PROCYCLICALITY AND THE NEW BASEL ACCORD – BANKS' CHOICE OF LOAN RATING SYSTEM[♦]

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Abstract

The Basel Committee on Banking Supervision is proposing to introduce, in 2005, new risk-based requirements for internationally active (and other significant) banks. These will replace the relatively risk-invariant requirements in the current Accord. This article examines the implications of these new risk-based requirements for procyclicality, in particular whether the choice of particular loan rating system by the banks would significantly increase the likelihood of sharp increases in capital requirements in recessions, creating the potential for classic credit crunches. The paper finds that rating schemes which are designed to be stable over the cycle, akin to those of the external rating agencies, would not increase procyclicality but ratings which are conditioned on the point in the cycle, akin to a Merton approach, could substantially increase procyclicality. This makes the question of which rating schemes banks will use very important. The paper uses a general equilibrium model of the financial system to explore whether banks would choose to use a countercyclical, procyclical or neutral rating scheme. The results indicate that banks would not choose a stable rating approach which has important policy implications for the design of the Accord. The Committee may need to rule out some types of rating scheme currently used by the banks.

1. Procylicality and the new Basel Accord

A long-standing concern with regard to the setting of minimum prudential capital requirements for banks is that pressure on bank capital in a recession (because specific provisions and write-offs if not absorbed in earnings will reduce bank capital) could lead to cutbacks in bank lending in stress periods. The introduction of the Basel Accord in 1988, marked a worldwide adoption of minimum capital requirements that had to be met at all times. A number of academic studies were carried out after the recession in the early 1990s to see if the minimum standards had indeed created procyclical effects. It would not be surprising if the introduction of capital requirements had some effect on lending, through encouraging banks to focus on the true cost of some of the riskier loans. But the concern was that fixed capital requirements could have significantly exacerbated the 1990 recession by creating a credit crunch and this was the focus of a number of academic papers. This literature is surveyed in a study carried out by the Basel Committee on Banking Supervision [Jackson, et al (1999)] and the conclusion for the US was that particular sectors such as real estate or small businesses may have been affected by pressure on bank capital [Hancock and Wilcox (1997), Hancock and Wilcox (1998) and Peek and Rosengren (1997a, 1997b)]. But there was no evidence of widespread problems.

The relatively muted effects found, however, probably reflect the fact that earnings are the first buffer against the need to raise provisions or write-off loans, limiting the impact of recessions on bank capital and therefore the procyclical effects. Also, modest falls in capital may be covered by increased use of subordinated debt which is included in Tier 2 capital. The new Accord which will be introduced in 2005 could, however, have a profound effect on the dynamics of bank capital and lending in recessions. In contrast to the current Accord where, for a given quantum of lending to a particular set of borrowers, the capital requirement is invariant over time, under the new Accord the capital requirements will depend on the current risk assessments of those borrowers. If borrowers are downgraded in a recession, then the capital requirements faced by the bank will rise. This would be in addition to the possible reduction in the bank's capital because of write-offs and specific provisions.

This paper examines the possible extent of variation in bank capital requirements for different profiles of bank portfolio, and sets this against the excess capital maintained by the banks, taking into account the possible reduction which might be experienced in a recession.
The extent to which banks need to downgrade borrowers in a recession will depend on the way in which borrowers are assigned to a rating band under the new Accord. If borrowers are assigned to a rating under the assumption that economic conditions prevailing when the loan was made were likely to hold over the life of a loan, then there would be substantial downgrading if economic conditions deteriorated (and vice versa if conditions improved). In contrast, if banks, when assessing the credit-worthiness of the borrower, consider the effect of a change in the economic climate, then downgrades might be rather less.

The new Accord is currently being designed and there is a live policy debate over whether different rating approaches would lead to different procyclical outcomes and if they did which approach banks would choose to adopt. If the banks seem likely to use rating systems which would make procyclicality worse the Committee might need to constrain their use. This is a very important policy issue because the original proposal for the new Accord was to allow banks to utilise their existing rating systems.

The paper uses a general equilibrium model to assess the costs/benefits for the banks of pursuing different approaches to setting ratings and therefore whether they would voluntarily choose to adopt a forward-looking approach which would give more stable ratings over the cycle.

A simplified version of Tsomocos (2001) is used. The model includes heterogeneity of economic agents and endogenous default. By introducing capital charges (in the form of risk weights) for bank assets which depend on the rating assigned by the bank which in turn depends on probability of default, we are able to assess the effect on bank profitability and welfare of the choice of different rating approaches (countercyclical, procyclical and neutral) by the banks under the proposed new Accord. The rating schemes differ in how they relate to the probability of default. Under the countercyclical the higher the probability of default the higher the rating assigned, whereas under the procyclical approach, the higher the probability of default the lower the rating assigned.

Section 2 sets out the background on the proposed new Basel Accord, section 3 looks at the different rating approaches used by the banks, Section 4 examines the effect of the new approach on bank capital requirements over the cycle, depending on the rating approach chosen by the banks. Section 5 summarises the Tsomocos general equilibrium model, sets out the modelling of default and default dependent risk weights and examines which rating scheme banks would choose to adopt. Section 6 considers the forward-looking approach to ratings. Section 7 sets out the conclusion.

2. Basel Accord

The Basel Accord sets the minimum capital requirements for most significant banks worldwide. The current Accord, agreed in 1988, is based on only a limited differentiation of risk using broad categories of exposure – with an 8% charge for all exposures except OECD government, OECD interbank and under one-year interbank and residential mortgages. The requirements reflect the type of loan and not the riskiness of the loan (except for the OECD/non OECD distinction) and therefore will not change if the creditworthiness of borrowers deteriorates.

In contrast, the new Accord on which the Committee is currently working will differentiate exposures according to the riskiness of the borrower. Capital requirements will therefore rise if the creditworthiness of borrowers deteriorates. The new Accord will offer two approaches for the setting of risk-based capital requirements. Under a standardised approach, banks will allocate borrowers to bands according to the external rating of the borrower (for example, from a rating agency) – see below.

Table 1: New Standard Approach - percentage capital charges according to external rating of the borrower

	AAA to AA-	A+ to A-	BBB+ to BBB-	BB+ to BB-	B+ to B-	Below B-	Unrated
Sovereigns	0	1.6	4	8	8	12	8.0
Banks Option 2*							
< 3 months	1.6	1.6	1.6	4.0	4.0	12	1.6
> 3 months	1.6	4.0	4.0	8.0	8.0	12	4.0
Corporates	1.6	4	8	8	12	12	8.0

(*There is also an option which uses the rating of the sovereign to rate banks)

Under an alternative, internal ratings-based (IRB) approach, banks will allocate borrowers to probability of default bands. The Committee has set out a function for calculating the capital requirement for each loan based on the probability of default (PD) of the borrower (set by the bank) and the loss given default (LGD) which would be experienced were the borrower to fail. Under the foundation (IRB) approach the Committee would set the loss given default, and under an advanced approach the bank would set it. The capital requirements were calculated by the Committee, using credit risk models, for losses over a one-year horizon with a 99.5% confidence level. It was assumed that the correlation between the returns on different corporate exposures was 20%. This was based on information on correlations used by the industry and also research carried out by the Committee on correlations implicit in economic capital allowed by firms. There was also an add-on to cover measurement error (the models tend to underestimate the tail events [see Nickell, Perraudin and Varotto (2001)] and the low loss absorbing capacity of Tier 2 capital because of the inclusion of subordinated debt. The banks' economic capital models assume that equity will be used to ensure a target solvency level is attained. In contrast, under the Basel Accord up to half the requirement can be met with subordinated debt. The following risk-weight function, based on this, was put forward for the corporate portfolio in the second consultation paper issued by the Committee Basel Committee (2001).

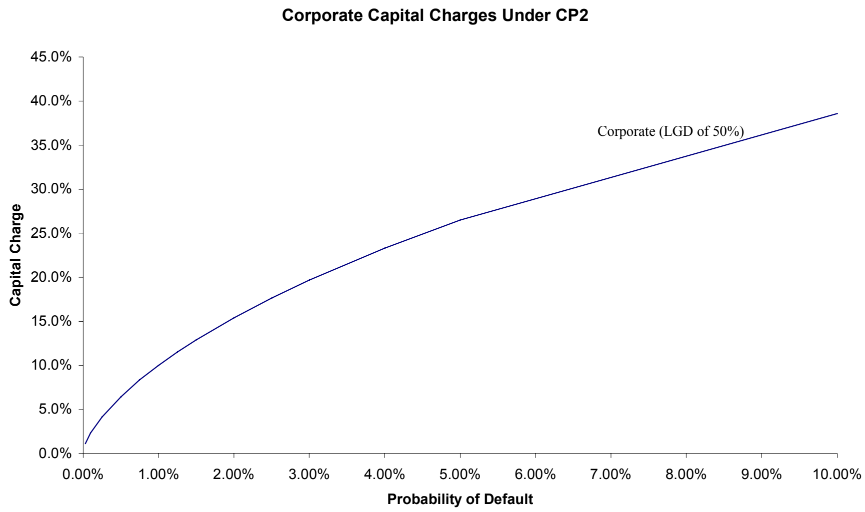
Benchmark risk weight = $976.5 \times N(1.118 \times G(PD) + 1.288) \times (1 + .0470 \times (1 - \text{PD}) / PD^{0.44})$.

Here, $N(.)$ denotes the standard cumulative normal distribution and $G(.)$ is the inverse of this.

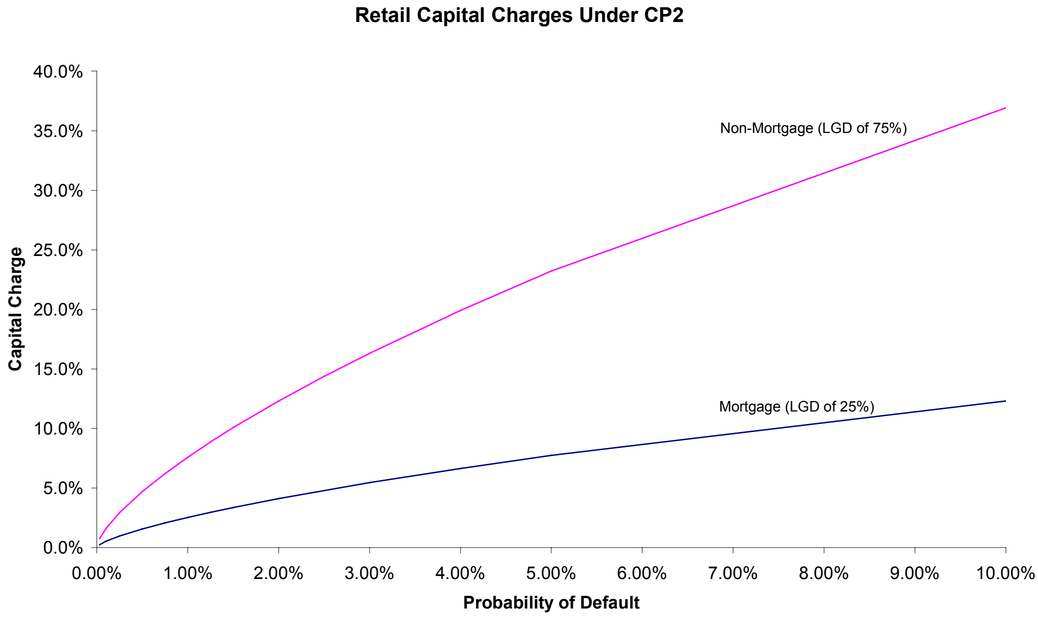
PD is the one year default rate.

As described in detail by Gordy (2000), the formula is derived from a restricted version of the CreditMetrics model.

Under this risk weight function the capital requirement for an unsecured exposure (50% LGD under the foundation approach) rises steeply as the probability of default increases.



Under the treatment for retail set out in the second consultative paper, the risk weights proposed were half those put forward for corporates for a given PD, and banks could set their own LGD – average LGDs for non-mortgage retail are around 75% and those for mortgage retail are around 25%. This gives capital requirements which rise somewhat less steeply with PD than is the case for the corporate book.



Since the release of the consultation paper the Committee has been carrying out further work to assess the appropriate corporate and retail curves – the corporate weighting function has been adjusted to take into account the fact that small and medium enterprise (SME) exposures account for a heavy proportion of the loans at higher PDs. These exposures have greater idiosyncratic risk which reduces the correlation for loans in the higher PD bands. The Committee is now considering setting correlation as a declining function of PD from 20% to 10%, using the following formula.

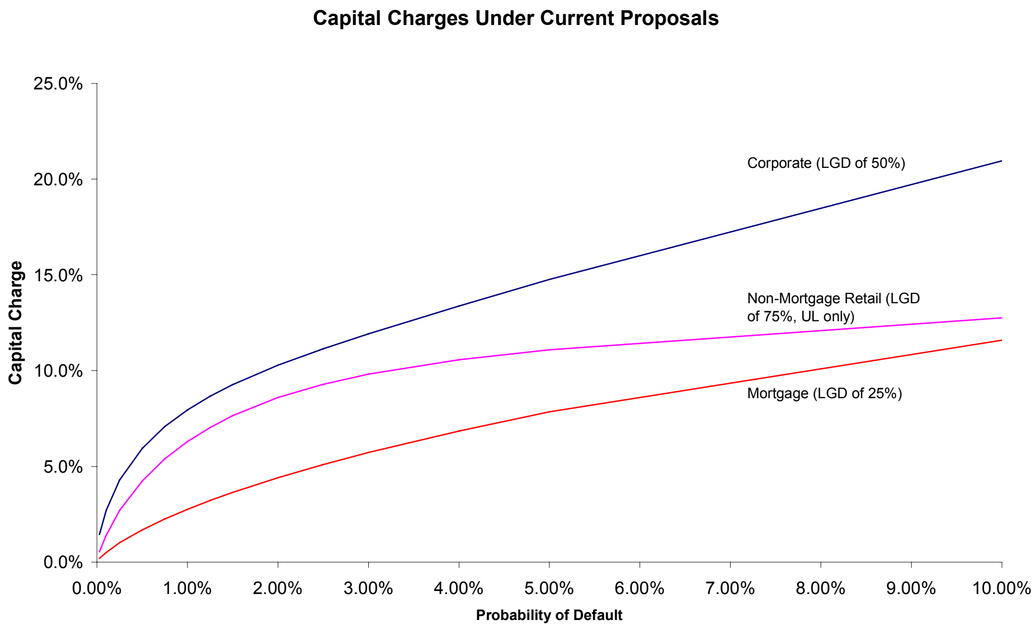
$$\rho(PD) = \left(\frac{1-e^{-50.PD}}{1-e^{-50}}\right)\times 10\% + \left(1-\frac{1-e^{-50.PD}}{1-e^{-50}}\right)\times 20\%$$

(The correlation relates to the correlation between the latent variables in a CreditMetrics model not correlation between defaults.)

The Committee is also considering calibrating the capital requirements using a 99.9% confidence level rather than 99.5% plus an add-on, which delivers a flatter curve. This still delivers a solvency level equivalent to a low investment grade rating because part of the capital held to deliver it is subordinated debt not equity – which was one of the reasons for the add-on on the CP2 proposals.

Following research on retail, the Committee is considering setting correlation for non-mortgage retail as a declining function of the PD – declining from 15% to 4%. In contrast, for mortgages a fixed correlation of 15% is thought appropriate because of the large cyclical influence on mortgage losses. The Committee is also considering calculating capital charges for non-mortgage retail on the basis of Unexpected Loss (UL) only to reflect the high margins on for example credit cards which cover expected loss.

The chart below sets out the new corporate and retail curves under consideration.



3. Bank ratings

The new Basel requirements would depend on banks' internal probability of default ratings to which borrowers are assigned. For banks on the advanced approach the requirements would also depend on the loss given default assigned by the different banks.

One issue with the probability of default ratings is the extent to which the rating approach chosen would affect the capital requirements and the degree of procycliclity. There is very little information available on the variation in internal bank ratings assigned to different borrowers over the cycle. One paper (Carling 2001) examines ratings assigned by a Swedish

Bank to a group of borrowers over the period 1994 to 2000 and shows that they are not stable over time.

But although there is little direct evidence on bank internal ratings there is evidence from other sources. Some banks have chosen to adopt through the cycle rating systems which are modelled on the approach taken by the rating agencies or are even more conservative. Indeed some banks have carried out careful mapping exercises to ensure that their rating approaches are very close to those of the main rating agencies. The approach taken to the cycle is clearly set out in the following comment by Moody's. "In coming to a conclusion [on the rating] rating committees routinely examine a variety of scenarios. Moody's ratings deliberately do not incorporate a single, internally consistent economic forecast. They aim rather to measure the issuer's ability to meet debt obligations against economic scenarios reasonably adverse to the issuer's specific circumstances". The rating would therefore not be conditioned on the point in the cycle.

The similarity in approach between some banks' internal ratings systems and the approach used by Moody's and Standard and Poor's means that evidence on the volatility of the rating agency ratings is indicative of the volatility which would be seen in some banks' internal ratings, where they have tried to adopt a similar through the cycle approach.

Many other banks have expressly adopted what is known as a 'point in time' approach to ratings where the current financial position of the borrower is assumed to remain unchanged. The closest parallel in terms of an external ratings approach is KMV which uses the current equity price of the borrower and current information on the borrower's liabilities to calculate a Merton default likelihood. A number of banks do use the KMV approach for their large corporate exposures. Evidence from a Merton approach can therefore provide some indication of the volatility of more 'point in time' approaches used by the banks. These are conditional on the point in the cycle.

A paper published by KMV (Uses and Abuses of Bank Default rates, March 1998) shows that KMV ratings are considerably more volatile than those from Standard and Poor's. The paper compares a KMV one-year transition matrix (which shows the various probabilities that a borrower starting the year in one rating band will end the year in that band or another band) with a Standard & Poor's transition matrix. They find that with the rating agency matrix there is around a 90% probability of remaining in a grade for a year which is around twice the probability in the KMV transition matrix – see Annex 1. The transition matrices are shown in tables A and B in the Annex.

4. The effect on bank capital requirements over a cycle

With risk weight a rising function of PD, an overall weakening in the credit quality of a bank's portfolio will result in an increase in that bank's overall capital requirements. Indeed, this risk sensitivity is an important part of the new capital framework. But a side effect will be that capital requirements are likely to rise in recessions because borrowers are more likely to be downgraded than upgraded. Banks will have to meet this higher capital requirement at a time when their overall capital is under pressure because of write-offs and specific provisions.

The pressure on individual banks will depend on the extent of downgrading in their loan books and the headroom they have to accommodate an increase in the minimum capital requirements. This would depend on the amount of excess capital maintained in better times and access to capital markets for new equity or subordinated debt.

An important policy question is therefore the likely extent of loan downgrading for different banks and banking systems in recessions and the consequent increase in capital requirements. This question is explored by taking the profiles of loan books across different PD bands seen for banks in different countries and across the G10, and applying recession ratings transition matrices to produce a stressed quality distribution. The change in the capital requirements under the new Basel Accord can then be calculated from the two quality distributions.

Information is available on the quality distribution of banks' corporate loan books from various sources. The Federal Reserve Board carried out a survey of the distribution of loans by rating band for a number of US banks, reported in Gordy (2000). The average and high quality distributions are shown below. A few banks publish ratings distributions – the distribution for Deutsche is shown in the table under high quality European.

In November, the Basel Committee put on the BIS website the results of a quantitative impact study, looking at the effect that the new Basel Accord proposals would have on the minimum capital requirements of a sample of large internationally active G10 banks. The study includes weighted[1] average information on the quality distributions of corporate, interbank and sovereign portfolios held by these banks. For corporate exposures 36% are in AAA, AA and A, 30% in BBB and 34% below BBB. This has been used to estimate an allocation across the finer bands used in the FRB survey which is included in Table 2.

Table 2: Portfolio distributions of credit quality for corporate exposures

	Average Quality – US (%)	High Quality– US (%)	High Quality – European (%)	G10 estimated
AAA	3	4	-	3.7
AA	5	6	32	5.5
A	13	29	19	26.8
BBB	29	36	26	30.0
BB	35	21	18	28.6
B	12	3	4	4.0
CCC	3	1	1	1.4

All these quality distributions, with the exception of that for the G10, which includes Japan, relate to a period of strong economic growth.

In order to estimate how these quality distributions would change in a recession, we have stressed them using the one-year ratings transition matrices (calculated from Moody's ratings) for business cycle troughs in the period 31.12.70 to 31.12.97 defined as the years with growth in the lowest third [produced by Nickell, Perraudin and Varotto (2000)]. They calculated two stress transition matrices, one for US industrials and one for the universe of Moody's ratings. The US matrix has been used for the US portfolios, and the matrix for the universe of ratings has been used for the other portfolios – the matrices used are shown in the attached Annex.

[1] The results have been weighted inside countries by the capital of the banks and between countries by the relative importance of the international banking sector.

Moody’s ratings are not conditional on the point in the cycle but even so there are more downgrades in a recession. This reflects the uncertain impact of stress periods on different borrowers/industries.

Applying these transition matrices, the quality distributions for the bank corporate portfolios set out in Table 2 and the implied distribution for the G10 would change to the following:

Table 3

	Average Quality – US (%)	**High Quality – US (%)**	**High Quality European (%)**	**G10 (%)**
AAA	2.7	3.6	0.3	3.4
AA	5.0	6.3	28.9	6.1
A	14.0	29.2	22.5	27.1
BBB	27.9	34.4	24.8	29.3
BB	32.2	20.0	16.8	25.8
B	13.4	4.6	4.9	5.9
CCC	2.6	0.9	0.9	1.2
Defaulted	2.1	0.8	0.9	1.2

Applying the Basel CP2 corporate risk weight curve and the modified corporate weights this would give rise to the increases in capital requirements for the various portfolios set out in Table 4. In all the capital calculations the loss given default is set at 50% (the proposed Basel Accord requirement for unsecured corporate loans) and defaulted assets are treated as having a PD of 100%.

Table 4: Percentage increase in capital requirements in a downturn

	Average Quality – US (%)	**High Quality – US (%)**	**Deutsche (%)**	**G10 (%)**
CP2	14	16	14	16
Modified	12	11	10	12

Note the transitions matrix is based on low growth as well as recession years. In order to look at a recession period, a transition matrix has been calculated for the recession in the early 1990s. Given that banks see a deterioration in their portfolios over several years in a recession and would find it difficult to raise new capital in that economic climate, the transitions have been calculated from Moody's’ratings (for a fixed group of 5022 obligors) over the period December 1990 to December 1992. This transition matrix is shown in attached table E. The value in row i and column j shows the probability that an obligor of rating i in December 1990 will have a rating j in December 1992. Using this transition matrix the quality distribution would change to that shown in Table 5.

Table 5:

	Average quality – US (%)	High quality – US (%)	High quality – European (%)	G10 (%)
AAA	2.5	3.3	0.2	3.0
AA	4.9	6.0	27.3	5.6
A	14.0	29.3	23.3	26.9
BBB	28.5	34.8	25.3	29.8
BB	32.2	20.2	17.1	26.2
B	12.0	4.2	4.6	5.6
CCC and below	2.0	0.7	0.7	0.9
Defaulted	3.9	1.5	1.5	2.0

The increase in capital requirements for the different portfolios which would result from the change in the quality distribution is set out in table 6.

Table 6

	Average quality US (%)	High quality US (%)	High quality European (%)	G10 (%)
CP2	20.7	21.2	20.2	21.6
Modified Corporate	19.3	15.7	15.8	16.9

The CP2 curves would therefore seem likely to lead to a significant increase in bank capital requirements in recession periods. The modified curves would reduce the effect but it would still be sizeable.

The increased capital requirements set out above include a requirement for defaulted assets. In fact where a bank has provided against the defaulted assets the Committee is considering allowing the specific provision to offset the capital requirement. For an unsecured loan in the foundation approach, where the LGD is 50%, a 50% provision would completely offset the capital charge. This means that for a bank which has fully provided against default risk in its loan book, the extra capital charge in a recession would only come through the deterioration in the economic value of loans rather than the increase in defaults. Provisioning is already providing cyclical pressure on banks' capital and is not therefore a new element caused by the proposed Accord. The new element is the increased capital requirement to reflect the deterioration in economic value for non-defaulting assets.

To look at the increased capital requirement coming from non-defaulted assets the defaulted assets in the quality distributions have been ignored. Using the transition matrix for Moody's ratings over 1990 to 1992 capital requirements for the non-defaulted assets would be largely unchanged and indeed would be lower for some portfolios.

Table 7

Change in capital requirements for non-defaulted assets

	Average quality US (%)	**High quality US (%)**	**High quality European (%)**	**G10 (%)**
CP2	-7.58	1.19	-1.31	-0.74
Modified	-6.95	-0.13	-1.53	-1.71

The reason for this result can be seen when the change in the quality distribution is examined. The change in the percentage of the portfolio in each rating band for the high quality European portfolio is set out in table 8.

Table 8

	High quality European portfolio - change in the percentage in each band
AAA	+0.2
AA	-4.7
A	+4.3
BBB	-0.7
BB	-0.9
B	+0.6
CCC and below	-0.3
Defaulted	+1.5

The changes in the lower quality bands have the dominant effect in terms of capital because of the steepness of the risk weight curves and therefore the net decline in assets in BBB to CCC (largely reflecting the move of assets into default) determines the overall fall in capital when defaulted assets are excluded.

But a further issue is whether this would be the answer for a more point in time rating approach such as Merton. To look a this we calculated a transition matrix for Merton PD's for the period 1990 to 1992 for 282 borrowers (admittedly not a very large sample). We calculated PDs for the individual borrowers using the Merton model for December 1990 and then recalculated the PDs for the same borrowers for December 1992. The PDs were fitted to the rating bands used in the Moody's transitions to give a AAA, AA etc. rating for each borrower. These 'ratings' could then be used to calculate a Merton transitions matrix. This matrix is shown in table F attached. Using this matrix to adjust the quality distributions, the capital requirements for the non-defaulted assets would change very substantially as set out in Table 9.

Table 9

	Average Quality US (%)	High quality US (%)	High quality European (%)	G10 (%)
CP2	18.02	84.14	70.5	59.2
Modified	8.92	51.14	44.9	35.5

For high quality books the point in time ratings would give a very large increase in capital requirements for the non-defaulted assets. This new procyclical element could therefore be very important for the largest banks.

Charts 1 and 2 below show the actual capital ratios of G10 banks with Tier 1 plus Tier 2 capital of more than € 3bn – i.e. large banks. They highlight the fact that few banks carry sufficient Tier 1 plus Tier 2 to be able to meet an 80% increase in their overall capital requirement – a jump from 8% to 14.4%. A larger number of banks could meet the Tier 1 component – an 80% increase would require a Tier 1 ratio of 7.2% - but many would not be able to do so. This would mean that many large banks using a rating system which was 'point in time' – i.e. conditioned on the point in the cycle – could be capital constrained in a recession. They would therefore either need to raise new equity, which could be very difficult, or reduce lending affecting the real economy.

Chart 1: Tier 1 risk asset ratio

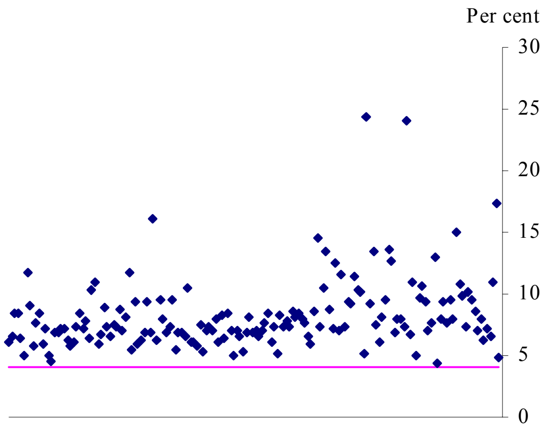
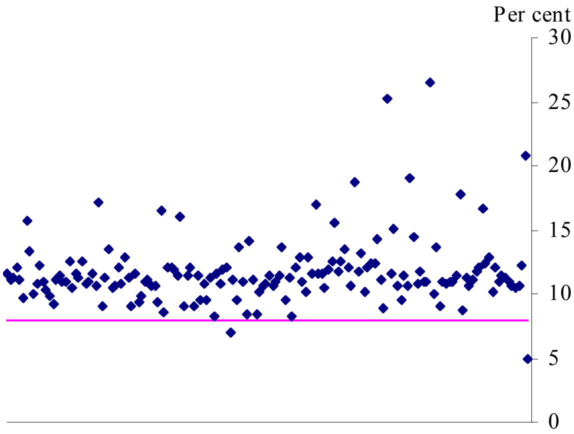


Chart 2: Tier 1 plus Tier 2 risk asset ratio



It will therefore be very important whether banks choose to adopt ratings which are more stable over this cycle or whether some banks will continue to use ratings which are strongly procyclical.

If the latter were the case the extenuation which could be covered by such a choice might lead to the conclusion that the Committee should prescribe certain rating schemes.

4. The preferred rating approach for a bank

To look at the question of whether bank would prefer stable to volatile ratings we employ a simplified version of the general equilibrium model set out in Tsomocos (2001). The closest methodological precursor to this model is the work of Martin Shubik (1999), who introduced a central bank with exogenously specified stocks of money, and cash-in-advance constraints in a strategic market game. Grandmont (1983) also introduced a banking sector into general equilibrium with overlapping generations and he pointed out the inefficiency of trade with money. The commercial banking sector of this model follows closely Shubik and Tsomocos (1992). The modelling of money and default in an incomplete markets framework is akin to the models developed by Dubey and Geanakoplos (1992) and Dubey, Geanakoplos and Shubik (2000). None of the previous papers incorporates a competitive commercial banking sector, and focuses on financial instability. Finally, default is modelled as in Shubik and Wilson (1977). None of the models focus on loan rating and procyclicality.

4.1 The Model

A multiperiod general equilibrium framework with heterogeneous agents has been used to study multiple market interactions and the identification of various channels that are affected by specific changes of policy parameters. A parameterized version of Tsomocos (2001) is used. The parameter values chosen are presented in Annexes 2 and 3 based on realistic figures for a large economy. It enables the main effects on the optimising behaviour of the agents and market forces to be considered. Heterogeneity permits us to conduct full-fledged welfare analysis.

The model consists of three sectors (the household, corporate and banking sectors), two time periods with two possible future scenarios, and a financial market with one single asset, assumed to be default free. The corporate sector can be thought of as firms which both borrow from banks and sell marketable financial assets. The banking sector raises funds by borrowing from the market and taking deposits from the household sector. These funds are used to make loans to the corporate sector and to buy marketable assets. Therefore, the financial structure of the economy is one of complete markets with two assets (loans and default free assets) and two states of nature (good and bad). Households and banks maximise consumption and profits respectively.

Agent α represents the household sector that maximises consumption in all periods and future states and borrows from the credit markets to achieve this. On the other hand, agent β – the corporate sector, is assumed to care only about consumption in period zero and in the ‘bad’ state (state 2) of period one. It represents a sector which only consumes when its investment in the asset market does not generate a positive return. Finally, the banking sector, agent γ, maximises profits only in the second period. With this framework, we capture the idea of a banking sector that, on average, maximises profits over the medium/long horizon and avoids speculative behaviour in the short run. The endowments for each of the three sectors are presented in Annex 2.

Uncertainty in the model comes from stochastic commodity and monetary endowments in the two future scenarios and from stochastic asset payoffs. The private and capital endowments, as well as the money supply in the economy, are also given. The optimisation problems and the balance sheet of the banking sector are presented in Annex 3. Thus, equilibrium in our model is defined as the solution to the three optimisation problems presented in Annex 2 plus the satisfaction of the six market clearing conditions (prices of goods at t=0, s=1, s=2, interbank market, loans market and asset market) that are presented in Annex 4.

Capital requirements of the banking sector are modelled as an extra constraint in the banks' optimisation problem. In particular, it is assumed here that shareholders' funds are fixed – banks cannot raise extra capital. (In other words, the numerator in the Capital Adequacy Ratio is assumed to be constant.) This is a reasonable assumption for periods of economic stress. Even in booms banks have to make a good business case to shareholders making it difficult to raise extra capital simply to meet their capital requirements. Thus our aim is to study the effects of changes in regulatory risk-weighted assets – i.e., the denominator in the risk asset ratio.

We now provide a formal description of the model.[2]

Let $t \in T = \{0,1\} =$ time periods

$s \in S = \{1,2\} =$ set of states $t = 1$

$h \in H = \{\alpha, \beta\}$ and $b \in B = \{\gamma\}$ set of economic sectors where

$\{\alpha\} =$ household, $\{\beta\} =$ corporate and $\{\gamma\} =$ banking

$l \in L = \{1\} =$ set of commodities

$e^h =$ endowment of $h \in H$ and e^b endowment γ.

The utility functions of $h \in H$ are:

$$U^h : \Re^3 \rightarrow R$$

and the objective function of γ

$$U^b : \Re^3 \rightarrow R.$$

We allow the banking sector to default on interbank loans and the corporate sector on commercial loans.

Thus, the payoffs given bankruptcy penalties L_1, L_2 for the corporate and the banking sectors respectively are:

$$\Pi_s^\alpha = U_s^\alpha$$

$$\Pi_s^b = U_s^b - L_1 \max[0, \text{DEBT}_s]$$

$$\Pi_s^\gamma = U_s^\gamma - L_2 \max[0, \text{DEBT}_s], \quad \forall s \in S, t \in T.$$

The payoffs of the household and corporate sectors are functions of consumption, χ^h, whereas of the banking are functions of profits, π^γ.

There also exists one default free asset (Arrow security), $A = [1,0]^T$.

[2] The presentation of the general model, its properties and the proof of existence theorem can be found in Tsomocos [24]. We present here the simplified version used for the simulations.

The optimisation problems with the corresponding budget sets, $B^h(\eta)$ where $\eta = (p_0, p_1, p_2, r, \rho, \theta)$, of all the sectors are provided in Annex 3.
The capital requirements constraints are always binding and take the forms described in section 4.3-4.4.

We say that $(\sigma^\alpha, \sigma^\beta, \sigma^\gamma; p_0, p_1, p_2, r, \rho, \theta^{3})$ is *a monetary equilibrium with commercial banks and default* (MECBD) for the economy iff:

(i)

(a) $\sigma^h \in \underset{\sigma^h \in B^h(\eta)}{\mathrm{Arg\,max}}\, \Pi^h(\chi^h)$

(b) $\sigma^\gamma \in \underset{\sigma^\gamma \in B^\gamma(\eta)}{\mathrm{Arg\,max}}\, \Pi^\gamma(\pi^\gamma)$

(ii) All markets of Annex 4 clear.

4.2 Endogenous default

Default is often assumed to be exogenous (e.g., Blum-Hellwig model) or derived implicitly from a particular equilibrium outcome. In this case default probabilities are typically calculated from historical data - for example the ratio of past defaults over the total amount of loans extended. The disadvantage with this method is that default probabilities are not explained but rather assumed to be a simple arithmetic average over whichever past period is chosen. We follow a different strategy by allowing the corporate sector and commercial banks to default in equilibrium. Therefore, we are able to investigate equilibria with active default whilst maintaining a solution.

We introduce default penalties**,** modelled as linear functions proportional to the size of default, that are subtracted from the utility function of the economic agents (corporate sector and commercial banks). Equivalently, one may incorporate default penalties by foreclosing parts of the endowments of debtors that have defaulted. Thus, by raising bankruptcy penalties, or equivalently by increasing the amount of endowments confiscated in case of default, we effectively increase the marginal disutility of default. The inclusion of differential default penalties is important because they are not uniform across countries or sectors reflecting differences in banking codes (e.g., Chapter 11 in the USA).

The upshot of this strategy is that *default is an endogenously determined phenomenon in equilibrium resulting from the optimising choices of the banks, corporate sector and the interacting forces of the market.* Consequently, default probabilities in each market are equal to aggregate default over the total amount of loans extended in equilibrium, i.e., the amount of actual default relative to the total amount of transactions in the respective markets, given the forward-looking behaviour of banks and the corporate sector. Furthermore, we use the frequency of corporate sector default as a proxy for the business cycle. In particular, high aggregate corporate default is considered to indicate recession periods in the economy whereas low levels the opposite.

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[3] The choice variables and prices are defined in Annexes 3 and 4.

In this setting, not *all* individuals can default in *all* the assets they hold. Households do not default and they only use their initial monetary endowments for making deposits in the banks. The corporate sector, on the other hand, take loans from banks on which they may default and invest in assets which are assumed to be default free. They will choose an optimal level of repayment for these loans (n_1^{β} (n_2^{β}) is 1 – default rate), as a percentage of the total state 1 (state 2) outstanding debt, so that they maximise their utility. In the model the corporate sector, however, is not allowed to default in the asset market[4]. Finally, banks invest in the asset market, give loans, and borrow from the central bank, where they are able to choose their repayment level (v_1^{γ} (v_2^{γ}) is 1 – default rate).

4.3 Introducing default varying risk weights

Under the proposed Accord, although the regulators will set constant risk weights for all loans assessed to have the same probability of default (PD), the risk weight for a particular loan will depend on the PD band into which the loan is slotted by the bank. This gives rise to the potential for time varying risk weights. To deal with this we introduce a proxy for banks' portfolio riskiness based on expected default of their customers.

As shown in the next section, the credit rating will be based only on the expected repayment levels of non-household borrowers from banks (corporate sector), n_1^{β} (n_2^{β}), i.e., for simplicity we ignore bank defaults. Therefore, banks maximise profits subject to a *risk sensitive* capital requirement. Ratings are captured in the risk-weights of various asset classes that in turn depend on expected default. The main determinant of banks' portfolio decision, besides their risk performance, is the risk embedded in their portfolio due to expected default. Expected default is the key variable that affects the investment decision of banks on how to allocate their funds between credit extension and equity investment.

Thus, in this model, given specific bankruptcy penalties, the corporate sector will rationally compare the marginal benefits and marginal costs of defaulting and will choose their optimal repayment levels accordingly. The corporate sector's default decisions on their bank loans will affect the capital requirements of the banking sector and this, in turn, will affect the credit expansion in the economy. In this sense, both banks and the corporate sector could choose higher levels of default than the original ones, if it were advantageous.

The contribution of the present work is not only the introduction of risk-sensitive capital ratios[5] but also through using a model with endogenous and multidimensional default, we are able to assess the effects of different policies on the decisions of the corporate sector and banks (who are utility and profit maximisers respectively in making their decisions and interacting with each other). It is possible to use this model to determine what rating system banks would choose in order to maximise their utility.

We examine which of the following ratings approaches banks would choose to adopt.

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[4] In this simplified set up, the asset market consists of only one default free asset (Arrow security) that costs θ and promises to pay 1 in the first state of nature and 0 in the second state. No default in the asset market, means that the corporate sector will be forced to fully repay the monetary equivalent in the good state (usually to a commercial bank) if, at t=0, they had sold the asset and received θ.

[5] This has been constantly appearing in the recent literature, for example, Heid (2000).

(1) constant risk weights per loan over the cycle;
(2) procyclical risk weights – which are higher in a recession;
(3) countercyclical risk weights – which are lower in a recession.

4.4 The default-varying risk-weights regulatory regimes

(a) <u>constant (neutral) risk weights</u>

This will be our benchmark case. The capital adequacy ratio of a bank in this economy is defined by:

$$k = \frac{c^{\gamma}}{(w_1 m^{\gamma}(1+r) + w_2 b^{\gamma})}$$

where c^{γ} stands for shareholders' funds available to meet the capital requirement, w_i's are the risk weights that the regulator chooses for each band, and because loans remain in the same probability of default band over the cycle this gives a constant risk weight for each asset, i=1,2, m^{γ} is the amount of credit extension from banks to the corporate sector, and b^{γ} represents banks' investment in the default-free asset markets. (Although the assets are assumed to be default free there is always risk involved in their payoffs hence $\mathbf{w_2}$ has a value.) r is the loan interest rate. The model was calibrated using 100% for $\mathbf{w_1}$ and 25% for $\mathbf{w_2}$. 100% is risk weight for most private sector loans under the current Accord and the Basel Committee has said that the new Accord will be calibrated to deliver the same average risk weight giving an 8% capital charge. 25% is approximately the weight on high quality short term securities issued by banks or corporates held in a bank's trading book.

(b) <u>procyclical default-dependent risk weights</u>

In this case, we replace the risk weight on loans to the corporate sector with $\mathbf{w_1}$***.** This is equal to the initial weight, $\mathbf{w_1}$, plus the linear term $(-0.4\bar{n}^{\beta}+0.2)$, i.e., it is set pro-cyclically $\mathbf{w_1}$***=** f $(\bar{n}^{\beta})$ with f' < 0 (i.e., the risk weight increases as corporate default increases), as it is shown below. The premium added to the risk weight $\mathbf{w_1}$ varies between –0.2 and +0.2. This reflects the variation between peak and trough in the capital requirements of a high quality European bank calculated in section 3, using ratings conditioned on the point in the cycle.

$$k = \frac{c^{\gamma}}{[\underbrace{(w_1 - 0.4(\bar{n}^{\beta}) + 0.2)}_{\text{w1*}} m^{\gamma}(1+r) + w_2 b^{\gamma})]}$$

, where $\bar{n}^{\beta} \equiv$ average expected recovery rate in the two states $= \frac{(n_1^{\beta} + n_2^{\beta})}{2}$

where n_1^{β} (n_2^{β}) are the expected recovery rates of the corporate sector's loans in state 1 (state 2).

The procyclical nature of this scheme is easily seen. In particular, in boom periods an average corporate sector's repayment level of 1 (i.e., loans are upgraded with respect to their credit because of lower credit risk due to full repayment) will cause a decrease in $\mathbf{w_1}$ of 0.2 (i.e. –0.4 + 0.2), allowing banks to expand their loans. Conversely, in recessions when the average repayment of loans could be close to 0, (loans are downgraded because of higher credit risk) the risk weight $\mathbf{w_1}$ would increase by 0.2, tightening banks' capital requirements and forcing banks to reduce loans (i.e., over the cycle, the risk weight is in the range $w_1 \pm 0.2$)[6].

(c) countercyclical default-dependent risk weights

Finally, by inverting the signs in our equation, we obtain a counter-cyclical policy. Loans move to a lower rating category when current default decreases in the expectation of higher expected credit risk in the future. Thus, the new risk weights are assumed to increase with current repayments (i.e., the higher the amount of loans that are currently expected to be repaid, the less will be expected to be paid in the future hence higher risk weights are assigned to loans). More formally, $\mathbf{w_1}$*= f $(\bar{n}^{\beta})$ with f' > 0, as shown below.

$$k = \frac{c^{\gamma}}{[\underbrace{(w_1 + 0.4(\bar{n}^{\beta}) - 0.2)}_{\text{w1*}} m^{\gamma}(1+r) + w_2 b^{\gamma})]}$$

, where $\bar{n}^{\beta} \equiv$ average expected recovery rate in the two states $= \frac{(n_1^{\beta} + n_2^{\beta})}{2}$

4.5 Comparative statics - evaluating the rating schemes

The comparative static experiments show that there is no "always-optimal" (i.e., first-best) policy in equilibrium. Basically, the preferred rating policy for a bank will change according to the specific point in the economic cycle – i.e., the specific value of the trend component of the risk weights (i.e., w_1). Since MFCBD are constrained inefficient, given initial parameter values we can determine the optimal rating scheme. In particular, there is a trade off between bank profitability and welfare of the corporate sector because of the variability of default and the effect this has on credit extension depending on the specific rating scheme.

[6] In our simplified version of Tsomocos' (2001) general equilibrium model, default rates are determined endogenously and move with the business cycle. In equilibria that describe recession periods in the economy (defined as those in which the output level and profits are significantly low) the default rates are high too. The opposite is true during booms. By means of our simple linear equation of default-dependent risk weights we have tried to capture this.

In Figure 5 we show the equilibrium values for the different relevant variables (profits, welfare, credit extension, asset investment, risk weighted assets, total assets, and default levels) for the procyclical and countercyclical rating regimes used by the banks. The Charts in Figure 5 can be compared to those presented in Figure 4, for the neutral case. The aim of the experiment is to highlight the changes in the variables, if any, under the three different rating regimes.

There are two variables where the differences between the three rating regimes are very noticeable. We observe a bank portfolio substitution effect between credit extension and asset investment (figure 5b) but, interestingly, we observe that the countercyclical scheme reduces the amplitude of the switch. This substitution effect occurs when the risk-weight on loans increases relative to the one on default-free assets, encouraging banks to switch from making loans to purchasing default free assets. Thus the higher the weight on loans, the stronger is the switch from loan investments to default-free assets. Under the countercyclical regime the allocation of bank portfolios is more equally balanced between default free assets and loans. The corporate sector decides on their rate of default taking into account the rate they pay on loans, which reflects the risk weight, which in turn is influenced by the rating scheme chosen by the banks.

In order to examine which rating scheme would be chosen by the banks it is necessary to consider the effect of different schemes on bank profits and corporate sector default. To show the differences under the three regimes Charts 1, 2 and 3 demonstrate how profits depend on default for different values of $\mathbf{w_1}$ – i.e., different points in the economic cycle. These show that the countercyclical or the procyclical rating schemes would be preferred to the neutral rating scheme because profits are more responsive to changes in default.

Under a countercyclical rating scheme, banks will increase the risk weight on loans in booms which will in turn lead to an increase in the interest rate paid by the corporate sector on loans. This leads the corporate sector to reduce their borrowing, which reduces the default dispersion of the corporate sector and increases bank expected profits.

In a recession, banks will reduce the risk weight on loans leading to a reduction in the interest rate paid by the corporate sector on loans. This leads the corporate sector to borrow more than would have been the case under other bank rating schemes and default rises. However, it remains below the levels that would have been seen with other bank rating schemes. Under the countercyclical rating scheme bank profits are, overall, higher across the cycle than they would be under either of the other rating schemes.

Under a procyclical rating scheme, banks will reduce the risk weight on loans in booms, increasing borrowing which will result in increased default dispersion by the corporate sector and will reduce bank expected profits. In recessions banks will increase the risk weight on loans leading the corporate sector to reduce borrowing and therefore to default less than otherwise. The procyclical regime delivers profits which are less affected by default rates than under the countercyclical approach but overall, across the cycle, bank profitability would be lower than under the countercyclical scheme for ratings.

Under the neutral, through the cycle, rating scheme the risk weights on loans would be invariant to the point in the economic cycle. This regime would manifest monotonic behaviour in booms and in recessions (Charts 2 and 3) but would not do so in the aggregate

(Chart 1). During expansionary periods it would resemble the countercyclical scheme and in recessions it would resemble the procyclical scheme. However, overall, it would deliver lower bank profits than either the countercyclical or the procyclical schemes.

In the calibration of the model which has been used (with $\mathbf{w_1}$ = 100% and $\mathbf{w_2}$ = 25%) the total profit of the bank would be ½% lower under the neutral rather than the countercyclical or procyclical ratings approach, with countercyclical delivering slightly higher profit than procyclical. This may seem a relatively small difference but it translates into a sizeable amount for a large bank - £35 mn per annum for a £7 bn profit bank.

These results show that given freedom to choose any rating scheme, banks would tend to opt for a countercyclical approach. Under the new Accord the supervisors will be assessing the plausibility of ratings transitions and default outturns per band. Importantly banks will also be required under Pillar 3 to publish the allocation of loans per probability of default band and the default outturns per band which will exert market discipline on the process. A rating approach which was countercyclical, where ratings were reduced in stress periods, would almost certainly not be allowed.

This will leave the banks with a choice between a through-the-cycle approach to rating or a point in time approach where the ratings for individual loans change markedly over the cycle, peaking in stress conditions. The model strongly suggests that, given this choice, the banks will opt for procyclical (point in time) ratings to boost profits relative to those under a through-the-cycle approach.

Figure 4. EVOLUTION OF MAIN ENDOGENOUS VARIABLES as LOANS RISK WEIGHT (W1) changes

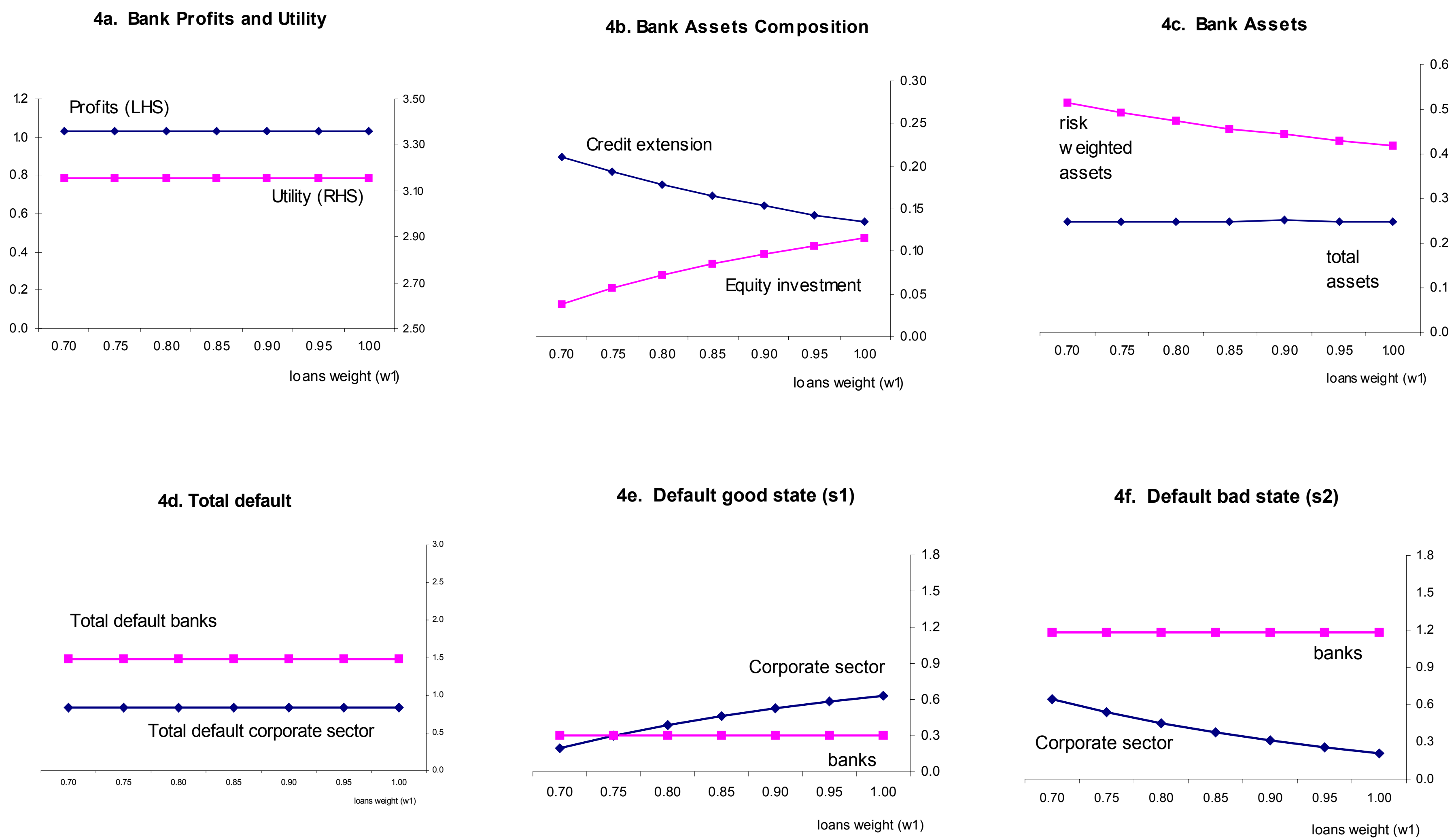


Figure 5. EVOLUTION OF MAIN ENDOGENOUS VARIABLES as LOANS RISK WEIGHT (W1) changes
Procyclical and countercyclical schemes

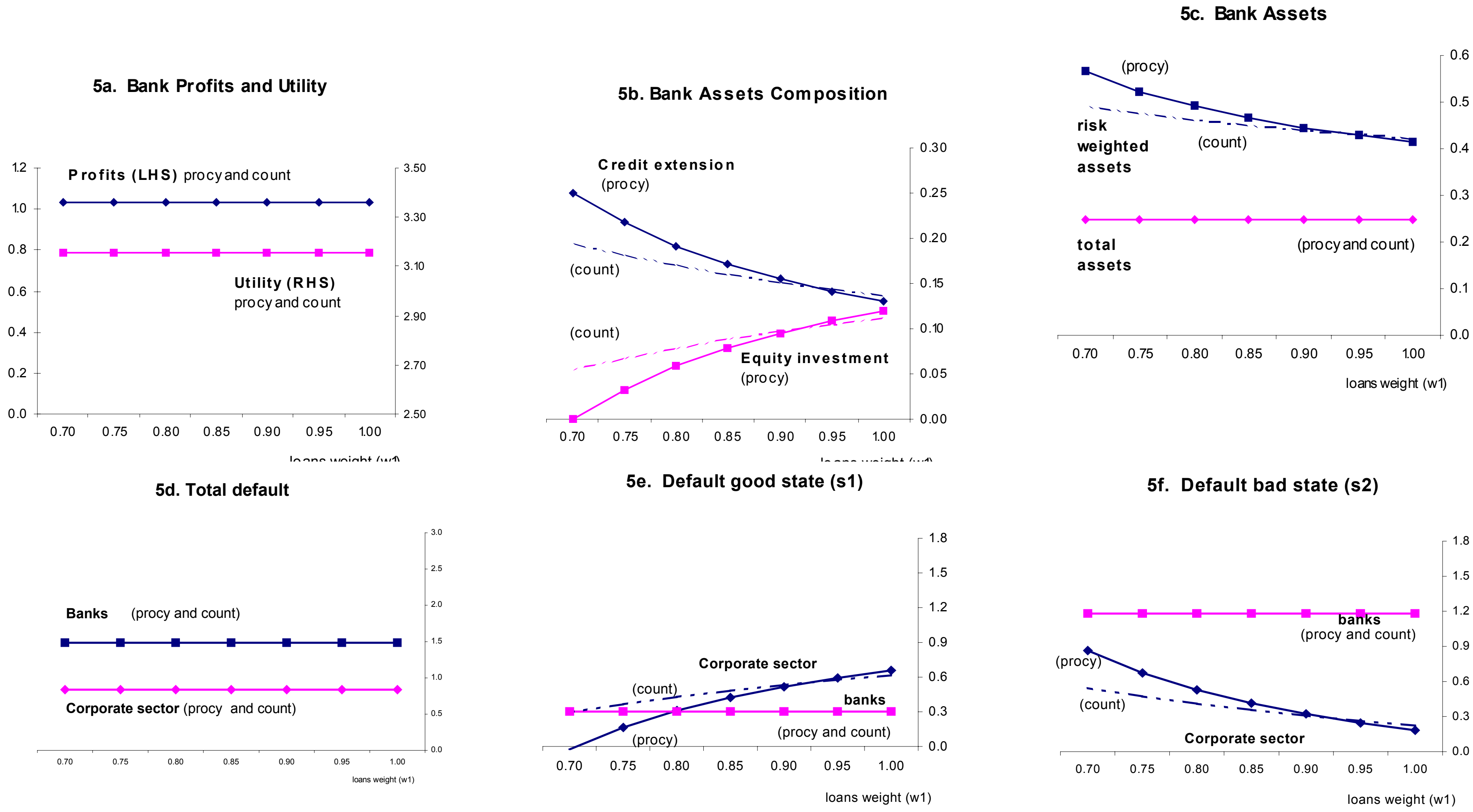


Chart 1. Expected total default and profits attainable under every regulatory regime. Polynomial trend line for all experiments.

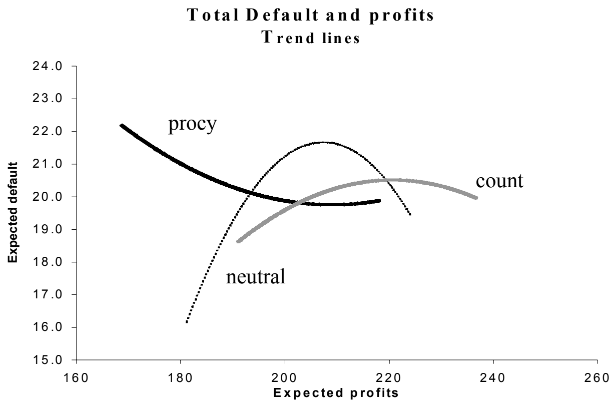


Chart 2. Total default in the bad state and profits attainable under every regulatory regime. Polynomial trend line for all experiments.

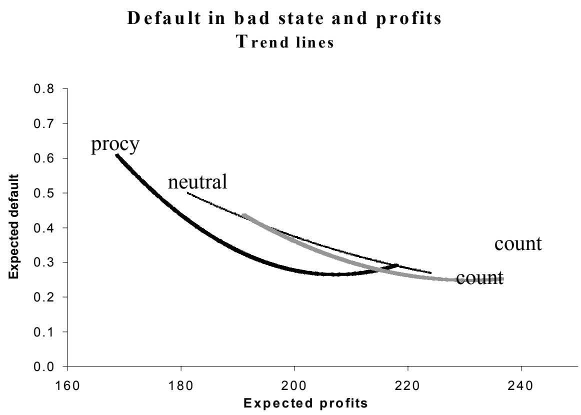
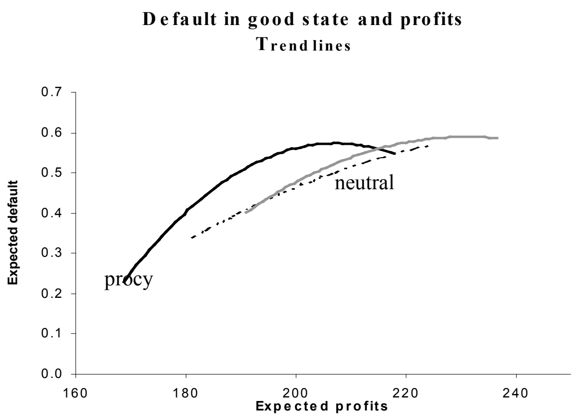


Chart 3. Total default in the good state and profits attainable under every regulatory regime. Polynomial trend line for all experiments.



4.5 Welfare effects of the choice in ratings

Thus banks, given the choice of rating scheme, would opt for a countercyclical regime, or if prevented from doing so would opt for a procyclical regime as a second best – see Charts 1-3. However, to maximise welfare or minimise default, the neutral, through-the-cycle, regime would be preferable. This is because under a procyclical or countercyclical regime the change in weights allows banks to transfer the dead-weight loss due to default to the corporate sector and households. The change in weights would be reflected in changes in investment rates and changes in borrower behaviour. The procyclical and countercyclical schemes lead banks to restructure their portfolio quickly when economic conditions change. By transferring the negative impact of a recession to the rest of the economy, banks can reduce the effect on their profits.

Table 5: Best performing policy when banks choose the risk weights

	Best regime in terms of MAXIMISING PROFITS is…	Best regime in terms of MAXIMISING WELFARE is…	Best regime in terms of MINIMISING DEFAULT Is…
IF THE BANKS CHOOSE THE RISK WEIGHTS…	Countercyclical weights	Constant weights	Constant weights

The essence of this result is not that risk sensitive weights reduce efficiency, and therefore that it would be preferable to maintain Basel I – with the insensitive risk-weight structure. Relative riskiness of loans on a bank's balance sheet should be reflected in the risk weights. However, there are advantages in having more stable risk weights over time. This points to the importance of rating approaches based on longer horizons which would make it more difficult for banks to free ride by changing ratings frequently to enhance profits.

5. Forward looking ratings

The likelihood that banks, given a choice of procyclical ratings or through the cycle, would choose the former resulting in welfare costs, points to the need for the supervisors to consider mechanisms which would provide incentives to the banks to adopt a more forward looking approach. It is unlikely that the banks could develop such an accurate through the cycle approach that the risk weighting of individual loans was constant as in the model set out above. The rating agencies try to take into account the effect of possible adverse economic conditions when rating borrowers but, even so, their ratings exhibit some procyclicality. However, point-in-time ratings where banks assume that the economic conditions prevailing at the time of the extension of the loan will remain unchanged would lead to substantially more procyclicality. Borio, Furfine and Lowe (2001) highlight the need for supervisors to consider rules which promote better measurement of the time dimension of risk, such as longer horizons for risk measurement, the use of stress testing and forward looking provisioning. Haldane, Hoggarth and Saporta (2001) suggest that it would be preferable if bank risk assessments attempted to take into account the economic cycle as a whole. This would not mean forecasting the path of the cycle but assessing the effect of an adverse change. in the economic environment on a borrower's creditworthiness when extending credit. Crockett (2000) points out that, although risks usually materialise in recessions, the actual increase in risk would have occurred in the previous upswing. This should be reflected in the banks' capital requirements. It has also been suggested that a solution might be for banks to estimate probabilities of default for borrowers over the life of a loan but this estimate too could be conditioned on the state of the cycle

6. Conclusion

The proposed new Basel Accord, in contrast to the Current Accord, has the potential for time varying risk weights for individual loans. Although the Basel Committee will set fixed weights for loans for a given probability of default for the borrower, banks will choose the probability of default band into which a loan will be slotted. It then becomes very important how the banks assign ratings. Taking the rating agency ratings as an example of a through the cycle approach, which takes into account the possible effect of adverse economic conditions on the borrower when assigning a rating, it can be seen that even this approach could lead to a 15% increase in bank capital requirements in a recession. However, much of this reflects defaults rather than the deterioration in quality of non-defaulted assets. The new element under Basel 2 is the procyclicality which will come from the latter element. A through the cycle approach would not seem to generate volatility caused by non-defaulted assets. A point in time approach, where the economic conditions prevailing when the loan was made are assumed to remain unchanged over the life of the loan, could lead to a much greater increase in capital requirements on non-defaulted assets. This would be more akin to the results from a Merton credit risk model, using the current equity price and balance sheet data to calculate the likely default probability for the borrower under an options pricing methodology. These results show that under such an approach capital requirements could increase by as much as 80% for high quality banks in a recession.

Strongly procyclical capital requirements could cause severe macro economic effects by creating credit crunches in recessions, thereby exacerbating the economic downturn. An important policy issue is therefore whether banks would choose to adopt more stable ratings across the cycle, which would moderate the procyclical effects, or whether they would adopt point in time ratings (i.e., ratings conditioned on the point in the cycle) even though this could lead to an inability to meet demands for credit in a downturn. The general equilibrium approach used in this paper strongly indicates that banks will not choose a more stable approach. Given complete freedom they would choose a countercyclical approach, reducing ratings in a recession and if regulators prevent this (as they are almost certain to do under the new Basel Accord) banks will adopt a procyclical (point in time) approach.

Given the welfare costs of a procyclical rating approach by the banks, the authorities will need to find a way of encouraging or requiring banks to adopt a more through the cycle approach.

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ANNEX 1

Table A: KVM one-year transition matrix based on non-overlapping EDF ranges

Initial Rating	Rating at year-end (%)							
	AAA	***AA***	***A***	***BBB***	***B***	***B***	***CCC***	***Default***
AAA	66.26	22.22	7.37	2.45	0.86	0.67	0.14	0.02
AA	21.66	43.04	25.83	6.56	1.99	0.68	0.20	0.04
A	2.76	20.34	44.19	22.94	7.42	1.97	0.28	0.10
BBB	0.30	2.80	22.63	42.54	23.52	6.95	1.00	0.26
BB	0.08	0.24	3.69	22.93	44.41	24.53	3.41	0.71
B	0.01	0.05	0.39	3.48	20.47	53.00	20.58	2.01
CCC	0.00	0.01	0.09	0.26	1.79	17.77	69.94	10.13

Source: KMV Corporation

Table B: Transition matrix based on actual rating changes

Initial Rating	Rating at year-end (%)							
	AAA	***AA***	***A***	***BBB***	***B***	***B***	***CCC***	***Default***
AAA	90.81	8.33	0.68	0.06	0.12	0.00	0.00	0.00
AA	0.70	90.65	7.79	0.64	0.06	0.14	0.02	0.00
A	0.09	2.27	91.05	5.52	0.74	0.26	0.01	0.06
BBB	0.02	0.33	5.95	86.93	5.30	1.17	0.12	0.18
BB	0.03	0.14	0.67	7.73	80.53	8.84	1.00	1.06
B	0.00	0.11	0.24	0.43	6.48	83.46	4.07	5.20
CCC	0.22	0.00	0.22	1.30	2.38	11.24	64.86	19.79

Source: Standard & Poor's CreditWeek, April 15 1996

Table C: Transition matrices derived from ordered profit models based on Moody's ratings between 31.12.70 and 31.12.97 reported in Nickell, Perraudin and Varotto "Stability of ratings transactions" (May 2001)

United States: Industrial									
Business cycle trough									
	Terminal Rating								
Initial rating	Aaa	Aa	A	Baa	Ba	B	Caa	C/Ca	Def
Aaa	89.0	10.0	0.0	-	-	-	-	-	-
Aa	0.6	87.8	10.9	0.5	0.1	-	-	-	-
A	0.1	2.3	92.4	4.7	0.4	0.1	-	-	-
Baa	-	0.2	4.6	89.5	4.8	0.7	0.1	-	0.1
Ba	-	-	0.2	3.5	85.7	8.5	0.3	-	1.8
B	-	-	0.2	0.5	5.7	83.5	2.1	0.5	7.5
Caa	-	-	-	-	2.2	7.5	68.1	3.9	18.3
Ca/C	-	-	-	-	-	3.9	13.1	61.8	21.2
Business cycle peak									

Table D: All ratings

Business cycle trough										
	Terminal rating									
Initial rating	Aaa	Aa	A	Baa	Ba	B	Caa	C/Ca	Def	No. of Issuer Years
Aaa	89.6	10.0	0.4	-	-	-	-	-	-	930
Aa	0.9	88.3	**10.7**	**0.1**	0.0	-	-	-	-	2195
A	0.1	2.7	**91.1**	5.6	0.4	**0.0**	-	-	0.0	4591
Baa	0.0	0.3	**6.6**	**86.8**	**5.6**	0.4	0.2	-	0.1	3656
Ba	-	0.1	0.5	5.9	**83.1**	**8.4**	0.3	0.0	1.7	2715
B	-	0.1	0.2	0.8	6.6	**79.6**	2.2	1.0	**9.4**	1459
Caa	-	-	-	0.9	1.9	9.3	63.0	1.9	23.1	108
Ca/C	-	-	-	-	-	5.9	**5.9**	64.7	23.5	34

Table E: Transition matrix generated using Moody's data 1990 to 1992

1990-2									
%	AAA	AA	A	BBB	BB	B	CCC	CC/C	Def
AAA	81.41	18.27	0.32	0.00	0.00	0.00	0.00	0.00	0.00
AA	0.61	84.79	14.36	0.24	0.00	0.00	0.00	0.00	0.00
A	0.00	0.59	92.89	6.19	0.33	0.00	0.00	0.00	0.00
BBB	0.00	0.14	3.97	88.39	6.80	0.57	0.00	0.00	0.14
BB	0.00	0.00	0.16	5.59	82.45	8.39	0.31	0.00	3.11
B	0.00	0.00	0.00	0.61	9.22	73.16	3.28	0.61	13.11
CCC	0.00	0.00	0.00	0.00	8.00	4.00	36.00	12.00	40.00

Table F: Transition matrix for ratings generated using Merton model 1990 to 1992

%	AAA	AA	A	BBB	BB	B	CCC	CC/C	Def
AAA	88.08	5.30	3.97	1.32	0.66	0.66	0.00	0.00	0.00
AA	41.30	17.39	19.57	8.70	8.70	4.35	0.00	0.00	0.00
A	0.00	5.00	25.00	35.00	30.00	5.00	0.00	0.00	0.00
BBB	11.11	7.41	7.41	7.41	44.44	22.22	0.00	0.00	0.00
BB	18.18	9.09	13.64	9.09	9.09	40.91	0.00	0.00	0.00
B	0.00	0.00	0.00	16.67	50.00	33.33	0.00	0.00	0.00
CCC	0.00	10.00	0.00	0.00	40.00	40.00	10.00	0.00	0.00

Table G: Transition matrices generated using Merton model

1989-90	AAA	AA	A	BBB	BB	B	CCC-C	Def
AAA	66.37	17.49	7.62	7.17	0.90	0.45	0.00	0.00
AA	10.34	24.14	10.34	20.69	34.48	0.00	0.00	0.00
A	0.00	0.00	0.00	66.67	33.33	0.00	0.00	0.00
BBB	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00
BB	0.00	0.00	0.00	8.33	33.33	33.33	25.00	0.00
B	0.00	0.00	0.00	0.00	0.00	20.00	80.00	0.00
CCC-C	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
1990-1	AAA	AA	A	BBB	BB	B	CCC-C	Def
AAA	94.04	4.64	1.32	0.00	0.00	0.00	0.00	0.00
AA	50.00	32.61	6.52	8.70	0.00	2.17	0.00	0.00
A	0.00	35.00	30.00	35.00	0.00	0.00	0.00	0.00
BBB	3.70	22.22	14.81	37.04	22.22	0.00	0.00	0.00
BB	0.00	22.73	4.55	18.18	50.00	4.55	0.00	0.00
B	0.00	0.00	0.00	0.00	66.67	33.33	0.00	0.00
CCC-C	0.00	0.00	0.00	10.00	10.00	20.00	60.00	0.00
1991-2	AAA	AA	A	BBB	BB	B	CCC-C	Def
AAA	87.95	6.02	4.22	0.60	0.60	0.60	0.00	0.00
AA	27.50	20.00	22.50	22.50	7.50	0.00	0.00	0.00
A	6.25	6.25	37.50	18.75	31.25	0.00	0.00	0.00
BBB	3.85	11.54	7.69	11.54	46.15	19.23	0.00	0.00
BB	0.00	0.00	4.55	9.09	27.27	54.55	4.55	0.00
B	0.00	0.00	0.00	0.00	33.33	66.67	0.00	0.00
CCC-C	0.00	0.00	0.00	0.00	50.00	50.00	0.00	0.00

ANNEX 2

Endowments (monetary and commodities) for the three sectors of the economy

States / Sectors	t = 0	T =1 S = 1	t =1 s = 2
e^{α}	9	0	0
m^{α}	0.05	0	0
e^{β}	0	6	2
m^{β}	0	0.9	0.02

Note: Time = {0,1}, States = {1,2}, Households ={α}, Corporate Sector = {β} Banks = {γ} Commodities = {1}

Where e (m) are the commodity (monetary) endowments of the various sectors

In addition:

$A = [1\ 0]^T$, asset payoffs
$\Delta M^G=0.2$, monetary supply
K=0.04 , capital ratio
$L_1=0.74$, default penalty 1
$L_2=0.95$, default penalty 2
$c^{\gamma}=0.035$, shareholders' fund
$W_2=1$, risk weight of bank financial assets
A = 0.8, $f_a = 0.017$, $f_b = 0.033$, $f_c = 0.5$, utility function parameters

ANNEX 3

Optimisation problems for each agent

- **HOUSEHOLD**

Max $\quad U^{\alpha} = (x_0^{\alpha} - 1/60(x_0^{\alpha})^2) + 0.8(x_1^{\alpha} - 1/60(x_0^{\alpha})^2 + x_2^{\alpha} - 1/60(x_2^{\alpha})^2))$

$b_1^{\alpha}, b_2^{\alpha}, q_0^{\alpha}$

$\lambda_1^{\alpha}, \lambda_2^{\alpha}$

s.t. $\quad b_1^{\alpha} = m_0^{\alpha}(1+r) + p_0 q_0$

(consumption demand in the "good" state) = (savings payments) + (revenues from commodities sales)

$b_2^{\alpha} = m_0^{\alpha}(1+r) + p_0 q_0$

(consumption demand in the "bad" state) = (savings payments) + (revenues from commodities sales)

- **CORPORATE SECTOR**

Max $\quad U^{b} = (x_0^{b} - 1/30(x_0^{b})^2) + (x_2^{b} - 1/30(x_2^{b})^2)$

$b_0^{b}, q_2^{b}, \mu^{b} \qquad - L_1 \max[0, \mu^{b} - n_1^{b}\mu^{b}] - L_1 \max[0, \mu^{b} - n_2^{b}\mu^{b}]$

n_1^{b}, n_2^{b}

$\lambda_1^{b}, \lambda_2^{b}, \lambda_3^{b}$

s.t $\quad b_0^{b} = \dfrac{\mu^{b}}{(1+r)} + \theta q^{b}$

(current consumption demand) = (loans) + (revenues from asset investment)

$n_1^{b}\mu^{b} + q^{b} = m_1^{b} + p_1 e_1^{b}$

(loan repayment + asset deliveries in the "good" state) = (monetary endowment) + (revenues from sales)

$n_2^{b}\mu^{b} = m_2^{b} + p_2 q_2^{b}$

(loan repayment in the "bad" state) = (monetary endowment) + (revenues from sales)

• COMMERCIAL BANKS

$$\max_{\substack{b^\gamma, m^\gamma, \mu^\gamma \\ v_1^\gamma, v_2^\gamma \\ \lambda_1^\gamma, \lambda_2^\gamma, \lambda_3^\gamma}} U^\gamma = 1.17\,((\pi_1^\gamma - 1/2(\pi_1^\gamma)^2) + (\pi_2^\gamma - 1/2(\pi_2^\gamma)^2)) - L_2 \max[0, \mu^\gamma - v_1^\gamma \mu^\gamma] - L_2 \max[0, \mu^\gamma - v_2^\gamma \mu^\gamma]$$

s.t.

$$b^\gamma + m^\gamma = \frac{\mu^\gamma}{(1+\rho)} + m_0^\alpha$$

(asset investment) + (loan extension) = (interbank loans) + (household deposits)

$$m_0^\alpha (1+r) + v_1^\gamma \mu^\gamma = \frac{b^\gamma}{\theta} + n_1^b m^\gamma (1+r)$$

(deposit repayments) + (loan repayment in the "good" state) = (asset deliveries) + (investor loan repayment in the"good" state)

$$m_0^\alpha (1+r) + v_1^\gamma \mu^\gamma = n_2^b m^\gamma (1+r)$$

(deposit repayments) + (loan repayments in the "bad" state) = (investor loan repayment in the "bad" state)

Balance sheet of the banking sector

A	L
- LOANS	- HOUSEHOLDS' DEPOSITS
- ASSET INVESTMENTS	- BANK BORROWING
	E
	- SHAREHOLDERS' FUNDS

ANNEX 4

Market clearing conditions of the existing six markets

→ **Commodity Markets**

$p_0 = \frac{b_0^b}{q_0^\alpha}$	;	price in s = 0	= money bid by the corporate sector / supply of goods
$p_1 = \frac{b_1^\alpha}{e_1^b}$	;	price in the "good" state	= money bid by the household in s=1 / supply of goods
$p_2 = \frac{b_2^\alpha}{q_2^b}$	;	price in the "bad" state	= money bid by the household in s=2 / supply of goods

→ **Central Bank Market Operations**

$1 + \rho = \frac{\mu^\gamma}{M^G}$	;	(1+ interest rate)	= I.O.U. notes by commercial banks / supply of base money

→ **Loan Market**

$1 + r = \frac{\mu^b}{m^\gamma}$	;	(1+loan interest rate)	= I.O.U. notes by the corporate sector / credit extension

→ **Asset Market**

$\theta = \frac{b^\gamma}{q^b}$	;	asset price	= money bid by banks / asset supply

ANNEX 5

BEST PERFORMING REGULATORY POLICY UNDER DIFFERENT POLICY OBJECTIVES

1. Policy Objective: MAXIMISE TOTAL EXPECTED PROFITS

For each policy, w_1 is chosen so that we obtain the maximum bank's total profits. Thus, the regulator will choose:

$w_1 = 0.95$ with a procyclical and countercyclical regimes

$w_1 = 1$ with a constant regime

According to this:

BEST PERFORMING REGULATORY POLICY	Assets sold by corporate sector (qb)	Loan's demand By corporate sector (mub)	Assets purchased by bank (bg)	Loan's extension By bank (mg)	Repayment rate corporate sector, good st. (n_1^b)	Repayment rate corporate sector, bad st. (n_2^b)
Criteria	Highest level	Highest level	highest level	Highest level	highest level	highest level
Best Policy	CONSTANT	COUNTERCY.	CONSTANT	COUNTERCY.	COUNTERCY.	CONSTANT

	Bank profits Good st (S1)	Bank profits Bad st (S2)	Bank Profits **TOTAL** (S1 + S2)	Corporate sector's **Utility** (Ub)	S1, Corporate sector's **Default rate (%)** ($1-n_1^b$)	S2, Corporate sector's **Default rate (%)** ($1-n_2^b$)	S1, Corporate sector's **total default (£)** (D1b)	S2, Corporate sector's **total default (£)** (D2b)	Corporate sector's **total default (£)** State 1 + 2
Criteria	highest level	Highest level	Highest level	Highest level	lowest level	Lowest level	lowest level	lowest level	lowest level
Best Policy	COUNTERCY.	CONSTANT	**COUNTERCY.**	**CONSTANT**	COUNTERCY.	CONSTANT	COUNTERCY.	CONSTANT	**CONSTANT**

- **VARIABLES NOT LISTED IN THE TABLE DID NOT CHANGE DURING THE COMPARATIVE STATICS EXPERIMENT.**