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 2006, 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 this new risk-based regime for procyclicality of minimum capital requirements – 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 that are designed to be more stable over the cycle, akin to those of the external rating agencies, would not increase procyclicality, but ratings that are conditioned on the current point in the cycle, akin in some respects 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. It makes it important that banks are given incentives to adopt more stable rating schemes. This consideration has been reflected in the Committee's latest proposals, in October 2002.

Summary

The Basel Committee on Banking Supervision is proposing to introduce, in 2006, new risk-based requirements for internationally active (and other significant) banks. Under this regime capital requirements for many banks will be based on their own assessments of the probability of default of individual borrowers. These will replace the relatively risk-invariant requirements in the current Accord which are based on the broad type of lending. This paper examines the implications of this new risk-based regime for the cyclicality of capital requirements – in particular whether the choice of particular loan rating systems by the banks would make sharp increases in capital requirements in recessions more likely. This is an important policy question because substantial changes in capital requirements would increase the likelihood of 'credit crunches'.

All regimes with minimum capital requirements have the potential to generate procyclical effects because capital available to meet the requirements becomes more scarce in recessions as banks make provisions and write off defaulted loans. The new element under the proposed revised Basel Accord is the potential for capital requirements on non-defaulted assets to rise in recessions if banks downgrade loans. The paper finds that the extent of this additional procyclicality depends on the nature of the rating systems used by the banks.

A number of banks have carried out careful mapping exercises to ensure that their rating approaches are very close to those of the main rating agencies which are designed to be relatively stable over the cycle. Many other banks have adopted an approach based on a Merton-type model which uses information on the current share price and liabilities. Because this approach uses current liabilities, it is in some respects akin to a rating that is conditioned on the point in the cycle. We estimate the likely increase in capital requirements in a recession, depending on whether a bank is using one or other of these two rating approaches. Portfolios of corporate exposures are constructed using information on the actual quality distribution of corporate loans made by some large banks. The extent to which banks would downgrade loans in their rating bands in a recession is estimated using transition matrices (for 1990-92) calculated from Moody's ratings and from ratings produced by a Merton-type model. We find that ratings based on Moody's approach lead to little, if any, increase in capital requirements for non-defaulted assets, whereas ratings based on a Merton-type model lead to a 40% to 50% increase.

This makes the question of which rating schemes banks will use very important. We use a general equilibrium model of the financial system to explore whether banks would choose to use a

countercyclical, procyclical or neutral rating scheme. 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 default-free asset and loans. Default is endogenous in the model. Capital requirements depend on the credit rating set by the bank, which is in turn based on the expected default rate of corporates. Expected default is also the key variable that affects the banks' decisions on how to allocate their portfolios between loans and other assets. This affects credit expansion in the economy. Demand for loans depends on the default rate and supply of loans on the bank rating and capital weight.

The results indicate that banks would not choose a stable rating approach. Bank profits would be higher if they adopted a system that produced ratings that varied over the economic cycle, because such a system would enable them to transfer the cost of recessions to the rest of the economy. Procyclical ratings could have macroeconomic consequences by encouraging overlending relative to risk in booms and reduction in lending in recessions. This underlines the need for banks to be given incentives to adopt more stable rating regimes to underpin their capital requirements. This consideration has been reflected in the current design of the Accord.

1 Introduction

The Basel Committee on Banking Supervision is currently revising the minimum capital standards for internationally active banks to introduce capital requirements which more closely reflect the risks. This offers economic benefits in reducing the possible distortions to the way that banking activity is conducted which can flow from risk-insensitive requirements. However, one unavoidable consequence of more risk-based requirements is that they could vary over the cycle, which could increase the likelihood that banks run-up against constraints on their lending in recessions.

It is important to understand the extent of likely variation in capital requirements and also whether bank behaviour is likely to modify or exacerbate the effect. This paper explores these issues, in particular whether the choice of internal rating system by the banks will influence cyclicality of capital requirements and what the banks' preference regarding rating systems might be.

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. This paper indicates that the new risk weight curves proposed by the Committee in October 2002 reduce the cyclical effect but less forward-looking rating systems operated by the banks, which do not take into account possible changes in economic climate, could still lead to a substantial increase in capital requirements in recessions. Looking at the 1990-92 recession, corporate ratings based on Moody's approach lead to little increase in capital requirements whereas ratings based on a Merton-type model lead to a 40% to 50% increase. Bank ratings which are not forward looking, and therefore do not take full account of risks taken in booms, could also exacerbate the economic cycle by encouraging overlending in booms.

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 (2003) 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.

Section 2 examines the issues of procyclical capital requirements. Section 3 sets out the background on the proposed new Basel Accord, 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 examines which rating approach would be preferred by the banks. Section 6 considers the forward-looking approach to ratings. Section 7 sets out the conclusion.

2 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 could lead to cutbacks in bank lending in stress periods with a constraint of this kind. 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 on lending. 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 United States was that particular sectors such as real estate or small businesses may have been affected by pressure on bank capital in some regions (Hancock and Wilcox (1997), Hancock and Wilcox (1998) and Peek and Rosengren (1997a, 1997b)). But there was no evidence of widespread problems across the United States nor any clear-cut evidence for other countries.

The effect of the current Accord on economic cycles is likely to be muted because 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 likelihood of credit crunches. Also, modest falls in capital may be covered by increased use of subordinated debt which is included in Tier 2 capital, because many banks carry a greater proportion of capital (than required) as Tier 1, giving them headroom to increase Tier 2. The new Accord which will be introduced in 2006 could, however, have a profound effect on the dynamics of bank minimum 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.

There are a number of aspects to the procyclicality debate. One is the extent of likely fluctuations in bank capital requirements over the cycle and whether any increase in requirements in recessions could be met by the banks – or whether capital requirements are likely to bind at that point requiring an adjustment to lending. A further aspect is whether, if the ability of banks to lend is restricted in recessions, other sources of funds would substitute for any shortfall, limiting the overall effect on the corporate and retail sectors. This paper examines the first set of issues – the likely extent of variation in bank capital requirements over the cycle, for different profiles of bank portfolio, under Basel II and whether any increase could be met given current capitalisation of the banks. This was also discussed in Jackson (2001), and Ervin and Wilde (2001). Allen and Saunders (2002) stress that other elements of the capital calculation for some banks (eg LGD for advanced approach banks) will also be subject to cyclical variation.

Under Basel II the minimum capital requirements of most large banks will be set with reference to each bank's internal assessment of the riskiness of the borrower. Borrowers will be assigned to rating bands tied to a probability of default. The extent to which banks need to downgrade borrowers in a recession will depend on the way in which the probability of default is assessed. If borrowers are assigned to a rating under the assumption that economic conditions prevailing when the loan was made were likely to remain unchanged 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.

Another effect of rating borrowers in booms using an assumption that buoyant economic conditions will continue could be over lending. Risks are taken in booms and the effect is felt when the economy turns down. If banks underestimate the longer-term risks of exposures this could exacerbate bubble conditions. This is also an issue raised in Danielsson *et al* (2001).

A possible explanation for underestimation of risks in booms is set out in Herring (1999). As memories of the last economic downturn fade, banks let their capital positions decline and lend on easier terms. They suffer from 'disaster myopia'. 'At some point, long after the occurrence of a disaster, the subjective probability of the recurrence of disaster may become so low that it is treated as zero'. As the probability is revised down so the bank will be able to lend to a broader range of creditors. It would also affect pricing of credit. To the extent that salaries and bonuses reflect short-term profit (and do not reflect the longer-term risks) so lending officers will have an incentive to disregard dangers. Once a shock occurs, subjective probabilities are revised upwards and the financial system may descend into crisis. It is also consistent with the theory of why bank credit policies fluctuate in Rajan (1994). Bank management is assumed to be rational but has short-term concerns – focusing on the bank's earnings and reputation. The bank management can achieve their goals with a liberal credit policy in booms, boosting current earnings at the expense of future earnings. The considerations that might lead banks to adopt ratings that lead capital requirements to fluctuate over the cycle are explored further in Section 5.

3 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, under one-year non-OECD 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 recognition of some types of financial collateral) 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 (standardised and internal ratings based) 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: Standardised 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	4.0	8.0	8.0	12.0	8.0
Banks Option 2* < 3 months > 3 months	 1.6 1.6	 1.6 4.0	 1.6 4.0	 4.0 8.0	 4.0 8.0	 12 12	 1.6 4.0
Corporates	1.6	4.0	8.0	8.0	12.0	12.0	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. See Basel Committee (2001).

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

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 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 50% of those put forward for corporates for a given PD, and banks could set their own LGD – average LGDs for non-mortgage retail are around 85% and those for mortgage retail are around 25%.

Since the release of the consultation paper (CP2) 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 (see Lopez (2002)). The Committee also focused on the need to flatten the curves somewhat because of concerns about procyclicality. The Committee is now considering setting correlation as a declining function of PD from 24% to 12%, using the following formula.

$$\rho(PD) = \left(\frac{1-e^{-50.PD}}{1-e^{-50}}\right)\times 12\% + \left(1-\frac{1-e^{-50.PD}}{1-e^{-50}}\right)\times 24\%$$

For the smaller corporates there is a further downward adjustment to correlation. See Basel Committee (2002) and a summary in Jackson (2002).

The Committee has calibrated the capital requirements using a 99.9% confidence level rather than 99.5% plus an add-on used for the CP2 version, which also helps to deliver a flatter curve. This still gives 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 has also set correlation for non-mortgage retail as a declining function of the PD – declining from 17% to 2%. Revolving retail such as credit card debt will be able to benefit from an even lower curve than non-mortgage retail. In contrast, for mortgages a fixed correlation of 15% is thought appropriate because of the large cyclical influence on mortgage losses and longer maturity.

The charts below show the main corporate and retail curves set out in the October 2002 QIS 3 technical document and the earlier curves proposed in CP2.

Chart 1a: Capital charges for corporate and SME exposures (LGD 45%)

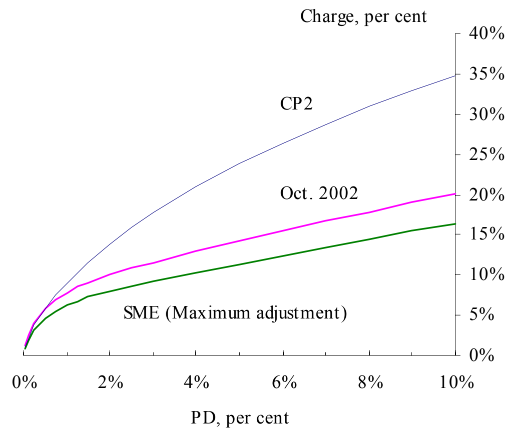


Chart 1b: Capital charges for mortgages (LGD 25%)

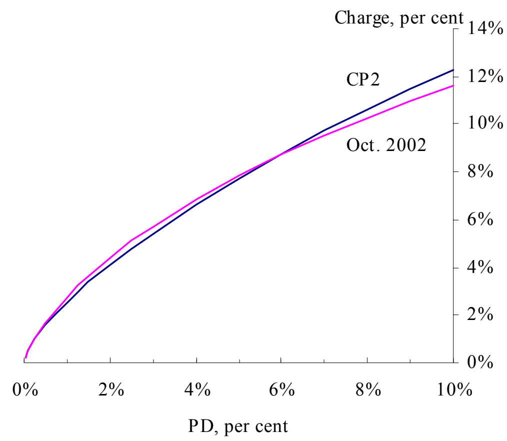
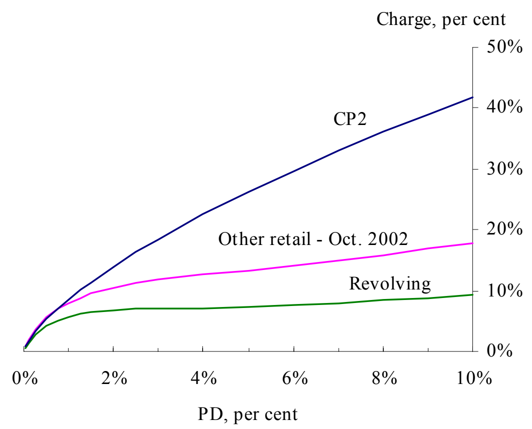


Chart 1c: Capital charges for other retail (LGD 85%)



The risk weight curves proposed by the Committee are based on credit modelling research and statistics provided by the banks. They have been designed to map more closely the capital required to the riskiness of individual loans. The proposed curves will reduce the distortions created by the current Accord where a flat 8% requirement for most private sector loans encourages banks to securitise their high quality loans, effectively increasing the risks carried for a given capital level (see Jones (2000)).

4 Bank ratings

Given the reliance on internal probability of default ratings under the IRB approach, an important question is the extent to which the rating approach chosen would affect the degree of procyclicality in the capital requirements. There is very little information available on the variation in internal bank ratings assigned to different borrowers over the cycle. One paper (Carling *et al* (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 – there is considerable movement peak to trough. Segoviano and Lowe (2002) looking at Mexican bank ratings also find substantial swings.

Although there is little direct evidence on bank internal ratings there is evidence from other sources. Some banks have chosen to adopt rating systems which are modelled on the approach taken by the rating agencies, which is designed to give less variability in ratings if economic conditions change. Indeed, a number of 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 economic climate is clearly set out in the following comment by Standard & Poor's: 'Standard & Poor's credit ratings are meant to be forward looking; that is, their time horizon extends as far as is analytically foreseeable. Accordingly, the anticipated ups and down of business cycles – whether industry-specific or related to the general economy – should be factored into the credit rating all along'.(1)

The similarity in approach between some banks' internal ratings systems and the approach used by Moody's and Standard & 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.

Many other banks have adopted an approach based on KMV which uses the current equity price of the borrower and current information on the borrower's liabilities to calculate a Merton default likelihood. Because these estimates use current liabilities of the borrower they may well show more variability as economic conditions change – with riskiness apparently increasing in the later stages of a boom (when indebtedness traditionally increases) and the subsequent downturn.

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 & 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

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(1)www.standardandpoors.com, Standard & Poor's 2002 Corporate Ratings Criteria, 29 October 2002.

in the KMV transition matrix – see Annex 1. The transition matrices are shown in Tables A and B in Annex 1.

There are therefore at least two industry standard rating methods used by the banks which may lead to a different amount of variability in ratings in a recession. This paper explores the likely changes in capital requirements (for different quality profiles of portfolio) in a recession according to which of these industry standard approaches to rating is used. There are other rating approaches which are used by banks but there is little information on these.

The question of the relative cyclicality of capital requirements based on (1) internal rating using a rating industry approach or (2) a Merton-type model, is explored by taking the profiles of loan books across different PD bands seen for banks in different countries and for the G10 as a whole, 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 2001, the Basel Committee put on the BIS web site 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[(2)] 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.

[(2)] 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.

Table 2: Portfolio distributions of credit quality for corporate exposures

	Average quality – US (%)	High quality– US (%)	High quality – European (%)	G10 Estimated
AAA	3	4	-	4
AA	5	6	32	6
A	13	29	19	27
BBB	29	36	26	30
BB	35	21	18	29
B	12	3	4	4
CCC	3	1	1	1

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 an adverse economic climate, 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 Annex 1.

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: Stressed distributions – business cycle troughs

	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 flatter corporate risk weight curves set out in the October 2002 QIS 3 technical guidance document, this change in the quality distributions 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 Basel Accord proposed LGD for unsecured corporate loans in CP2)[3] 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 (%)**	**High quality – European (%)**	**G10 (%)**
CP2	14	16	14	16
October 2002	11	11	10	10

Note the transition 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 5,022 obligors) over the period December 1990 to December 1992. This transition matrix is shown in Table E in Annex 1. 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.

[3] This has now been reduced to 45% in the October 2002 QIS 3 technical document.

Table 5: Stressed distributions – early 1990s transition matrix

	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	21.1	20.2	21.6
October 2002	17.9	15.2	15.3	16.0

The CP2 requirements would therefore seem likely to lead to a significant increase in bank capital requirements in recession periods. The flatter October 2002 curves would reduce the effect but it would still be sizable.

Under the proposals in CP2, defaulted assets even where substantially provided against, could give rise to large capital requirements. Once a loan has been fully written off it is, of course, removed from the calculation of capital requirements. But while loans remain on a bank balance sheet, even where partially provided against, they are subject to capital requirements reflecting the borrower PD. For all defaulted assets a full requirement was required on the net of the loan minus the specific provision assuming a PD of 1 even though, for a bank which had raised substantial provisions against defaulted loans, little additional risk might remain. The Committee is now considering allowing the requirement to be calculated on the gross amount of the loan. The specific provision would offset the capital requirement. For an unsecured loan in the foundation approach, where a 45% LGD is proposed, a 45% provision would completely offset the capital charge. This means that, for a bank which has provisions of at least 45% of the value of the loans against defaulted assets, the extra capital charge in a recession, from the introduction of the Basel risk-based requirements, would only come through the deterioration in the economic value of non-defaulting loans rather than the increase in defaults. Provisioning on defaulted loans is already giving rise to cyclical pressure on banks' capital and is not therefore a new element caused by the proposed Accord. However, in terms of the overall procyclical effect, the issue is the combination of both elements.

Table 7 sets out the increased capital requirements on non-defaulted assets. Using the transition matrix for Moody's ratings over 1990 to 1992 to generate the changed quality distribution the capital requirements. For the non-defaulted assets capital requirements 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	-7.6	1.2	-1.3	-0.7
October 2002	-7.0	-0.1	-1.5	-1.8

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 muted effect would be the answer for the other industry standard rating approach based on a Merton-type model. To look at 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 in Annex 1. 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	18.0	84.1	70.5	59.2
October 2002	8.8	53.2	47.1	36.3

For high quality books the Merton ratings would give a very large increase in capital requirements for the non-defaulted assets even after the flattening in the proposed risk weight curves by the Committee. This is particularly the case for the higher quality portfolios. This new procyclical element could therefore be very important for the banks using the IRB approach under Basel II.

An important question is whether a bank could meet the increase in capital requirements that might be seen in a recession were it using an approached akin to Merton. A 50% increase in the 4% Tier 1 ratio would bring the minimum to 6% and a 50% increase in the Tier 1 plus Tier 2 ratio would bring the minimum to 12%. 12% of large G10 banks could not meet the Tier 1 increase and 70% of large G10 banks could not meet the Tier 1 plus Tier 2 increase – see Charts 1 and 2 which show the actual capital ratios of G10 banks with Tier 1 plus Tier 2 capital of more than €3 billion (end 2001). Bank capitalisation varies but not substantially and these are therefore indicative of a longer period. Banks would, of course, in this period also be facing pressure on their capital from the need to build up specific provisions to cover defaulted assets which would make it even more difficult to meet the increase in capital requirements.

Chart 2: Tier 1 risk asset ratio

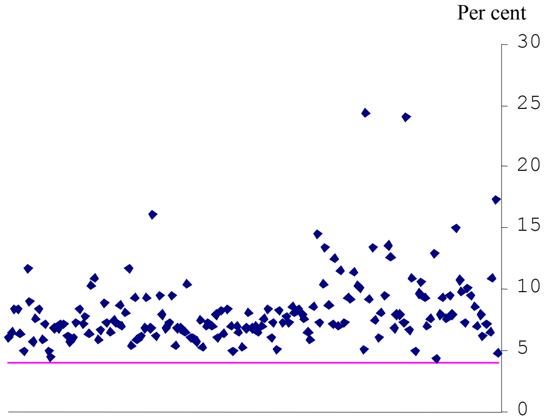
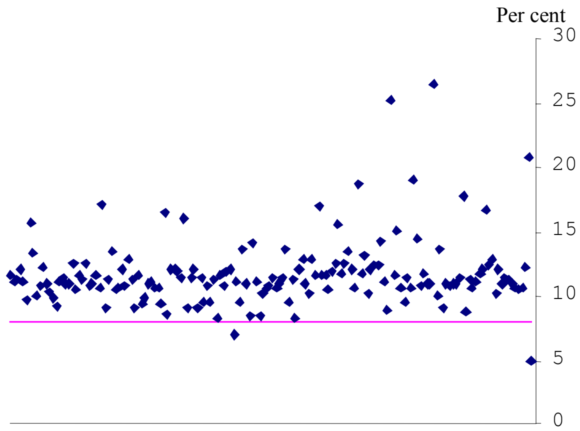


Chart 3: Tier 1 plus Tier 2 risk asset ratio



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

If the latter were the case it might lead to the conclusion that the Committee should use standards to limit or discourage the use of certain rating schemes or in some other way try to change the banks' incentives.

5 The preferred rating approach for a bank

Section 2 explored some reasons why banks might take an over optimistic view of risk (and therefore ratings) in booms which could lead to volatility in ratings across the cycle. To look at the question of whether a bank would prefer stable to volatile ratings we employ a simplified version of the general equilibrium model set out in Tsomocos (2003) to estimate the effect on bank profits of different approaches to ratings.

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.

5.1 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 parameterised version of Tsomocos (2003) 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 fully fledged welfare analysis.

A general equilibrium approach enables us to consider a richer institutional structure incorporating market interactions. However, by increasing the dimensionality of the model simplifications are made and some aspects that may be useful in analysing procyclicality are sacrificed. For example, our model does not permit fully fledged dynamic analysis since it is only a two-period model with complete markets. Second, the multitude of variables that characterise the equilibrium of the model prevents us from providing analytical solutions. Finally, some of the institutional assumptions may be considered *ad hoc* even though they are widely used in the literature and reflect the workings of the economy. A partial equilibrium or game theoretic analysis of the issues could certainly add insights and be complementary to the general equilibrium methodology we adopt.

The model[(4)] consists of three sectors (the household, corporate and banking sectors), two time periods with two possible future scenarios, and a financial market with one default-free asset and loans. The corporate sector can be thought of as firms that both borrow from banks and sell marketable financial assets. The banking sector raises funds by borrowing from the market and

[(4)] Ideally, we should study a parameterisation with more than two periods to analyse the dynamics of moving from one equilibrium to another and also incorporate the entire cycle into it. However, the dimensionality would increase precipitously without leading to substantially different results. Our analysis depends primarily on the direction of the economy, ie, recessionary or expansionary, that characterises a specific point in the cycle.

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.

Without loss of generality, we consider a two-period parameterisation in which the second period consists of two possible future economic scenarios (states) - a favourable and an unfavourable one. During the first period, agents engage themselves in the credit markets (ie interbank and consumer loan markets) and subsequently trade in the asset and commodity markets. In each state in the second period, loans and deposits are settled, assets payoff and then commodity trading occurs. Finally, default settlement and consumption occurs.

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 that only consumes when its investment in the asset market does not generate a positive return; otherwise it reinvests its portfolio. 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 3 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. We want to focus on regimes where capital requirements are more likely to be binding rather than those where some part of the problem may be alleviated by the capacity to raise new capital. This is a reasonable assumption for periods of economic stress. Even in booms banks wishing to make a rights issue 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 – ie the denominator in the risk asset ratio.[5]

We now provide a formal description of the model.[6]

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:

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

where $U^h = U^h(x_0^h, x_1^h, x_2^h)$ and x 's are consumptions in each state.

and the objective function of γ

$$U^\gamma : \Re^3 \to R$$

where $U^\gamma = U^\gamma(\pi_0^h, \pi_1^h, \pi_2^h)$ and π's are the corresponding profits in each state.

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:

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

$$\Pi_s^b = U_s^b - L_1 \max[0, DEBT_s]$$

[5] Of course, if access to capital markets is uninhibited even in times of financial stress then dynamic capital management may mitigate some of the adverse effects of banks' choice of rating system. However, since such adjustments are more sluggish than risk-weights changes, it remains highly unlikely that the adverse effects would be completely neutralised.
[6] The presentation of the general model, its properties and the proof of existence theorem are set out fully in Tsomocos (2003). We present here the simplified version used for the simulations.

$\Pi_s^\gamma = U_s^\gamma - L_2 \max[0, DEBT_s], \quad \forall s \in S, t \in T.$

The payoffs of the household and corporate sectors are functions of consumption, $x^h = (x_0^h, x_1^h, x_2^h)$, whereas of the banking are functions of profits, $\pi^\gamma = (\pi_0^h, \pi_1^h, \pi_2^h)$.

There also exists one default-free asset (Arrow security), $A = [1,0]^T$.
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 Sections 5.3-5.4.

We say that $(\sigma^\alpha, \sigma^\beta, \sigma^\gamma; p_0, p_1, p_2, r, \rho, \theta\ )$[7] is *a monetary equilibrium with commercial banks and default* (MECBD) for the economy if:

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

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

(ii) All markets of Annex 4 clear.

5.2 Endogenous default

Default is endogenous in the model. The corporate sector take loans from the banks on which they may default and invest in assets which are assumed to be default free. They will choose an optimal default rate to maximise their utility. (n_1^β (n_2^β) is the repayment rate (1- the default rate). Likewise banks invest in the asset market, give loans and borrow from the central bank and they choose an optimal default rate to maximise profits subject to a risk sensitive capital requirement. The repayment rate, v_1^γ (v_2^γ), is (1- the default rate). Households do not default – they only use their initial monetary endowments to make deposits in the banks.

The capital requirements depend on the credit rating set by the bank which in turn is based on the expected default rate of corporates. Expected default is also the key variable which affects the banks' decisions on how to allocate their portfolios between loans and other assets and the interest rate to be charged on loans. This will affect credit expansion in the economy. Demand for loans depends on the default rate and supply of loans on the bank rating and capital weight.

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(7) The choice variables and prices are defined in Annexes 3 and 4.

The frequency of corporate sector defaults is used as a proxy for the business cycle with high levels indicating recession periods.

5.3 Default varying risk weights

Under the proposed Accord, although regulators will set constant risk weights (ie capital requirements) for all loans assessed to have the same probability of default (PD), the risk weight of a particular loan will depend on the PD band into which a borrower is assigned by the bank. This gives rise to the potential for capital requirements (ie risk weights) which vary across the cycle.

In the model, the rating band to which corporate loans are assigned by the bank depends on the endogenous corporate default rate. We examine the effects on bank profitability of three different approaches to assigning ratings which in turn affect the minimum capital requirements or risk weights.

(1) PD ratings which vary positively with expected corporate sector default;
(2) PD ratings which vary negatively with expected corporate sector default;
(3) PD ratings which do not vary.

In (1), banks would reassign loans to a higher PD band when expected corporate default rates rise. In a boom loans would be assigned to rating bands reflecting the borrower's default likelihood given the favourable economic conditions (not taking into account the possibility of future recession) and then loans would be downgraded in recessions .This would be consistent with Herring (1999) 'disaster myopia' or the short-term profit focus in Rajan (1994).

In (2) the opposite would be the case – when expected corporate defaults are high banks would assign loans to a lower PD band. In the model the PD band to which the borrower is assigned is reflected in the interest rate charged. This scenario could be seen as banks charging what the market will bear combined with issues arising from relationship banking. In good times the borrowers are able to pay more and the banks can therefore place them in more conservative rating bands. This would be consistent with Greenbaum *et al* (1989), Sharpe (1990) and Wilson (1993), who argue that banks' improved knowledge of a borrower, as the relationship continues, enables banks to charge above cost interest rates. In recessions, the borrowers would be more under pressure and, to avoid causing defaults, banks could soften lending terms by placing them in less conservative rating bands.

The final option (3) is clearly a very extreme version of forward-looking ratings. The rating would be set according to the long-run average default rate for corporates. In practice even forward-looking ratings would probably show some variation across the cycle.

These three types of rating process give different profiles of minimum capital:

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

Constant (neutral) risk weights

We start with constant (neutral) risk weights as the 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.

Procyclical default-dependent risk weights

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 ($-0.4\bar{n}^{\beta} + 0.2$),

where $\bar{n}^{\beta} \equiv$ average expected recovery rate in the two states $= \frac{(n_1^{\beta} + n_2^{\beta})}{2}$ ie it is set procyclically $\mathbf{w_1}$*= f ($\bar{n}^{\beta}$) with f' < 0 (ie the risk weight increases as corporate default increases). The premium added to the risk weight $\mathbf{w_1}$ varies between –0.2 and +0.2 (ie a peak to trough variation of 40%). This reflects the variation between peak and trough in the capital requirements of an average G10 bank in Section 4, using ratings from a Merton-type model.

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

, 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).

Countercyclical default-dependent risk weights

Finally, by inverting the signs in our equation, we obtain a countercyclical policy. Loans move to a higher PD rating category when current default decreases. Thus, the new risk weights are assumed to increase with current repayments (ie the higher the amount of loans that are currently <u>expected</u> 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 $= \frac{(n_1^{\beta} + n_2^{\beta})}{2}$

5.4 Comparative statics – evaluating the rating schemes

The comparative static experiments show that there is no 'always-optimal' (ie first-best) policy in equilibrium. Basically, the preferred rating policy for a bank will change according to the specific point in the economic cycle – ie the specific value of the trend component of the risk weights (ie w_1). Since MECBD 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.

In Chart 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 Chart 5 can be compared to those presented in Chart 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 (Chart 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 evenly balanced between default-free assets and loans.

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 6, 7 and 8 demonstrate how profits depend on default for different values of $\mathbf{w_1}$ – ie 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 higher, more sensitive to changes in default levels. Thus, in the optimal levels banks prefer to restructure their portfolios using the counter or procyclical rating scheme.

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. Default rises but 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. This is because banks benefit from higher interest payments in booms and lower default rates in recessions. This is consistent with some theories of relationship banking.

Under a procyclical rating scheme, banks will reduce the risk weight on loans in booms, leading to increased borrowing which will result in increased default dispersion by the corporate sector but overall defaults are lower than in the countercyclical case (see Chart 5e). In recessions banks will increase the risk weight and interest rates on loans leading the corporate sector to reduce borrowing. Default rates are higher than in the countercyclical case. 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 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 7 and 8) but would not do so in the aggregate (Chart 6). During expansionary periods it would resemble the countercyclical scheme and in recessions it would resemble the procyclical scheme. 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 sizable amount for a large bank – £35 million per annum for a £7 billion profit bank.

These results show that given freedom to choose any rating scheme, banks would tend to opt for a countercyclical approach. Some bankers are arguing for a countercyclical approach to capital requirements. Ervin and Wilde (2001) suggest that regulators could let the aggregate amount of capital in the system float with the cycle. Banks would be judged relative to an overall benchmark rather than an absolute level. Regulators would require less capital when this was necessitated by economic circumstances – ie when perceived risk is higher. Taylor (2002) also suggests that capital requirements should be anti-cyclical.

However, a countercyclical approach would cut across the objectives of the new Accord, which is to deliver more capital when risks rise, making it unlikely that the Committee or any supervisors would be willing to adopt this approach.

This will leave the banks with a choice of ratings which are (1) designed to be less likely to vary as economic conditions change or (2) are procyclical demonstrating more downgrades in recessions. The first could be achieved by taking into account the possibility of future economic downturns when credit is extended in booms so that capital is built up earlier and then is sufficient, or at least less likely to have to increase sharply, in recessions. Ratings based on current economic conditions would be an example of the second approach. In recessions banks would face the need for substantial increases in minimum capital requirements. Alternatively as Ervin and Wilde point out if a bank wished to avoid pressure on its capital ratios it could stop lending or sell assets leading to a significant impact on overall credit markets.

The model suggests that, given this choice, the banks will opt for procyclical ratings because this would lead to higher profits than a rating approach which delivered more stability over the cycle. Under the procyclical approach, banks would extend more loans in booms than under the neutral approach (this can clearly be seen from Chart 5b relative to Chart 4b) and would charge a lower rate of interest. The greater extension of credit leads to higher default rates (see Chart 5e relative to Chart 4e) but overall because of the much greater volume of loans bank profitability in booms would be higher under the procyclical than under the neutral rating approach. In recessions banks using the procyclical rating approach would charge higher interest rates than banks using the neutral approach and extend less credit causing more corporate defaults (see Chart 5f relative to Chart 4f). Profitability would be lower in recessions under the procyclical approach than under the neutral but across the whole cycle the reverse would be true. The higher profits in booms outweigh the lower profits in recessions giving banks with the procyclical rating approach higher overall profitability than banks with neutral ratings. This indicates that banks which follow a procyclical approach to ratings will tend to exacerbate overlending in booms, and contractions in recessions.

Chart 4: Evolution of main endogenous variables as loans risk weight (W1) changes
All charts show the neutral risk weight regime

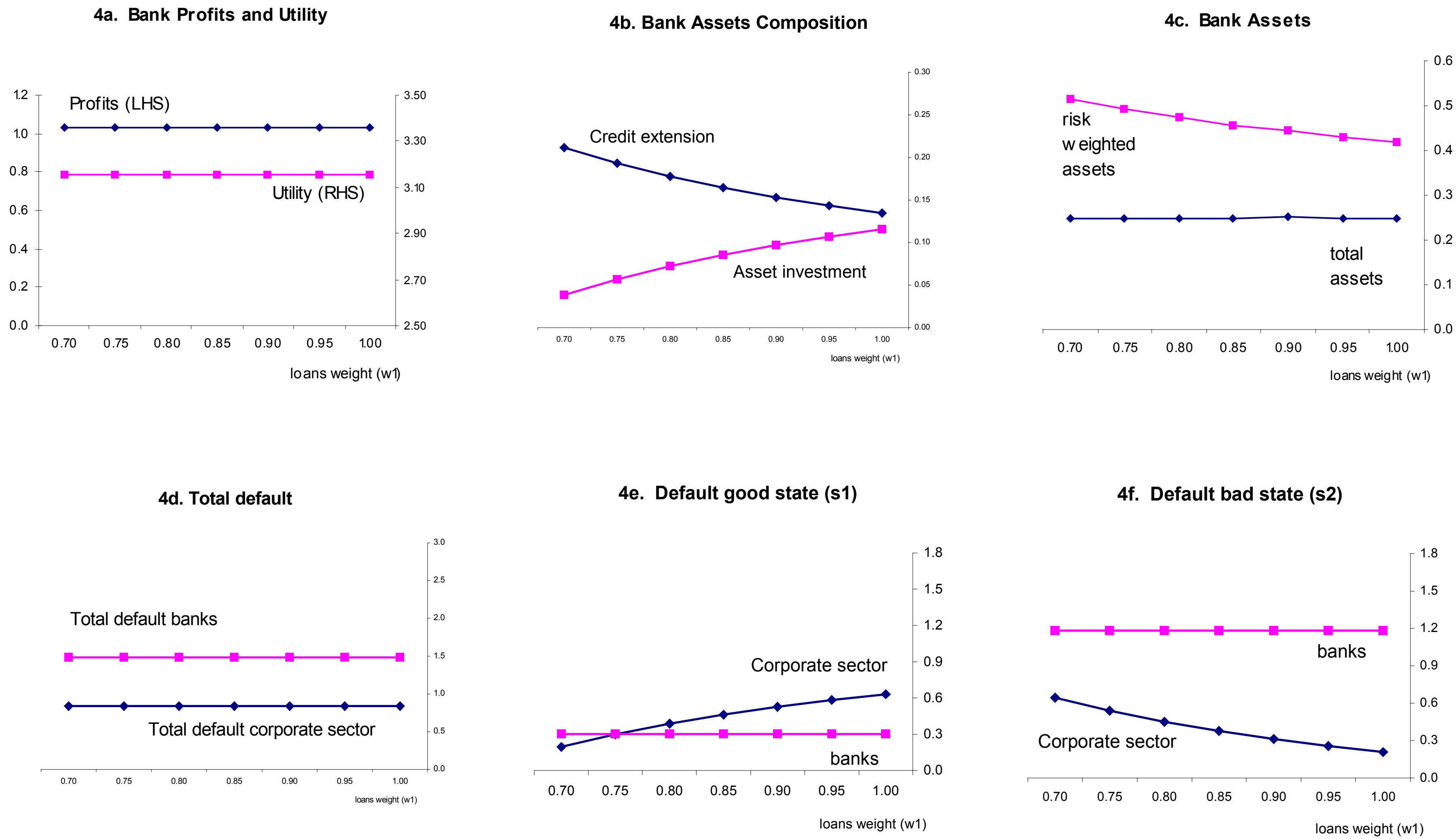


Chart 5: Evolution of main endogenous variables as loans risk weight (W1) changes
Procyclical and countercyclical schemes

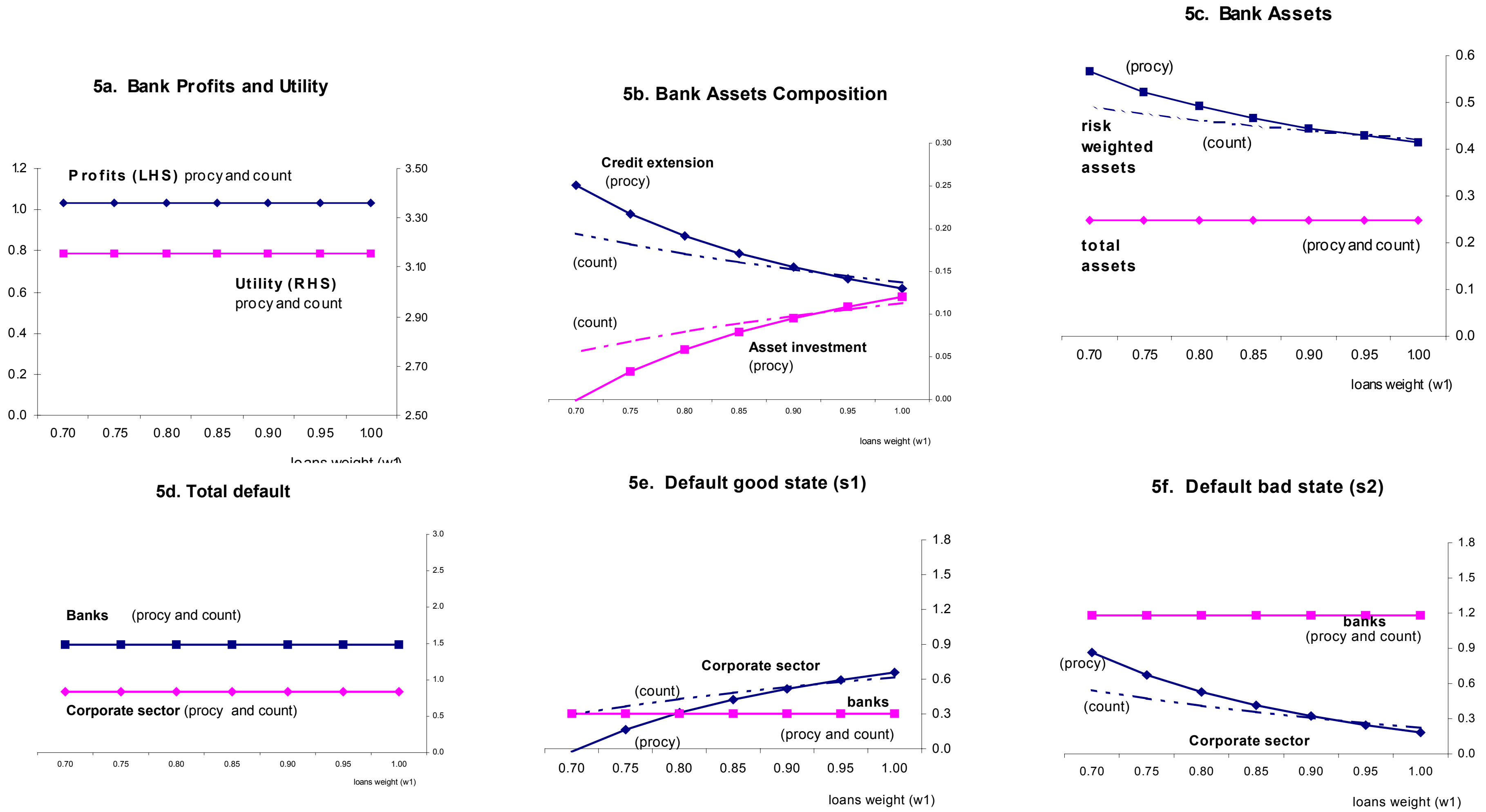


Chart 6: Expected total default and profits attainable under every regulation regime. Polynomial trend line for all experiments.

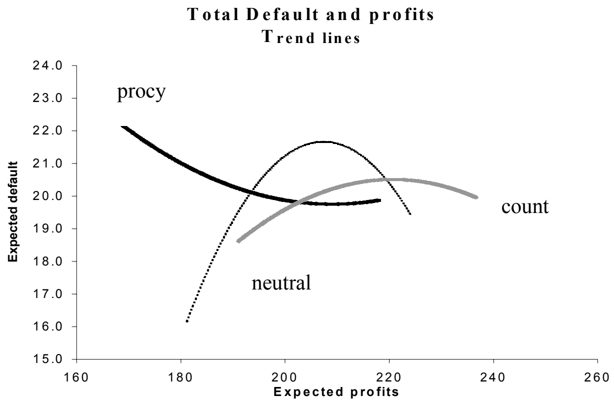


Chart 7: Total default in the bad state and profits attainable under every regulatory regime. Polynomial trend line for all experiments.

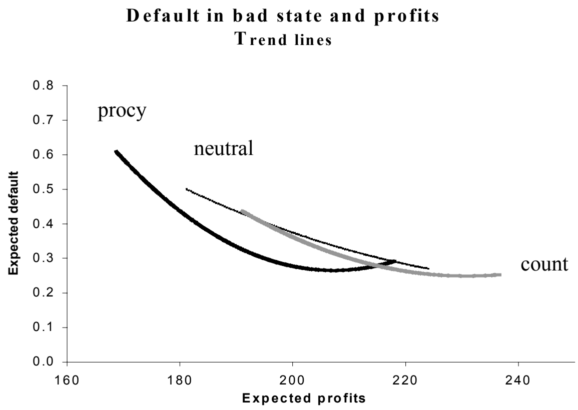
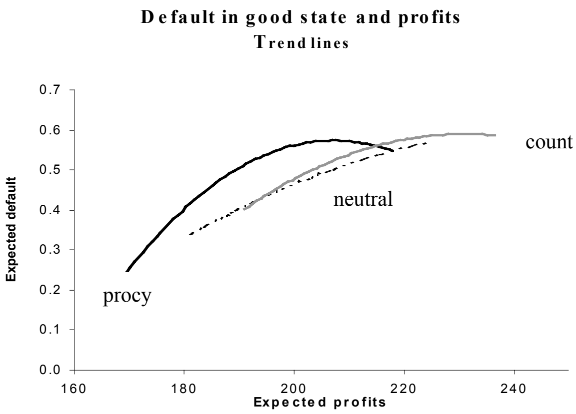


Chart 8: Total default in the good state and profits attainable under every regulatory regime. Polynomial trend line for all experiments.



5.5 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. However, to maximise welfare or minimise default, the neutral, 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 10: 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 constant risk weights could reflect the relative riskiness of different loans over the long term. The model has not explored the welfare costs of constant risk weights for private sector loans which did not reflect relative riskiness (as in Basel I). These effects could be severe.

5.6 Effect on bank capital

Banks currently maintain capital in excess of the regulatory minimum probably because of market pressure to achieve a particular external rating (see Jackson, Perraudin and Saporta (2002)). An important question therefore is whether banks which adopt the more procyclical rating approach would in turn simply build up a larger excess over the regulatory minimum in booms to enable the minimum capital constraint to be met in recessions without reducing bank lending. This would, however, be tantamount to adopting the neutral loan rating scheme which the model indicates they would not choose. Under the neutral regime they in effect build up a capital buffer in the boom to reflect the deterioration which will occur in the recession but do so through their rating scheme rather than using an excess.

6 Forward-looking ratings

The likelihood that banks, given a choice of procyclical ratings or more neutral ratings, 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 an approach that was completely neutral across different economic conditions, as in the model set out above. 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.

The latest Basel II proposals set out by the Basel Committee included a number of changes to encourage banks to use more forward-looking ratings. A borrower's rating must represent the bank's assessment of the borrower's ability and willingness to meet commitments despite adverse economic conditions or the occurrence of unexpected events. In addition, banks must stress test their capital requirements to assess how they may change in a recession.

7 Conclusion

The proposed new Basel Accord, in contrast to the Current Accord, makes provision for time varying risk weights for individual loans. Although the Basel Committee will set fixed weights for loans with a given probability of borrower default, banks will choose the probability of default band into which a loan will be slotted. It then becomes very important how the banks carry out this 'slotting'. When banks assess a borrower's probability of default the assessment can be based on current economic conditions (where the rating will be conditioned on the point in the cycle) or can take into account the effect on the borrower of a possible adverse change in the climate. Taking rating agency ratings as an example of the latter approach, it emerges that even this approach could lead to a 15% increase in bank capital requirements in a recession. Much of this reflects defaults rather than the deterioration in quality of non-defaulted assets. The new element under Basel II is the additional procyclicality which will come from the latter element. A rating approach conditioned on the economic conditions prevailing when the loan was made 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-type credit risk model, using the current equity price and importantly current balance sheet data to calculate the likely default probability for the borrower under an options pricing methodology. These results show that under a Merton approach capital requirements could increase by as much as 50% 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. They could also encourage excessive lending in booms. 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 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 approach.

References

Allen, L and Saunders, A (2002), 'A survey of cyclical effects of credit risk management models', *Working Paper Series, N. Stern School of Business*, New York University.

Basel Committee on Banking Supervision (2001), 'The New Basel Accord', Bank for International Settlements, January.

Basel Committee on Banking Supervision (2002), *Quantitative Impact Study 3 Technical Guidance*, www.bis.org/bcbs/qis/index.htm

Blum, J and Hellwig, M (1995), 'The macroeconomic implications of capital adequacy requirements for banks', *European Economic Review*, Vol. 39, pages 739-49.

Borio, C, Furfine, C and Lowe, P (2001), 'Procyclicality of the financial system and financial stability: issues and policy options', in Marrying the Macro- and Micro-prudential Dimensions of Financial Stability, *BIS Papers*, No. 1, pages 1-57.

Carling, K, Jacobson, T, Linde, J and Roszbach, K (2001), 'The internal ratings based approach for capital adequacy determination: empirical evidence from Sweden', paper prepared for the Workshop on Applied Banking Research, Oslo, 12-13 June.

Crockett, A (2000), 'Marrying the micro- and macro-prudential dimensions of financial stability', speech at the International Conference of Bank Supervisors, Bank for International Settlements, September.

Danielsson, J, Embrechts, P, Goodhart, C, Keating, C, Muennich, F, Renault, O and Shin, H S (2001), 'An academic response to Basel II', *LSE Financial Markets Group, an ESRC Research Centre Special Paper Series*, May.

Dubey, P and Geanakoplos, J (1992), 'The value of money in a finite-horizon economy: a role for banks', in Dasgupta, P, Gale, D *et al* (eds), *Economic analysis of market and games*, Cambridge: MIT Press.

Dubey, P, Geanakoplos, J and Shubik, M (2000), 'Default in a general equilibrium model with incomplete markets', *Cowles Foundation DP 1247*, Yale University.

Ervin, D W and Wilde, T (2001), 'Procyclicality in the new Basel Accord', *Risk*, October.

Estrella, A (2001), 'The cyclical behaviour of optimal bank capital', Federal Reserve Bank of New York, working paper (forthcoming).

Goodhart, C and Danielsson, J (2002), 'The inter-temporal nature of risk', *Technology and Finance*, Chapter 2, pages 18-40, Routledge International Studies in Money and Banking.

Gordy, M (2000), 'A comparative anatomy of credit risk models', *Journal of Banking and Finance*, Vol. 24, pages 119-150.

Grandmont, J M (1983), *Money and value*, Cambridge: Cambridge University Press.

Greenbaum, S, Kanatas, G and Venezia, I (1989), 'Equilibrium loan pricing under the bank-client relationship', *Journal of Banking and Finance*, Vol. 13, pages 221-35.

Haldane, A, Hoggarth, G and Saporta, V (2001), 'Assessing financial stability, efficiency and structure at the Bank of England', in Marrying the Macro- and Micro-prudential Dimensions of Financial Stability, *BIS Papers*, No. 1, pages 138-59.

Hancock, D and Wilcox, J A (1997), 'Bank capital, non-bank finance, and real estate activity', *Journal of Housing Research*, Vol. 8, pages 75-105.

Hancock, D and Wilcox, J A (1998), 'The "credit crunch" and the availability of credit to small business', *Journal of Banking and Finance*, forthcoming.

Herring, R (1999), 'Credit risk and financial instability', *Oxford Review of Economic Policy*, Vol. 15, No. 3, pages 63-79.

Jackson, P *et al* (1999), 'Capital requirements and bank behaviour: the impact of the Basle Accord', *Basle Committee on Banking Supervision Working Papers*, No. 1, April.

Jackson, P (2001), 'Bank capital standards: the new Basel Accord', *Bank of England Quarterly Bulletin*, Spring, pages 55-63.

Jackson, P (2002), 'Bank capital: Basel II developments', *Bank of England Financial Stability Review*, December, pages 103-09.

Jackson, P, Perraudin, W and Saporta, V (2002), 'Regulatory and "economic" solvency standards for internationally active banks', *Journal of Banking and Finance*, special issue on Banks and Systemic Risk, Vol. 26, No. 5, May.

Jones, D (2000), 'Emerging problems with the Basel Capital Accord: regulatory capital arbitrage and related issues', *Journal of Banking and Finance Special Edition on credit risk modelling and regulatory issues*, Vol. 24 (1/2), pages 35-58, January.

Lopez, J A (2002), 'The relationship between average asset correlation, firm probability of default and asset size', *Federal Reserve Bank of San Francisco Working Paper Series 2002-05*.

Nickell, P, Perraudin, W and Varotto, S (2000), 'Stability of ratings transitions', *Journal of Banking and Finance*, Vol. 24, (1/2).

Nickell, P, Perraudin, W and Varotto, S (2001), 'Ratings versus equity-based credit risk modelling: an empirical analysis', *Bank of England Working Paper no. 132*.

Peek, J and Rosengren, E S (1997a), 'The international transmission of financial shocks: the case of Japan', *American Economic Review*, September, pages 495-505.

Peek, J and Rosengren, E S (1997b), 'Collateral damage: effects of the Japanese real estate collapse on credit availability and real activity in the United States', *Working paper, Federal Reserve Bank of Boston*, August.

Rajan, R (1994), 'Why bank credit policies fluctuate: a theory and some evidence', *The Quarterly Journal Of Economics*, May.

Segoviano, M A and Lowe, P (2002), 'Internal ratings, the business cycle and capital requirements: some evidence from an emerging market economy', paper presented at a conference on *The impact of economic showdowns on financial institutions and their regulators*, Federal Reserve Bank of Boston, 17-19 April.

Sharpe, S (1990), 'Asymmetric information, bank lending and implicit contracts: a stylized model of customer relationships', *Journal of Finance*, Vol. 45, pages 1,069-87.

Shubik, M (1999), *The theory of money and financial institutions*, Cambridge, Massachusetts: The MIT Press.

Shubik, M and Tsomocos, D P (1992), 'A strategic market game with a mutual bank with fractional reserves and redemption in gold', *Journal of Economics*, Vol. 55 (2), pages 123-50.

Shubik, M and Wilson, C (1977), 'The optimal bankruptcy rule in a trading economy using fiat money', *Journal of Economics*, Vol. 37, pages 337-54.

Taylor, C (2002), 'A new general approach to capital adequacy: a simple and comprehensive alternative to Basel 2', *CSFI*.

Tsomocos, D P (2003), 'Equilibrium analysis, banking, contagion and financial fragility', *Bank of England Working Paper no. 175.*

Wilde, T (2001), 'IRB approach explained', *Risk.*

Wilson, P (1993), 'The pricing of loans in a bank-borrower relationship', *Working Paper, Indiana University*.

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	0.9	-	-	-	-	-	-
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**
$\mathbf{e}^{\alpha}$	9	0	0
$\mathbf{m}^{\alpha}$	0.05	0	0
$\mathbf{e}^{\beta}$	0	6	2
$\mathbf{m}^{\beta}$	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
ΔM^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^{γ}=0.035 , shareholders' fund
W_2 =1 , risk weight of bank financial assets

Annex 3

Optimisation problems for each agent

- **HOUSEHOLD**

$$\max_{\substack{b_1^\alpha, b_2^\alpha, q_0^\alpha \\ \lambda_1^\alpha, \lambda_2^\alpha}} U^\alpha = (x_0^\alpha - 1/60(x_0^\alpha)^2) + 0.8(x_1^\alpha - 1/60(x_0^\alpha)^2 + x_2^\alpha - 1/60(x_2^\alpha)^2))$$

s.t.

$$b_1^\alpha = m_0^\alpha(1+r) + p_0 q_0$$

(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**

$$\max_{\substack{b_0^b, q_2^b, \mu^b \\ n_1^b, n_2^b \\ \lambda_1^b, \lambda_2^b, \lambda_3^b}} U^b = (x_0^b - 1/30(x_0^b)^2) + (x_2^b - 1/30(x_2^b)^2) - L_1 \max[0, \mu^b - n_1^b \mu^b] - L_1 \max[0, \mu^b - n_2^b \mu^b]$$

s.t

$$b_0^b = \frac{\mu^b}{(1+r)} + \theta q^b$$

(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)

<u>Balance sheet of the banking sector</u>

A	L
- LOANS - ASSET INVESTMENTS	- HOUSEHOLDS' DEPOSITS - 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 = $\frac{\text{money bid by the corporate sector}}{\text{supply of goods}}$

$p_1 = \frac{b_1^\alpha}{e_1^b}$; price in the 'good' state = $\frac{\text{money bid by the household in s=1}}{\text{supply of goods}}$

$p_2 = \frac{b_2^\alpha}{q_2^b}$; price in the 'bad' state = $\frac{\text{money bid by the household in s=2}}{\text{supply of goods}}$

→ **Central Bank Market Operations**

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

→ **Loan Market**

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

→ **Asset Market**

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

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.**