence of good representativeness of the discrete states of the business cycle (e.g. Bangia et al. (2002))
- Econometric models for prediction of the business cycle states more accurate and stable than the ones for prediction of specific macroeconomic variables
- From a regulatory point of view: the binary representation induce less variability than the continuous one

The proposed model

Underlying HP: ratings assigned through the cycle

A.1 One-period model: period length equal to the credit horizon k , $k \in N$.

A.2 Business cycle state S binomial:

$$S = \begin{cases} E & P(E) \\ R & P(R) \end{cases}$$

$P(E)$, $P(R)$ probability of expansion/recession over the horizon, $P(E)=1-P(R)$

A.3 $P(R)$ time-varying and predictable: given information

I_t , the recession probability over $[t,t+k]$

$$P_t(S_{t+k} = R) = P(S_{t+k} = R | I_t) = f(\mathbf{b}'x_t)$$

where:

S_{t+k} = business cycle state over $[t,t+k]$;

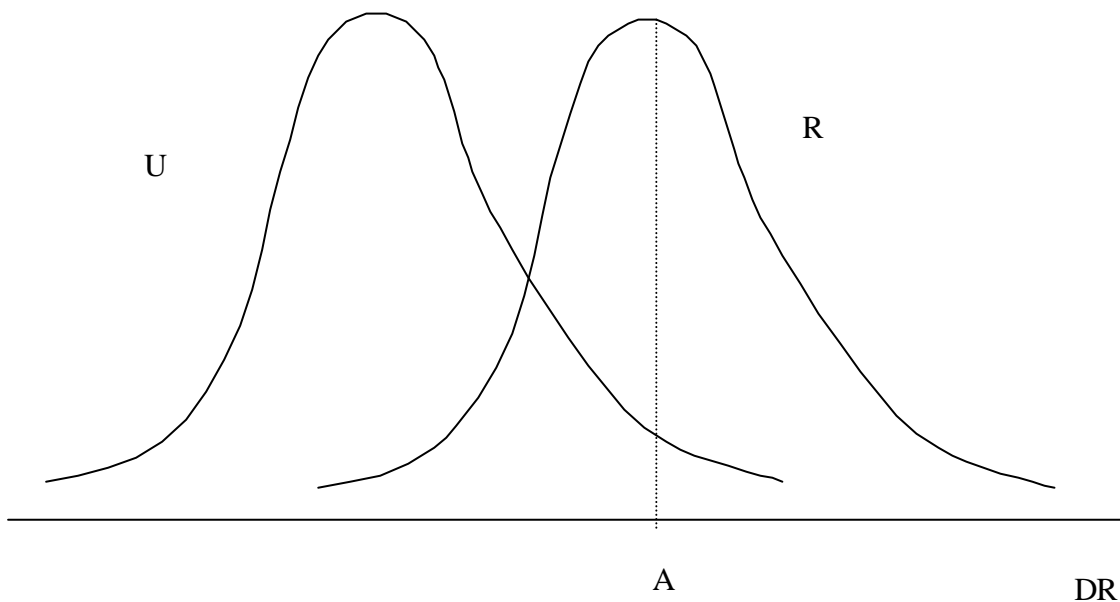
x_t = vector of explanatory variables for the business cycle

regime, $x_t \in R^n$;

A.4 Default rate DR stochastic variable with state-dependent distribution:

$$f(DR | S) = \begin{cases} f_E(DR) & \text{if } S = E \\ f_R(DR) & \text{if } S = R \end{cases}$$

Conditional and unconditional default rate distribution



→ ex-ante mixture distribution:

$$f(DR) = P(E)f_E(DR) + P(R)f_R(DR)$$

By defining the conditional default probabilities as:

$$PD_E = E(DR | E) \quad PD_R = E(DR | R)$$

the ex-ante (unconditional) default probability is :

$$PD = E(DR) = \int DR f(DR) dDR = P(E) \times PD_E + P(R) \times PD_R$$

→ analogous to NBCA if $P(E)$, $P(R)$ long-run sample proportion

→ but $P(E)$, $P(R)$ forward-looking over the credit horizon:

DR_{t+k} = default rate over [t, t+k]

$$P_{t+k}(E) = P(S_{t+k} = E | I_t), \quad P_{t+k}(R) = P(S_{t+k} = R | I_t)$$

$$f_t(DR_{t+k}) = P_{t+k}(E) f_E(DR) + P_{t+k}(R) f_R(DR)$$

$$PD_t = E_t(DR_{t+k}) = P_{t+k}(E) \times PD_E + P_{t+k}(R) \times PD_R$$

“An obligor’s unconditional default probability, also known as its PD or expected default frequency, is the probability of default before some horizon given all information currently observable. The conditional default probability is the PD we would assign the obligor if we also knew what the realized value of the systematic risk factors at the horizon would be.”, Gordy (2002).

The credit horizon

NBCA (and credit risk models in general): $k =$ one year

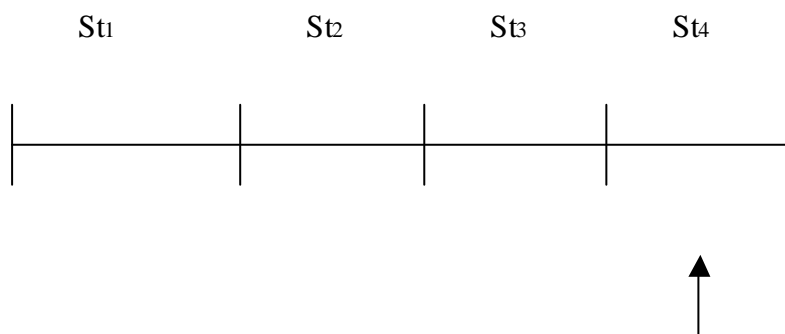
Business cycle chronology \rightarrow months/quarters

By dividing $[t, t+k]$ in n sub-periods of length k/n :

$$S_{t_i} = \begin{cases} E & \text{if } [t_{i-1}, t_i] \text{ expansion} \\ R & \text{if } [t_{i-1}, t_i] \text{ recession} \end{cases} \quad i = 1, \dots, n$$

$$t_i = t + i \times \frac{k}{n} \quad i = 0, \dots, n$$

$k = 12$ months; $n = 4$.



\rightarrow Forecast over each quarters

\rightarrow Alternatively, proxy consistent with procyclicality target:

forecast of S_{t_4}

Applications to US data

1. Identification of the expansion and recession regimes in the default rates and estimation of regimes PDs (PD_E and PD_R) for each rating class;
2. Business cycle forecast: estimation of the recession probabilities;
3. Calculation of the time-varying PDs and the associate capital requirements through the NBCA formula for the IRB approach.

1. Conditional PDs

Bangia et al. (2002): S&P database for US obligors → according to NBER chronology, identification of expansion and recession regimes in quarterly transition matrices

US Expansion quarterly transition matrix

	AAA	AA	A	BBB	BB	B	CCC	D
AAA	0.9821	0.0166	0.0011	0.0002	0.0002	0.0000	0.0000	0.0000
AA	0.0015	0.9808	0.0161	0.0012	0.0001	0.0003	0.0001	0.0000
A	0.0002	0.0053	0.9806	0.0121	0.0011	0.0006	0.0000	0.0000
BBB	0.0001	0.0007	0.0147	0.9694	0.0125	0.0022	0.0002	0.0002
BB	0.0001	0.0003	0.0019	0.0193	0.9531	0.0225	0.0016	0.0012
B	0.0000	0.0002	0.0007	0.0010	0.0170	0.9591	0.0131	0.0088
CCC	0.0005	0.0000	0.0019	0.0023	0.0047	0.0357	0.8732	0.0817
D	0	0	0	0	0	0	0	1

Source: Bangia et al (2002)

US Recession quarterly transition matrix

	AAA	AA	A	BBB	BB	B	CCC	D
AAA	0.9799	0.0176	0.0025	0.0000	0.0000	0.0000	0.0000	0.0000
AA	0.0018	0.9689	0.0279	0.0005	0.0009	0.0000	0.0000	0.0000
A	0.0002	0.0088	0.9644	0.0259	0.0007	0.0000	0.0000	0.0000
BBB	0.0004	0.0004	0.0111	0.9631	0.0233	0.0007	0.0000	0.0011
BB	0.0000	0.0006	0.0006	0.0139	0.9498	0.0272	0.0042	0.0036
B	0.0000	0.0006	0.0006	0.0011	0.0072	0.9502	0.0272	0.0177
CCC	0.0000	0.0000	0.0000	0.0000	0.0000	0.0120	0.8560	0.1320
D	0	0	0	0	0	0	0	1

Source: Bangia et al (2002)

H_p : default process time-homogeneous Markov chain over expansion and recession sub-periods

→ yearly conditional PDs (PD_E and PD_R)

2. Business cycle forecast

Estimation of the regimes probabilities

- Financial variables as explanatory variables: interest rates term spread, equity prices [Estrella and Mishkin (1998)]

- Probit Model:

$$P_t(S_{t4} = R | I_t) = P(R_{t4} = 1) = \Phi(\mathbf{b}' X_t)$$

$$R_{t4} = \begin{cases} 1 & \text{if } [t_3, t_4] \text{ recession} \\ 0 & \text{if } [t_3, t_4] \text{ expansion} \end{cases}$$

X_t = explanatory variables

Explanatory variables considered:

1) Term spread:

10 years Treasury bond rate – 3 months Treasury bill rate

2) Equity:

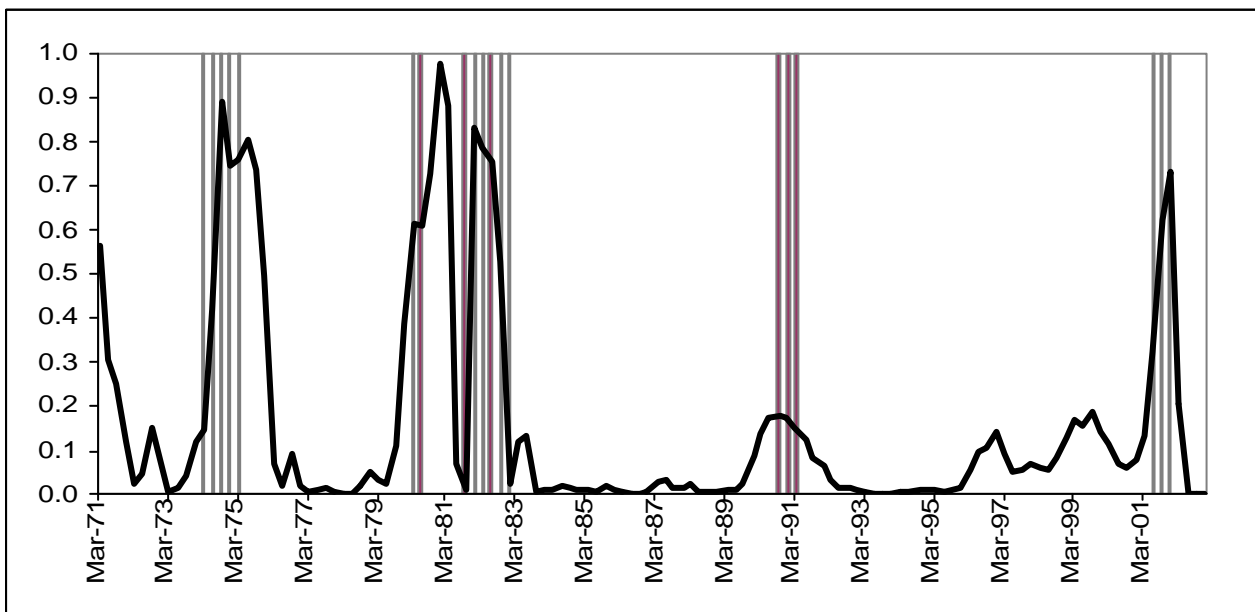
S&P stock index

Estimation sample: 1951-1970

Forecast sample: 1971-2002

SIC \Rightarrow term spread only

Quarterly Recessions Probability Forecast



3. Capital requirements

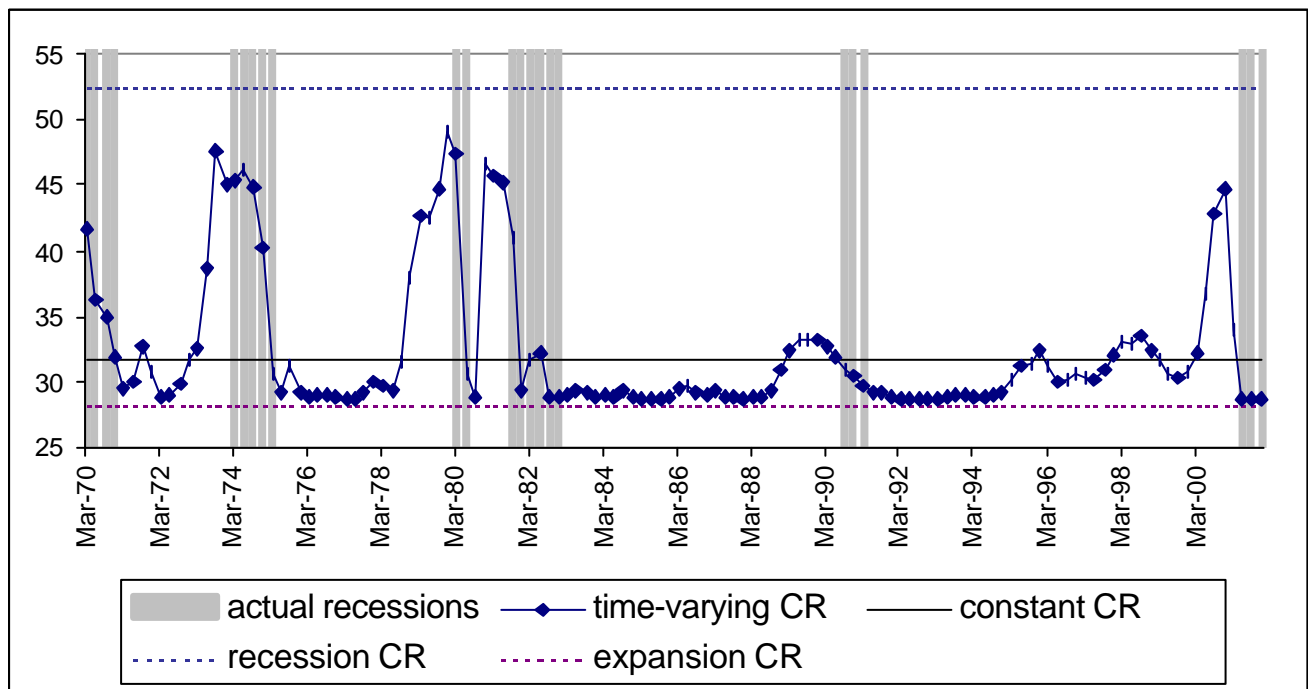
Portfolio: exposures to ratings BBB, BB, B, CCC

proportional to the S&P database average ratings distribution

IRB Foundation Approach (April 2003)

LGD = 45% M=2,5

Capital Requirements (CR)



Further Research

- Model validation: evaluation of the model both from a micro- and macro-economic point of view:

→ portfolio composition of the individual bank under either constant or time-varying forward-looking capital requirements;

→ macroeconomic consequences, dependent on the relation between capital requirement, lending and output.

- Dataset: analysis of default and business cycle data for countries other than US (Italy, European business cycle)