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Procyclicality in Basel II: Can we treat the disease without killing the patient? ☆

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Abstract

The debate over the potential procyclicality of bank capital requirements under Basel II has focused overwhelmingly on peak-to-trough variation in minimum regulatory requirements. In this paper, we re-examine the problem from the perspective of market discipline. First, we show that the marginal impact of introducing Basel II depends strongly on the extent to which market discipline leads banks to vary lending standards procyclically in the absence of binding regulation. Second, we evaluate policy options not only by their efficacy in dampening cyclicality in capital requirements, but equally by how well the information value of Basel II market disclosures is preserved.
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Academics, practitioners and policy makers have commented on the potential procyclicality of the New Basel Capital Accord (Basel II). So long as bank rating systems are responsive to changes in borrower default risk, capital requirements under the Internal Ratings Based (IRB) approach will tend to increase as an economy falls into recession and fall as an economy enters an expansion. To the extent that banks curtail (expand) lending in response, recessions (expansions)

☆ This research was conducted while Brad Howells was at the Board of Governors of the Federal Reserve System. The views expressed herein are our own and do not necessarily reflect those of the Board of Governors or its staff.

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will be amplified. Thus, many have argued that the New Accord will make it more difficult for policy makers to maintain macroeconomic stability.

In this paper, we re-examine the procyclicality issue from the perspective of market discipline. First, in trying to assess the likely magnitude of the problem, we show that the marginal impact on procyclicality of introducing the New Accord depends strongly on a question that earlier studies have not considered: To what extent does market discipline lead banks to vary lending standards procyclically in the absence of binding regulation? Second, can we identify policy options that will serve to lessen cyclicality in capital requirements while still preserving the informativeness of Basel II market disclosures? Put another way, can we dampen procyclicality without garbling the signal?

Our concerns and the manner in which we address them are best understood in the context of the goals and "three pillar" structure of the New Accord. Pillar 1 is a regulatory standard for minimum capital requirements. The primary objective under Pillar 1 is better alignment of regulatory capital requirements with "economic capital" demanded by investors and counterparties. In the final Basel II agreement (Basel Committee on Bank Supervision, hereafter BCBS, 2004), as in earlier drafts, the great bulk of the documentation is devoted to the rules for determining minimum capital requirements, and it is this aspect of the New Accord that has drawn the most commentary from practitioners and academics.[1] In particular, the burgeoning literature on the procyclicality of the New Accord is written mainly from the perspective of Pillar 1. That is, the focus is on estimation of the likely range of variation in regulatory capital requirements from peak to trough in a business cycle, and on how modifications to the capital formula might increase or decrease this variability.

Pillar 2 is the supervisory review process. The New Accord sets forth broad principles and some specific guidelines for review of capital adequacy that are intended to push both banks and supervisors beyond mechanical application and satisfaction of Pillar 1 standards. Banks are expected to establish and document internal processes for assessing capital adequacy relative to portfolio risk. The intent of the Basel Committee (BCBS, 2004, §757a) is that large, internationally active banks will choose for their own competitive reasons a level of creditworthiness that exceeds that embodied in Pillar 1 standards, which corresponds approximately to a BBB− rating.[2] Furthermore, banks' internal processes are expected to include consideration of interest rate risk, liquidity risk, concentration risk, and other risks not explicitly addressed under Pillar 1. Therefore, "[s]upervisors should expect banks to operate above the minimum regulatory capital ratios and should have the ability to require banks to hold capital in excess of the minimum" (BCBS, 2004, §756). Regulatory capital requirements should properly be viewed as a composite of formulaic Pillar 1 rules and judgmental Pillar 2 buffers, so the volatility of regulatory capital over the business cycle will depend in practice on whether supervisors guide Pillar 2 buffers in a manner that offsets or augments changes in Pillar 1 requirements. Borio et al. (2001) and

[1] Very few academic discussions of the New Accord place any emphasis on Pillars 2 and 3. Decamps et al. (2004) analyze the role of supervisory review and market discipline as a complement to minimum capital requirements in an optimal supervisory regime.

[2] At face value, the 99.9% target solvency probability to which the New Accord is calibrated would appear more consistent with a rating of A− or BBB+. However, both the current Accord and Basel II permit limited recognition of subordinated debt and other non-equity liabilities towards the regulatory capital requirement. Such instruments may limit the burden on deposit insurance funds in the event of a bank insolvency, but do not lower the probability of such an insolvency and therefore do not constitute economic capital.

Estrella (2004), among others, point to supervisors' discretionary powers under Pillar 2 as a possible means of attenuating procyclicality.

Pillar 3 is market discipline. In order to improve the transparency of banks to counterparties and investors, banks will be required to disclose detailed information on their risk profile and capital adequacy. Specific reporting requirements include IRB capital for each of the major portfolio components (e.g., corporate, retail mortgages, securitization exposures) as well as for the bank as a whole. We take the view that the ultimate success of Pillar 1 standards rests on how well the resulting disclosures serve Pillar 3 goals. A well-functioning bank will hold capital well in excess of the minimum requirement, so the regulatory capital ratio will not be binding under Pillar 1. If, for such institutions, the disclosed capital ratio provides a reliable measure of *economic* capital adequacy, then it will allow market participants to better assess relative creditworthiness both cross-sectionally (i.e., across investment-grade banks at a moment in time) and across time. The earlier market participants are able to identify and punish a faltering institution, the less the need for supervisory intervention.[3]

Relative to capital ratios under the current Accord, the IRB approach of the New Accord offers a far more sophisticated and informative measure of capital adequacy. IRB capital formulae are derived from asymptotic approximations to the risk-factor models that are now in widespread use in the banking industry. For large, well-diversified banks, regulatory capital under the IRB approach should roughly approximate VaR for a one-year solvency probability of 99.9%. For whatever its limitations, the IRB capital ratio represents the first *standardized* modern metric of portfolio risk. Even if it comes at some sacrifice in sophistication and risk-sensitivity, an imposed common standard provides the benefit of easier and more direct comparison of creditworthiness between banks and across time. This enhanced comparability is indeed an explicit Basel Committee objective under Pillar 3 (BCBS, 2004, §810), and its preservation a primary motivation for this paper.

Broadly speaking, there are three methods by which the procyclical impact of the IRB approach could be dampened. First, banks could adopt through-the-cycle rating methodologies which filter out the impact of the business cycle on borrower ratings. Assuming that the probability of default (PD) associated with each rating grade is calculated as a long-term historical average, through-the-cycle systems dampen the sensitivity of borrower PDs to macroeconomic conditions. By smoothing these critical inputs to the IRB capital function, smoothing of the output (i.e., the regulatory capital requirement) is obtained. Second, procyclicality can be reduced simply by flattening the capital function in order to reduce the sensitivity of capital charges to changes in PD. Third, supervisors can apply a smoothing rule directly to the output of the IRB capital function. Let C_{it} denote the unsmoothed output from the IRB capital formula for bank i at time t, expressed as a percentage of portfolio book value, and let $\hat{C}_{it}$ denote the corresponding regulatory minimum applied to the bank. At present, the New Accord sets $\hat{C}_{it} = C_{it}$. One simple smoothing rule would specify $\hat{C}_{it}$ as an autoregressive process that adjusts towards C_{it}, i.e.,

$$\hat{C}_{it} = \hat{C}_{i,t-1} + \alpha\big(C_{it} - \hat{C}_{i,t-1}\big). \tag{1}$$

The current Accord can be represented in stylized fashion as setting $\alpha = 0$, whereas the New Accord sets $\alpha = 1$. An intermediate value of α would offer a compromise between the current Accord and New Accord in sensitivity to the business cycle. A more sophisticated smoothing rule

[3] This principle motivates many proposed reforms to bank regulation, e.g., proposals for requiring banks to issue subordinated notes and debentures (Study Group on Subordinated Notes and Debentures, 1999).

would apply a time-varying multiplier to the IRB formula, that is, $\hat{C}_{it} = \alpha_t C_{it}$. The multiplier α_t would be reduced by regulators during a recession to offset the effect of higher borrower PDs on required capital. During an expansion, α_t would be increased, and similarly offset the effect of falling PDs. We call this alternative "counter-cyclical indexing."[4]

From a Pillar 1 perspective, any of these approaches could in principle provide a practical solution to the procyclicality problem. From a Pillar 3 perspective, however, the three approaches have very different implications. We show that adoption of through-the-cycle rating systems would destroy the comparability across time of the IRB capital requirement. Market participants would be unable to infer changes in portfolio risk from changes in a bank's capital ratio. As through-the-cycle rating is also poorly suited for internal pricing and risk-management purposes, we strongly recommend against this approach. We find that flattening the IRB capital function is much less destructive to the information value of the capital ratio across banks and across time, but one can achieve only very modest degree of smoothing without causing significant distortion to relative capital charges across borrowers. Finally, we demonstrate that smoothing the IRB output can dampen procyclicality significantly. The autoregressive rule has somewhat different implications from counter-cyclical indexing for cross-sectional variation in capital adequacy and for robustness to changes in bank lending strategy. However, so long as the dampening rule is publicly announced, the unsmoothed capital requirement (C_{it}) can be inferred from the regulatory minimum ($\hat{C}_{it}$). Thus, the prospect of transparent and informative Pillar 3 disclosure is undiminished under either alternative.

The empirical evidence on the degree of procyclicality in the IRB capital formula is examined in Section 1. Existing studies have focused on the mechanics of the regulatory capital minimum, rather than on the constraints placed on banks in the marketplace, and so may overstate the marginal procyclical impact of replacing the current Accord with the New Accord. In Section 2, we describe a flexible simulation engine for exploring the cyclical behavior of regulatory and economic capital under different rating philosophies, various assumptions on how bank lending behavior responds to the business cycle, and alternative proposed modifications to the New Accord. Results are presented in Section 3. A concluding Discussion addresses practical issues in implementation.

1. Evidence on procyclicality in the New Accord

Existing studies of procyclicality in the New Accord have focused on Pillar 1 IRB treatment of whole commercial loans.[5] Regulatory capital charges are set at the individual loan level and are given by a formula with five inputs: the borrower's one-year PD, the instrument's expected loss given default (ELGD) and remaining maturity (M), the asset-value correlation (ρ) which parameterizes dependence across borrowers, and a target one-year solvency probability (q) for

[4] Ervin and Wilde (2001) refer to counter-cyclical indexing as "explicit regulatory guidance," and appear to have been the first to suggest this method for dampening procyclicality. Similar proposals have also been put forward by Kashyap and Stein (2004), Purhonen (2002), Rösch (2002), and Cosandey and Wolf (2002). An autoregressive rule akin to Eq. (1) has been proposed by Estrella (2004). Pennacchi (2005) incorporates a similar smoothing feature in a proposal for risk-based deposit insurance premia.

[5] Large banks typically have significant portfolios of retail loans, sovereign loans, commercial real estate project finance, and securitization exposures. Treatment of these other lending classes is based on the same principles and models that underpin treatment of commercial lending. The New Accord introduces a significant capital requirement against operational risk, which is unlikely to show any cyclicality. Therefore, an exclusive focus on capital for credit risk is likely to overstate the procyclicality of regulatory capital requirements.

the bank. Parameters q and ρ are controlled by the regulator. Under the New Accord, q is fixed to 99.9% and ρ is specified as a decreasing function of PD. For details, see BCBS (2004, §212).

The IRB capital formula is derived from the large-portfolio asymptotic behavior of a Merton model with a single common risk-factor. As shown by Gordy (2003), an instrument's marginal contribution to portfolio VaR converges in the asymptotic limit to its expected loss conditional on the common factor suffering a qth percentile "stress event." In the IRB implementation, this conditional expected loss is approximated as a separable equation of three terms: ELGD; the one-year actuarial conditional expected loss; and a maturity adjustment that approximates the ratio of mark-to-market capital charges to actuarial-loss capital charges.

Since the release of the Second Consultative Paper (BCBS, 2001), nearly a dozen studies have assessed empirically the magnitude of procyclicality in the IRB capital formula. Both within and between studies, one sees a wide range of estimated response to a cyclical downturn. Required capital can double in some simulations, and in others can actually decline. Kashyap and Stein (2004) point to differences across studies in sample and methodology that account for some of the differences in results. These include the average credit quality of the sample portfolio, and the country, time period and rating system from which historical experience was drawn. Some differences across studies may be attributed to successive revisions to the New Accord.

Kashyap and Stein (2004) also identify methodological issues in survivorship bias and treatment of missing observations that appear to have been mishandled in some earlier studies. Perhaps more important are two issues that can be cast as methodological, but have strong substantive implications. First, should measurement of changes over time in required capital be inclusive or exclusive of charge-offs due to defaulted loans? Second, should the simulated portfolio be passively or actively managed? A passively managed portfolio is fixed at the beginning of the simulation, and so shrinks as defaults accumulate. In an actively managed portfolio, defaulting or maturing loans are replaced with new loans. We can assume a simple time-invariant rule for new lending, or we can attempt to emulate the behavior of bank managers in loosening or tightening lending standards over the credit cycle.[6]

As Kashyap and Stein (2004) observe, if we retain defaulted loans in the sample, then we measure the cumulative demands on bank capital over the simulated period. The accumulated charge-offs would have been incurred under the rules of the current Accord as well. From a policy perspective, we are interested only in the *additional* procyclicality associated with a change in capital regime.[7] Furthermore, in our view it is somewhat misleading to include accumulated charge-offs without also imputing accumulated interest income net of dividend payments. Dividends can be raised and lowered with the anticipated capital needs of the bank, so would need to be modeled endogenously. Therefore, we concur with Kashyap and Stein in preferring to measure capital changes exclusive of defaulted obligors. In most of their simulations, Kashyap and Stein (2004) find that roughly 40% to 60% of total change in capital (inclusive of defaulted loans) is attributable to accumulated charge-offs. When Catarineu-Rabell et al. (2005) and Rösch (2002)

[6] In the last few years, banks have begun to use credit default swaps and secondary loan markets to manage the stock of existing loans from earlier cohorts. Our study, like earlier studies, does not attempt to model this aspect of active management.

[7] In practice, treatment of defaulted loans may change somewhat under the New Accord. Defaulted loans are often not charged off immediately, but rather may remain for some time on the balance sheet while in work-out. The New Accord assigns higher capital to such loans than does the current Accord. To the extent that there are more loans in work-out during a recession, eliminating loans from the sample upon default may cause us to underestimate slightly the additional procyclicality associated with the New Accord.

similarly decompose total changes in required capital, they in some cases find that capital on the non-defaulting portfolio can *decrease* in a credit cycle downturn. By sweeping away the weakest borrowers, a stress event can paradoxically improve the average credit quality in a portfolio.

On the second issue, Kashyap and Stein favor a passive simulated portfolio because

> "active management muddles together the direct effect of a tightened capital constraint with the bank's endogenous response. For example, suppose we look at the evolution of a bank's actively managed portfolio during a recession and find that average credit quality ... is roughly unchanged. Should we conclude from this that there is no cyclicality problem deserving of policymaker attention? Probably not—it may just be that the bank has reacted to a tightening capital constraint by cutting off credit to its riskier borrowers, which is precisely the policy problem that concerns us" (Kashyap and Stein, 2004, p. 23).

Here we disagree. If the goal is to estimate the additional procyclicality associated with the change in capital regime, then we need to simulate active portfolio management as it occurs under the *current* regulatory regime. Put another way, we agree with Kashyap and Stein that portfolio management should not be made endogenous to the regulatory rule, but disagree on the appropriate alternative benchmark. Since the mid 1990s, large banks have been more or less unconstrained by regulatory capital requirements, so changes in lending standards over recent years ought to have been driven mainly by economic capital considerations. Such considerations are independent of regulatory regime, and thus would persist (though not necessarily as the binding constraint) into a New Accord.[8]

Empirical evidence is limited on this point, but suggests that banks currently do tighten lending standards during a recession and loosen lending standards in an expansion. Bassett and Zakrajšek (2003) show that the average quality of new loans decreased at the start of the recent recession, while the Federal Reserve Board's Senior Loan Officers Survey showed a contemporaneous tightening of lending standards. These results are not necessarily contradictory. Many or most nominally "new" loans are actually drawdowns under existing commitments. Tighter lending standards presumably increase the quality of *newly established* lending facilities. Thus, the change in new loan quality takes effect with a lag. Taking a more behavioral view of lending practices, Berger and Udell (2004) find evidence for a "memory hypothesis" under which standards soften as time passes since a bank's most recent period of large credit losses. The ability to differentiate accurately between high risk and low risk borrowers deteriorates over time as loan officers forget the lessons of the last credit cycle. When large losses are again experienced, standards are tightened drastically, and the cycle begins again.

Results in Kashyap and Stein (2003) are consistent with this story. In addition to studying procyclicality on their simulated passive portfolios, Kashyap and Stein calculate the time-series of IRB required capital for Deutsche Bank's actual German commercial loan portfolio. The capital

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[8] It should also be noted that endogenous response by banks to a New Accord might serve to reduce cyclicality in regulatory capital *without* exacerbating macroeconomic cycles. If the New Accord encourages more forward-looking behavior on the part of bank managers, then banks might exhibit less "irrational exuberance" during an expansion. The (BCBS, 2001, Overview, §41) points out that "The 1988 Accord, which does not adequately reflect changes in risk, creates incentives for banks to make high-risk investments that may contribute to cyclicality over the business cycle." Jordan et al. (2003) argue that improved risk-sensitivity under the New Accord will encourage banks to recognize and correct capital inadequacies earlier in the cycle, and so may prevent the sudden precipitous declines in capital adequacy that trigger credit crunches.

increase (excluding charge-offs) in this actively managed portfolio was only about one fourth of the increase in required capital for the passively managed, simulated KMV Germany portfolio. As the Deutsche Bank rating system is designed to be point-in-time like KMV, it is reasonable to attribute the difference to active management of lending standards.[9] Thus, even under the current risk-insensitive Accord, internal management processes cause banks to respond to a downturn in a manner that would also serve to dampen the cyclicality of IRB capital requirements.[10]

2. Simulation engine

We construct a simulation engine to generate bank portfolios and capital requirements in a stylized economy. Two broad sets of goals shape the exercise. First, we want to assess the sensitivity of estimated procyclicality in economic capital to model assumptions on bank strategy for portfolio management. Second, we want to evaluate alternative proposals for dampening procyclicality in regulatory capital. We examine the extent to which the dampening rule would leave intact the reliability of regulatory capital in rank-ordering banks cross-sectionally and in signaling directional changes in capital strength through time.

The simulation tracks a set of I stylized bank portfolios over T years. There is a single "global" risk-factor representing shocks to the overall macroeconomy through time, as well as bank-specific "local" risk-factors. Each bank maintains a portfolio of N equal sized corporate loans that are equal in exposure size, but heterogeneous in credit quality and remaining maturity. For each loan, we track the "true" (i.e., point-in-time) probability of default through time until maturity or default. Once these data are generated, we can emulate alternative rating schemes (such as through-the-cycle ratings) by applying an appropriate filter to the point-in-time ratings. We next calculate for each year and each bank the annual portfolio-level economic capital requirement and the annual regulatory capital minimum under the final IRB formula and alternative proposals. For all our simulations we set $N = 2000$ loans, $I = 20$ banks, and $T = 100$ years.

Borrower credit quality in each portfolio of loans is governed by a single-factor CreditMetrics model. Borrowers are distributed across G non-default (i.e., "live") grades with grade 1 representing best credit quality and grade G worst credit quality. Grade $G + 1$ denotes default. The transition process is assumed to be Markov with time-homogeneous one-year transition matrix $\overline{P}$. Associated with borrower j at time t is a latent variable $R_{j,t}$ that represents the performance of borrower j in the interval since time $t - 1$. As CreditMetrics draws its inspiration from the model of Merton (1974), $R_{j,t}$ is typically interpreted as a standardized return on the assets of the borrower. If that return is sufficiently negative, the borrower defaults. More generally, the outcome of $R_{j,t}$ determines the borrower's change in creditworthiness (and so its rating) in the interval $(t - 1, t]$. For each live grade g, we divide the real line into $G + 1$ intervals using a vector of thresholds

$$-\infty = \gamma_{g,G+1} \leqslant \gamma_{g,G} \leqslant \cdots \leqslant \gamma_{g,1} \leqslant \gamma_{g,0} = \infty.$$

[9] The characterization of Deutsche Bank's ratings as point-in-time is consistent with the bank's public statements on the issue. Historical transition frequencies for Deutsche Bank's rating system, found in Kalkbrenner and Overbeck (2002), are indeed more consistent with a transition matrix from KMV migration data than with the S & P transition matrix.

[10] The distribution of credit ratings is only one dimension of lending standards for banks to manage. Banks can tighten standards by reducing maturity or increasing collateral. Active management of these terms would tend to dampen the cyclicality of capital requirements under the Advanced IRB approach.

If borrower j is in grade g at time $t-1$, then its rating at time t depends on the interval into which $R_{j,t}$ falls. If we assume that $R_{j,t}$ has standard normal distribution, then consistency with the given transition matrix $\overline{P}$ requires that

$$\gamma_{g,k} = \Phi^{-1}\left(\sum_{\ell=k+1}^{G+1} \overline{p}_{g,\ell}\right) \tag{2}$$

for $1 \leqslant g \leqslant G$ and $1 \leqslant k \leqslant G$, where Φ^{-1} is the inverse normal cumulative distribution function.

The implications of imposing a time-homogeneous Markov transition process are often underappreciated. The model rules out serial dependence of any form in the rating process, so the rating must be interpreted as a sufficient statistic for the one-year probability of default. Put another way, while the ex post default frequency for a grade might vary over time, the ex ante probability of default associated with the grade is constant. As firm-level accounting variables and macroeconomic indicators may be serially correlated, the rating system must incorporate all *expected* change in those variables into rating assignments, so that only *unexpected* shocks determine rating change over the subsequent interval. This property is the defining characteristic of a *point-in-time* (PIT) rating system. Equity markets filter information in much this manner, so structural default models calibrated to equity returns ought to yield (more or less) PIT ratings. The KMV model is a well-known and widely-used example, so we set $\overline{P}$ to a matrix tabulated from annual changes in KMV EDFs (Gupton et al., 1997, Table 6.3). This matrix displays greater rating volatility than comparable rating agency matrices. As demonstrated by Kashyap and Stein (2004) and Catarineu-Rabell et al. (2005), the KMV matrix will generate much more cyclicality in capital charges than a more stable rating agency matrix.

In CreditMetrics, dependence across borrower defaults and rating migrations is generated by decomposing borrower asset–returns into a systematic component and an idiosyncratic component. We divide borrowers into sectors so that firms in the same sector share a common systematic factor. If firm j is in sector i, then we write

$$R_{j,t} = X_{i,t}\sqrt{\rho} + \epsilon_{j,t}\sqrt{1-\rho} \tag{3}$$

where $X_{i,t}$ is the sector risk factor. The $X_{i,t}$ are distributed standard normal and serially independent, and the $\epsilon_{j,t}$ are i.i.d. standard normal. The so-called "asset-correlation" parameter ρ determines the strength of dependence across borrowers within the same sector.

In principle, ρ might vary across borrowers and even across time. One feature introduced in CP3 and carried into the New Accord is a declining functional relationship between borrower PD and the imposed value of ρ in the IRB formula (BCBS, 2004, §272). This was motivated partly by the belief that smaller firms tend to be both higher in PD and lower in ρ than larger firms, which would imply a negative cross-sectional correlation between PD and ρ. This feature also served to flatten the IRB formula relative to CP2, which may have been perceived as desirable for moderating procyclicality. In our simulations, we maintain the assumption of a constant $\rho = 0.18$ across borrowers and across time. It is not our intention to take any stance on whether ρ is indeed decreasing with respect to PD, as we lack data sufficient to test the adopted functional form against a constant ρ. Rather, we adopt the constant ρ assumption merely to create a convenient benchmark against which to test the efficacy of a declining ρ in reducing the volatility of regulatory capital relative to economic capital.

Finally, the model allows also for dependence across the sectors. The $X_{i,t}$ are decomposed as

$$X_{i,t} = \sqrt{\beta_i}X_t^* + u_{i,t}\sqrt{1-\beta_i} \tag{4}$$

where X_t^* is a univariate factor representing the overall macroeconomy, $u_{i,t}$ is a sector specific factor, and parameter $\beta_i \in [0, 1]$ determines the strength of dependence across sectors. As above, we assume that X_t^* is distributed standard normal and serially independent, the $u_{i,t}$ are i.i.d. standard normal, and (for simplicity) that $\beta_i = \beta$ for all i. Our baseline calibration is $\beta = 0.9$, but we examine the robustness to lower values of β in Section 3.3.

In a typical practitioner implementation of this model, sector i would be associated with some combination of geographic region and industrial sector. In our exercise, sector i will be identified with the borrower's bank. The intuition is that bank portfolios can differ in regional or industrial sector concentrations that cause them to experience somewhat different systematic risk from other banks in the same national market. So long as there are barriers to expansion across bank markets, the bank-specific factor $X_{i,t}$ is effectively the single macroeconomic risk factor as experienced by bank i. The conditions of Gordy (2003) then hold, and the IRB formula provides an asymptotic approximation to the bank's internal economic capital allocation rule (for its internally measured asset-correlation ρ and chosen target solvency probability q).[11] Of course, if $\beta = 1$ then $X_{i,t} = X_t^*$ for all banks, and the model resolves to the standard single factor model associated with the New Accord.

Our motivation for introducing market segmentation is to make the regulator's problem more challenging. If we simply imposed $\beta = 1$, then we would effectively be granting the regulator access to information (namely the history of X_τ^* for $\tau \leqslant t$, which could be estimated accurately by looking at the performance of the banking system over time) that would summarize precisely the state of the macroeconomy at time t as experienced by every bank in the market. The regulator could then form a perfect counter-cyclical index and costlessly eliminate cyclical volatility in capital. We do not wish to assume that regulators have such perfect information. In practice, credit problems do not necessarily emerge simultaneously across all banks in the same national market, and the regulator must make do with macroeconomic indicators that are imperfectly correlated with the true conditions faced by each bank under its authority.

2.1. Reinvestment in new cohorts of loans

Existing studies have taken two different approaches to portfolio construction. Under one approach, the portfolio is fixed at the beginning of the simulation period. Defaulting obligors disappear and are not replaced. Under the other, the portfolio is the actual universe of rated instruments in a bank portfolio or rating agency database. Loosely speaking, the first approach measures a partial derivative of the effect of the business cycle on capital volatility, while the latter approach incorporates the portfolio's response to changing business conditions and so gives a total derivative. We have argued that this total derivative is more informative for policy purposes, but in any case want to explore the sensitivity of results to our assumptions. As a practical matter, we cannot avoid introducing some form of reinvestment behavior. Otherwise, over a long simulation period (100 years), the portfolio would shrink dramatically in size as borrowers reach the absorbing state of default.

Our reinvestment rules are built from three primitive "idealized" rules. Each idealized rule can be represented as a vector, S, that gives a multinomial probability function over rating grades 1 through G. New loans, issued at the end of year t to replace all loans that matured or defaulted

[11] As our simulated portfolios are finite, there is a residual of undiversified idiosyncratic risk that contributes to VaR. The granularity adjustment introduced in CP2 (but eliminated in CP3 and thereafter) could be used to provide a correction accurate to first order in $1/N$. See Gordy (2004) for a survey article on this technique.

Table 1
Fixed reinvestment rule distributions

	AAA	AA	A	BBB	BB	B	CCC
Average quality, %	3	5	13	29	35	12	3
High quality, %	4	6	29	36	21	3	1

during that year, are drawn i.i.d. from S. The new loans are included in calculation of portfolio capital at time t (i.e., capital held against risk at horizon $t+1$). The first idealized rule, which we shall refer to as "fixed" replacement, assumes that a bank maintains a consistent credit quality standard over time in its loan origination. The ratings of newly originated loans are therefore drawn from a time-homogeneous probability vector, denoted S^{fixed}. In our simulated economy, the same S^{fixed} is applied to all banks. Table 1 shows the "average quality" and "high quality" distributions reported by Gordy (2000) for large US banks. Unless otherwise noted, we set S^{fixed} to the average quality distribution.

The second idealized rule, which we refer to as "passive" replacement, assumes that the distribution of ratings across surviving loans in its portfolio at the end of period t is representative of the bank's lending opportunities. The distribution associated with this rule, $S_{i,t}^{\text{survive}}$, is therefore simply given by the frequency distribution of ratings in the non-defaulted portion of the existing portfolio of bank i at the end of period t. Under this rule, reinvestment does not alter the overall distribution of ratings within each portfolio, so it generates behavior similar to the passive management strategy of Kashyap and Stein (2004) and Rösch (2002).

The third idealized rule, which we refer to as "cyclical" replacement, assumes that bank lending "leans against the wind." That is, banks tighten standards in a recession and loosen standards in an expansion. A simple and flexible mechanism for implementing this notion starts with a vector of baseline thresholds that divide the real line into G intervals:

$$-\infty = \zeta^*(0) \leqslant \zeta^*(1) \leqslant \cdots \leqslant \zeta^*(G-1) \leqslant \zeta^*(G) = \infty.$$

The baseline thresholds are transformations of the average quality S^{fixed} probability vector. Similar mechanically (though not in any substantive sense) to the CreditMetrics methodology, we set

$$\zeta^*(g) = \Phi^{-1}\left(\sum_{k=1}^{g} S^{\text{fixed}}(k)\right) \tag{5}$$

for $1 \leqslant g \leqslant G-1$. Next we form a vector of cyclically-shifted $\zeta_{i,t}$ thresholds which determine $S_{i,t}^{\text{cyclical}}$ as

$$S_{i,t}^{\text{cyclical}}(g) = \Phi\big(\zeta_{i,t}(g)\big) - \Phi\big(\zeta_{i,t}(g-1)\big).$$

When $X_{i,t-1}$ is negative (positive), bank i has just experienced a negative (positive) macroeconomic shock. In response, we shift probability mass to the higher (lower) quality grades by setting

$$\zeta_{i,t}^{\text{cyclical}}(g) = \frac{\zeta^*(g) - \delta \cdot X_{i,t-1}}{\sqrt{1-\delta^2}} \tag{6}$$

where $\delta \in [0, 1]$ controls the sensitivity of ζ^{cyclical} to the bank's macroeconomic environment (we set $\delta = 0.3$).

A wide variety of plausible reinvestment rules can be generated as weighted combinations of the idealized rules. For example, the findings of Bassett and Zakrajšek (2003) suggest that some portion of new lending is determined by pre-existing relationships, but that the bank cyclically tightens and loosens standards for lending to new customers. We therefore specify a "Bassett/Zakrajšek" (BZ) reinvestment rule as a weighted average of the passive and cyclical rules:

$$S_{i,t}^{\mathrm{BZ}} = \omega \cdot S_{i,t}^{\mathrm{survive}} + (1-\omega) \cdot S_{i,t}^{\mathrm{cyclical}}. \tag{7}$$

For simplicity, we set the weight parameter ω to $1/2$.

In order to ease comparison of results across reinvestment rules, our simulation engine first draws the global systematic factor (X_t^*) and the bank-level systematic factors ($X_{i,t}$) for each bank and time period. Holding these histories fixed, we draw for each bank the individual borrower histories generated under each reinvestment rule. Thus, bank portfolios are exposed to the same systematic shocks across simulation runs that differ in reinvestment rules. In all simulations, regardless of the reinvestment rule, we draw ratings in the initial portfolio at the beginning of the simulation ($t = 0$) from the S^{fixed} distribution. To dilute sensitivity of our results to initial conditions, we treat the first T_{burn} years as a "burn-in" period. That is, we run each simulation for $T_{\mathrm{burn}} + T$ years and then drop the first T_{burn} years. We set $T_{\mathrm{burn}} = 40$.

In principle, we could develop a variety of rules to govern the assignment of ELGD and initial maturity to new loans. We draw a random initial maturity for each new loan such that $(M - 1)$ is distributed Poisson with mean parameter ϕ. As noted in Section 1, ϕ might well vary cyclically. Evidence in Berger et al. (2005) suggests that ϕ should vary across the initial grade of the loan as well. The simulation has enough "moving parts" as is, so for simplicity we impose a uniform value of $\phi = 2.92$ across all new loans at all times. This value is calibrated to match the mean initial maturity of 3.92 years observed in the Loan Pricing Corporation's Dealscan database of loans issued to US business borrowers from 1988 to 2002.[12] For ELGD, we impose the Foundation approach assumption of a constant 45% of face value (BCBS, 2004, §287).

2.2. *Through the cycle ratings*

Credit ratings provided by external rating agencies such as Moody's and S & P are often characterized as through-the-cycle (TTC) by market participants, academics and the agencies themselves. These ratings tend to be more stable over time than the PIT ratings generated by KMV and most bank internal systems. So long as the PDs assigned to each grade are estimated by taking long-run average default frequencies, stable rating assignments imply stable PD assignments, and so diminish capital volatility. For this reason, Catarineu-Rabell et al. (2005) recommend that regulators encourage banks to adopt TTC systems in order to mitigate procyclicality.[13]

[12] This database is considered representative of US banks' commercial lending to medium-sized to large firms and contains almost 70000 loan agreements over our sample period; see Carey et al. (1998) for more detailed description of Dealscan data.

[13] Of course, as demonstrated by Heitfield (2006), the long-run average default frequency will in general not be the best estimate for a TTC grade's one-year default probability given contemporaneously observable information on the state of the macroeconomy. Like a clock stuck at twelve o'clock, the long-run average default frequency will align with the optimal full-information estimate of PD roughly twice per business cycle.

Despite the ubiquity of the term "through the cycle" in descriptions of rating methods, there seems to be no consensus on precisely what is meant. The agencies' own documentation describes a set of qualitative and sometimes conflicting objectives in their rating processes. One view is that TTC ratings in some way filter out changes in the state of the business cycle from changes observed in borrower creditworthiness. Carey and Hrycay (2001) find evidence in agency ratings that TTC systems assign rating based on the borrower's likelihood of survival in the event of a macroeconomic stress scenario. Because the stress scenario is fixed, the current state of the macroeconomy is irrelevant. Another view is that TTC ratings are simply long-term ratings. Altman and Rijken (2004) find that agency ratings and PIT models perform comparably in predicting default over a six year horizon. To explain this result, the model of Löffler (2004) assumes that firm asset values are subject to both permanent and transitory shocks, but TTC ratings react to only the permanent shocks. By filtering out the transitory shocks, TTC systems also avoid rating reversals, which the agencies acknowledge as a goal. Cantor (2001) reports that Moody's attempts to assign ratings so as to minimize "abrupt changes in rating levels" and as such "a rating action is taken only when it is unlikely to be reversed within a relatively short period of time." Altman and Rijken (2004) suggest that agencies wait until the "appropriate" rating predicted by the agency's model differs from the borrower's current rating by a certain amount before they adjust a borrower's rating, and, even then, the rating is only partially adjusted. Löffler (2005) offers a formal model in this vein; see also Christensen et al. (2004) for a slightly different interpretation.

We do not propose to reconcile these characterizations into a single model. Rather, we focus on the view that "the prime objective of [rating] agencies is to provide an accurate *relative* (i.e., ordinal) ranking of credit risk at each point in time" (Cantor and Mann, 2003). This objective is satisfied by a rating scheme that sorts borrowers in the economy by their one-year probability of default.[14] At the beginning of period t, all $N \times I$ "live" borrowers in the rated universe are sorted according to PIT rating (by descending credit quality). The ordinal scheme assigns the top fixed share S_1^{ord} of the borrowers to grade 1, the next share S_2^{ord} to grade 2, and so on. The implication is that the number of borrowers assigned to each grade is time-invariant for the economy as a whole, but the distribution within each bank is free to vary.[15] For simplicity, we set the S^{ord} vector equal to the S^{fixed} vector.

After borrowers are assigned TTC ratings for each year in the simulation, we calculate the average PIT default probability (across time and borrowers) for each ordinal grade. Our "Basel II–TTC" capital rule merely substitutes into the IRB formula the "time-averaged PD" associated with the borrower's TTC rating grade in place of the borrower's "true" PIT PD.

2.3. Smoothing the regulatory minimum

Our primary objective in the simulations is to explore the behavior of smoothing rules that are applied directly to the output of an unmodified IRB capital function. Assume that bank rating systems are point-in-time, and let C_{it} denote the unsmoothed output from the IRB capital formula for the portfolio of bank i at time t, expressed as a percentage of portfolio book value. One

[14] In our homogeneous model, every rating horizon implies the same sorting, so it is meaningless to distinguish between short-term and long-term ratings.

[15] We also explored an alternative ordinal scheme in which borrowers were sorted within each bank rather than across the rated universe. Not surprisingly, capital requirements were perfectly smooth and completely uninformative both across time and across banks.

simple method for generating a smoothed regulatory requirement $\hat{C}_{it}$ from the C_{it} is to apply an autoregressive (AR) filter:

$$\hat{C}_{i,t} = \hat{C}_{i,t-1} + \alpha \cdot \left(C_{i,t} - \hat{C}_{i,t-1}\right) \tag{8}$$

where α is an adjustment parameter that controls the degree of smoothing. We set $\alpha = 0.25$ in our simulations.[16] The intuition is that shocks to C_{it} are absorbed into the regulatory minimum over several years, rather than all at once.

A second approach to smoothing the output is counter-cyclical indexing. Under a "CC smoothing" rule, the regulatory minimum is expressed as $\hat{C}_{it} = \alpha_t C_{it}$, where α_t is a time-varying multiplier that is announced publicly by the national regulator in each period and applies uniformly to every bank in the regulator's jurisdiction.[17] In the context of our model, we specify the multiplier as

$$\alpha_t = \exp\left(a \cdot \left(\omega_1 X^*_{t-1} + \omega_2 X^*_{t-2} + \cdots + \omega_k X^*_{t-k}\right) - a^2/2\right) \tag{9}$$

where the lag weights satisfy $\omega_1^2 + \omega_2^2 + \cdots + \omega_k^2 = 1$. We use $k = 1$ or $k = 2$ lags in our simulations.[18] Parameter a controls the degree of smoothing. To calibrate, let V_α denote the desired unconditional variance of the multiplier across time (we set $V_\alpha = 0.005$). Setting $a = \sqrt{\log(1 + V_\alpha)}$ implies $\mathrm{Var}(\alpha_t) = V_\alpha$ as desired. The $a^2/2$ term in Eq. (9) guarantees that $\mathrm{E}[\alpha_t] = 1$.

3. Results

3.1. Reinvestment rules and portfolio quality

We begin with a question that has not yet been formally addressed in the procyclicality literature: How sensitive are our estimates of capital volatility to the assumptions governing portfolio management over time? Figure 1 plots the time-series of Basel II capital requirements needed by a single representative bank under the four different reinvestment rules defined in Section 2.1. Recall that all four histories are generated using the same draws of the global systematic factor and bank-specific systematic factor, so simulation noise is negligible in this comparison. Under a "fixed" reinvestment rule, which draws new loans from the time-invariant distribution S^{fixed}, Basel II capital ranges from 3.9 to 8.0%. As might be expected, capital under "cyclical" reinvestment is somewhat less volatile than under the fixed rule and the least volatile of the rules we explored. Assuming "passive" portfolio management produces very much the largest changes in capital requirements over time (a range of 3.2 to 11.1%). The "BZ" rule is a weighted combination of the "cyclical" and "passive" rules, and so produces an intermediate level of volatility. The same ordering is seen in summary measures of capital volatility across time. For each bank, we

[16] As a starting condition, we also impose $\hat{C}_{it} = C_{it}$ at $t = 0$. As the first 40 years are discarded as a "burn-in" period, this assumption does not influence our results.

[17] As an alternative to a time-varying multiplier, we could adopt a time-varying target solvency probability (i.e., q_t in place of q). Kashyap and Stein (2004) suggest that this is a natural and intuitive policy lever for optimal capital regulation when the opportunity cost of foregone positive-NPV loans can change relative to the social cost of bank failure. Its appeal to economic intuition notwithstanding, such a rule would be awkward to implement because the calibration of the maturity adjustment in the IRB formula depends on q.

[18] Two lags of X^* are needed to smooth reliably when we use the BZ reinvestment rule, because the "passive" component in S^{BZ} induces a long memory effect. If we use the "fixed" reinvestment rule, portfolio dynamics are simplified and we find that a single lag of X^* suffices.

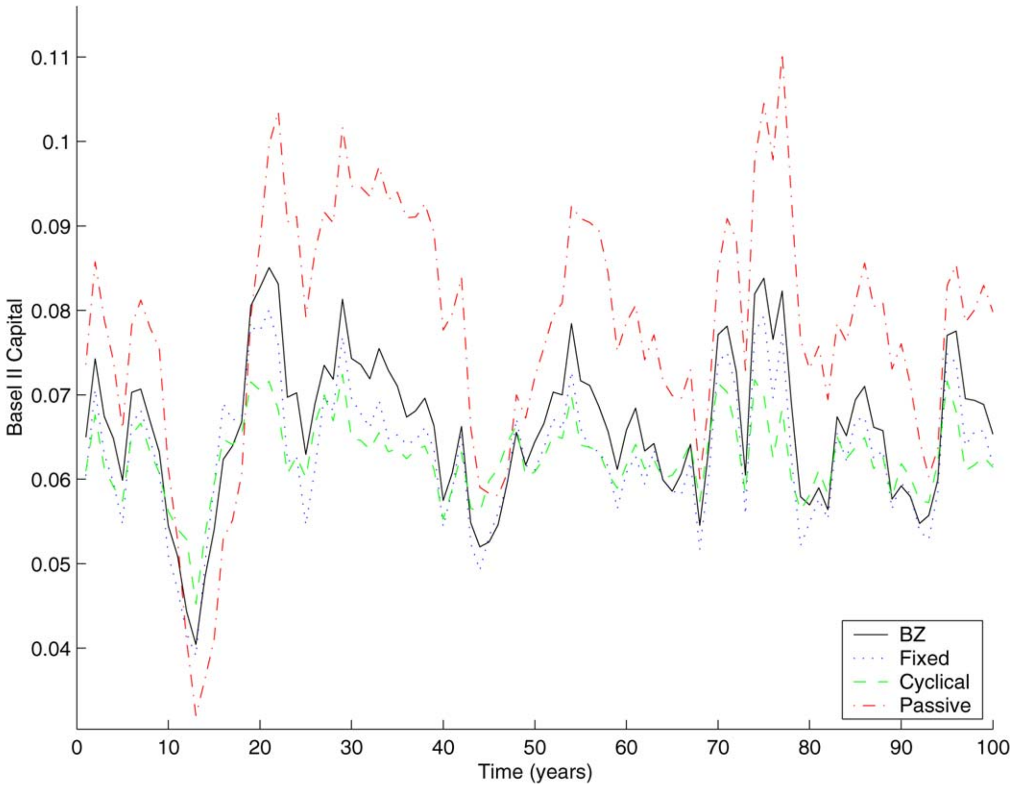

Fig. 1. Effect of reinvestment rule on capital volatility.

Table 2
Effect of reinvestment rule and portfolio quality on Basel II capital volatility

Reinvestment rule	Quality	Mean capital charge	Volatility	Vol./Mean
Fixed	Average	6.30%	0.79%	0.126
Cyclical	Average	6.25%	0.45%	0.072
Passive	Average	7.62%	1.48%	0.194
BZ	Average	6.63%	0.83%	0.125
BZ	High	5.68%	0.85%	0.149

take the standard deviation across time of capital requirements. Volatility, reported in Table 2, is the mean across banks of this standard deviation. We find that passively managed portfolios have almost twice the volatility of portfolios with “fixed” reinvestment. The mean capital charge is also much higher under the passive rule, because the portfolio is more likely to accumulate low quality borrowers. Even relative to the higher mean (last column), volatility is much higher under passive reinvestment than under the other reinvestment rules.

Comparisons across simulated portfolios of differing quality by Kashyap and Stein (2004), Catarineu-Rabell et al. (2005), and others all indicate that higher quality portfolios are subject to larger relative swings in capital requirements. We address the issue by examining how volatility changes when we calibrate S^{fixed} to the high quality portfolio in Table 1 instead of the average quality portfolio.[19] Comparing the last two rows in Table 2, we see that the high quality portfolio has a lower mean capital charge, as expected, but roughly the same absolute capital volatility. Relative to the mean capital charge, the high quality portfolio experiences slightly higher capital volatility.

These simulations demonstrate that technical assumptions imposed on the management of bank portfolios over time have a first-order effect on the extent of procyclicality in economic capital. Sensitivity to overall portfolio credit quality, which has been noted often in the literature, is modest relative to sensitivity to reinvestment rules.

All remaining simulations will impose the BZ reinvestment rule, and S^{fixed} will be calibrated to the average quality portfolio in Table 1.

3.2. *Rating through-the-cycle and flattening the capital formula*

Successive revisions to the New Accord have resulted in a significant flattening of the IRB capital formula. Reducing the risk-sensitivity of the capital formula decreases volatility in required capital, and so further flattening of the capital formula is one possible way to address excessive procyclicality. Imposing or promoting the adoption of through-the-cycle rating systems is another means to the same end. In this section, we first examine the impact of revisions to the IRB formula on the volatility of capital charges. Next, we evaluate the efficacy of TTC rating systems in dampening procyclicality and the associated costs to the reliability of the IRB capital requirement as a measure of portfolio risk. We then show how this trade-off contrasts with that implicit in flattening the capital formula.

In Table 3, we report the capital charge means and volatilities under the various iterations of the IRB formula. CP2, which assigned a constant ρ of 0.2 and covered total capital (i.e., sum of expected and unexpected loss), exhibits both the highest mean capital charge and capital volatility. Changes to the capital formula introduced in CP3 brought large reductions in both the mean and volatility. In the finalized New Accord, total capital is decomposed into capital (against unexpected loss) and reserves (against expected loss), so we report results under the final Basel II formula both inclusive and exclusive of expected losses. When only UL is considered, the final formula appears to offer material reductions in both the mean and volatility of capital, but on a total capital basis the change is negligible. As reserves are essentially an alternative form of capital, the change in label does not imply any change in the demands on the resources of the bank. For this reason, all economic and regulatory capital requirements are calculated as total capital (EL + UL) for the remainder of the paper.

Table 3
Effect of changes to the IRB formula on capital volatility

Rule	Definition	Correlation	Mean capital charge	Volatility	Vol./Mean
CP2	EL + UL	constant (0.2)	9.61%	1.80%	0.188
CP3	EL + UL	declining	7.46%	1.06%	0.142
Basel II	EL + UL	declining	7.61%	1.08%	0.142
Basel II	UL	declining	6.63%	0.83%	0.125

[19] The rating histories for each quality distribution are generated under the BZ reinvestment rule which is sensitive to S^{fixed} through S^{cyclical}.

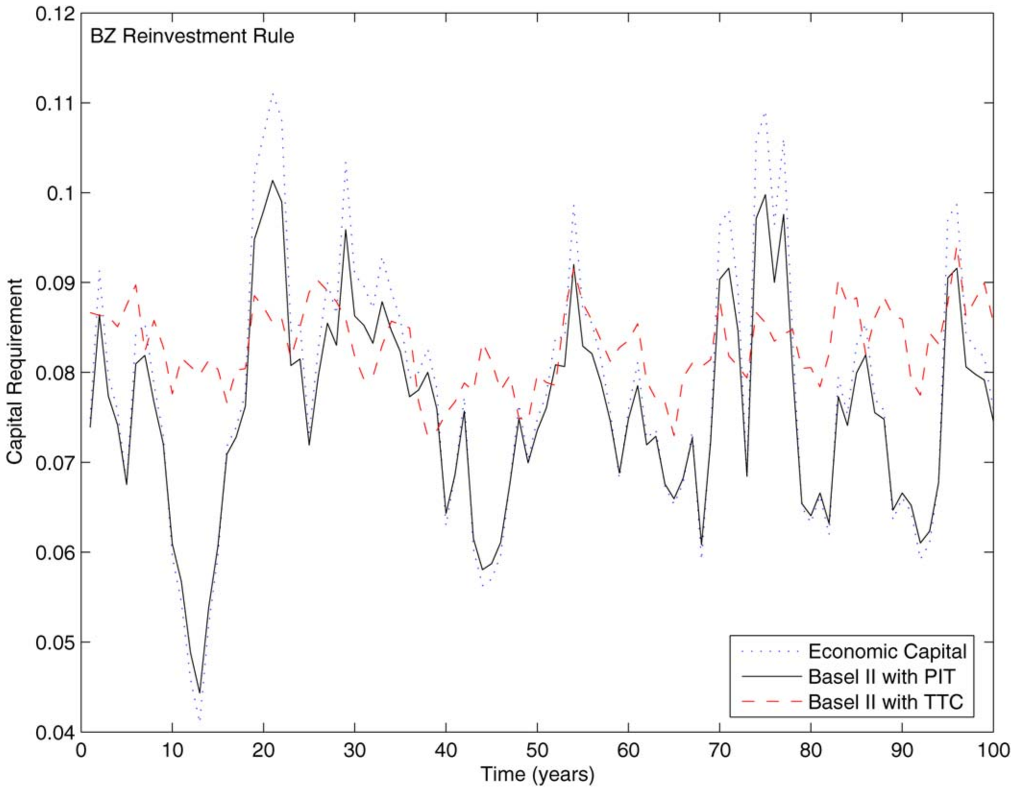

Fig. 2. Dampening capital volatility with TTC ratings.

We next contrast the consequences of flattening the IRB curve with those of imposing through-the-cycle ratings. In Fig. 2, we plot the capital requirement time-series for a representative bank. The dotted line plots economic capital for the bank (assuming a target solvency probability of $q = 0.999$ and a "true" asset-correlation of $\rho = 0.18$). The solid line plots Basel II capital requirements under PIT rating, and the dashed line plots the corresponding Basel II capital under TTC rating. The Basel II–TTC time-series displays only a small portion of the capital volatility of the economic capital time-series. Observe, however, that directional changes in Basel II–TTC appear to be uncorrelated with directional changes in economic capital. The opposite conclusion is drawn from comparing economic capital with Basel II–PIT. Falsely imposing a negative relationship between PD and ρ when the "true" relationship (in the simulation) is constant brings about a relatively modest dampening of procyclicality. The sharpest peaks and troughs in the economic capital time-series are blunted in the Basel II–PIT series. Otherwise, the two series track very closely, which suggests that little harm is done to the Basel II–PIT capital requirement as a signal for changes in portfolio risk over time.

The intertemporal concordance between the three time series is best displayed by plotting the series against one another as scatterplots. In Fig. 3, we plot economic capital against Basel II–TTC capital requirements. We plot all points in the time-series for three representative banks (the banks are distinguished by using three different marker symbols). We see the efficacy of TTC rating as a dampening measure in the horizontal compression of the plot. The range of realized economic capital requirements spans seven percentage points, while the range of realized

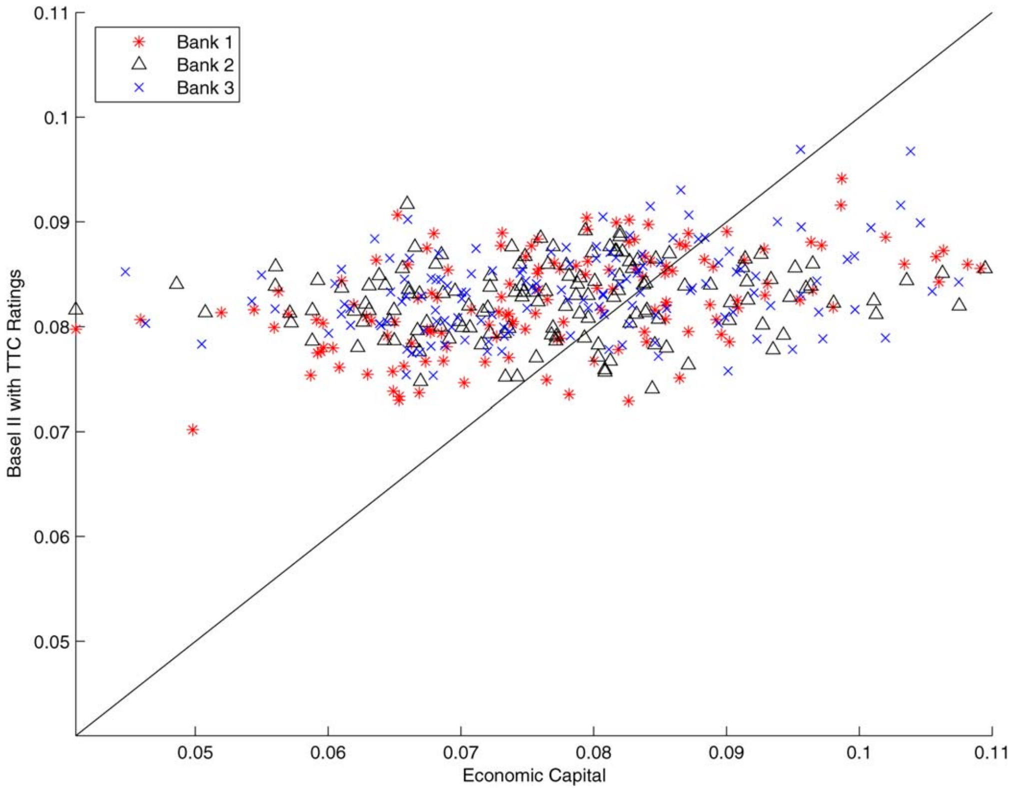

Fig. 3. Intertemporal concordance of economic capital with Basel II–TTC.

Basel II–TTC capital requirements spans just over two percentage points. However, we also find little discernible correlation between economic capital and Basel II–TTC capital requirements, so we can conclude that market participants would not be able to draw reliable inferences on changes in portfolio risk from observing changes over time in disclosed Basel II–TTC capital requirements.

A similar scatterplot for the relationship between Basel II–PIT and economic capital requirements is seen in Fig. 4. Again we see the stark contrast with the properties of TTC smoothing. Relative to the economic capital benchmark, a modest dampening of volatility is achieved by reducing (increasing) capital charges on high (low) risk portfolios.[20] The two time-series are almost perfectly co-monotonic, which implies that a market participant could precisely infer economic capital requirements from disclosed Basel II requirements (when the bank maintains a PIT rating system). Therefore, there is no cost to the information value in Pillar 3 disclosures.

3.3. Smoothing the regulatory minimum

Our final task is to evaluate the efficacy of our proposed autoregressive and counter-cyclical indexing rules in dampening procyclicality. In Fig. 5, we plot capital requirement time-series

[20] The degree of dampening is revealed geometrically in the rotation of the plotted relationship relative to the 45° line. Near the mean economic capital requirement of 7.8%, an increase in economic capital of 1% is associated with an increase in regulatory capital of 0.8%.

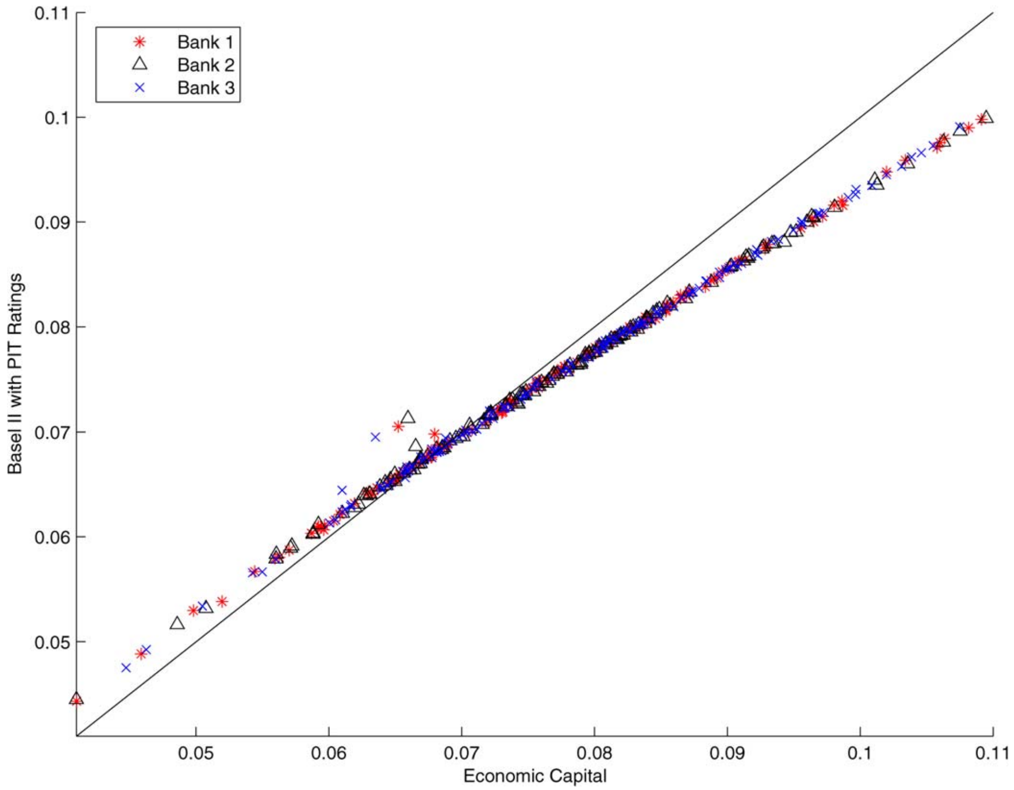

Fig. 4. Intertemporal concordance of economic capital with Basel II–PIT.

for a representative bank. The solid line represents Basel II capital requirements under PIT rating. The dashed and dotted lines are the corresponding CC smoothed and AR smoothed capital requirements, respectively. The two smoothing rules perform similarly. Each tracks Basel II capital reasonably well but with much less volatility. The average (across banks) of the standard deviation of regulatory capital across time is 1.08% for Basel II–PIT and only 0.67% under either smoothing rules. The average correlation between AR smoothed capital and Basel II–PIT is 0.74, and the average correlation between CC smoothed capital and Basel II–PIT is 0.89. If we examine scatterplots for the AR and CC smoothing rules comparable to Fig. 3, we see an obvious positive slope. This shows that AR smoothed and CC smoothed capital requirements would retain significant information value for use in monitoring a bank across time. Cross-sectional ordering is perfectly preserved under CC smoothing by construction, and reasonably well preserved under AR smoothing. From a Pillar 3 perspective, however, these questions are irrelevant because, under the CC and AR smoothing rules, the unsmoothed IRB capital requirements for each bank can be easily calculated from public information.

For counter-cyclical indexing to work well, the CC multiplier α_t must have a large negative correlation with the unsmoothed Basel II capital C_{it} for the individual banks. Indeed, if α_t and C_{it} were independent, then the "smoothing rule" would only add noise, and the variance of $\hat{C}_{it}$ across time would exceed that of C_{it}. The multiplier is set by the regulator at the national level, so depends only on the "global" systematic factor X^*. Portfolio performance for bank i, however, depends on the local factor X_{it}. Conditional on X_{it}, C_{it} is independent of X_t^*. Therefore, the

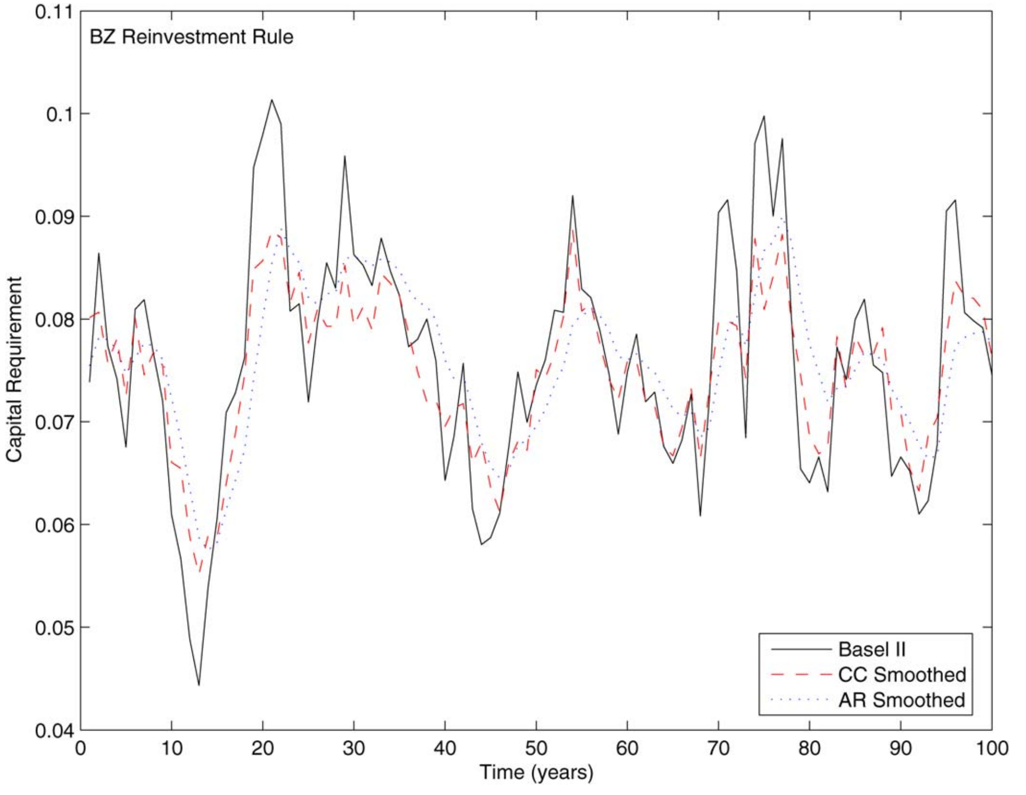

Fig. 5. Smoothing rules for regulatory capital.

correlation between α_t and C_{it} depends on the correlation between X_t^* and X_{it}, which is equal to $\sqrt{\beta}$. By contrast, the AR smoothing rule depends only on the current and lagged values of the bank's *own* Basel II and smoothed regulatory requirements, and so is robust to lower values of β. In our baseline calibration of $\beta = 0.9$, we are assuming a reasonably close alignment between the global and local risk-factors. When we set $\beta = 0.5$ in our simulations, we find that average standard deviation of regulatory capital across time is 1.09% for Basel II–PIT, and 0.683% and 0.833% for AR and CC smoothing rules, respectively. Relative to the case of $\beta = 0.9$, volatilities of Basel II–PIT and the AR smoothing rule are roughly unchanged, but the volatility of CC smoothed capital increases markedly.[21]

4. Discussion

The pure simulation approach employed in this paper offers a complementary perspective on the data-driven methodologies of most earlier studies of procyclicality. What our approach might sacrifice in fidelity to historical experience, it gains from greater flexibility and precision. We can explore the consequences of alternative rating philosophies and lending strategies in a controlled

[21] Correlations between Basel II and smoothed capital do not change significantly for either AR or CC.

environment, and draw panels of simulated data large enough to eliminate sampling variation from the results.[22]

Our simulations make clear that the extent of cyclicality in capital requirements depends quite strongly on how new lending varies with macroeconomic conditions. Our methodology does not allow rules for new lending (what we term the *reinvestment strategy*) to be endogenous to the bank's capital position. This, as Kashyap and Stein (2004) argue, would defeat the purpose of the exercise. Rather, we allow the reinvestment rule to depend *exogenously* on the bank's macroeconomic environment. If we are interested in identifying the marginal increment to procyclicality associated with shifting from the current Accord to a New Accord, then the current response of new lending to macroeconomic shocks is the correct baseline. We find that empirically realistic reinvestment rules reduce procyclicality dramatically when compared to the passive portfolio strategy imposed by Kashyap and Stein (2004).

As a caveat, we should emphasize that the *economic costs* associated with a marginal increment to procyclicality are not invariant to the choice of baseline. If we believe that such costs are convex, then the greater the degree of procyclicality in the adopted baseline, the higher the marginal cost of additional procyclicality. Nonetheless, fixing a well-defined baseline is essential to the policy debate. Lack of a common baseline explains much of the wide range of estimates in earlier research on procyclicality in the New Accord, and thus has been a source of confusion. One practical advantage to our choice of baseline is that policy makers have some intuitive grasp of the cost of procyclicality under the current Accord and, indeed, do not seem to view it as a particular concern.

For all the attention that the issue has drawn, it is not obvious that procyclicality in the New Accord requires that corrective measures be adopted in advance of implementation. The existing literature shows a fairly wide range of empirical estimates on the magnitude of the problem, even when the baseline is held fixed. Our simulations confirm and extend these results in demonstrating the sensitivity of one's conclusions to assumptions imposed in the simulation. Furthermore, there is as yet no evidence on the extent to which regulatory capital (as opposed to bank's internal economic capital) will be the binding constraint for banks. Even if regulatory capital is smoothed by one means or another, procyclicality in economic capital requirements cannot be dampened by regulatory fiat.

Despite the lack of compelling evidence on the magnitude of the problem, evaluation of alternative proposals should not be delayed. In the absence of some consensus on policy options, national regulators may pursue their own informal measures (such as encouragement of through-the-cycle rating methodologies). This may have competitive implications, as well as implications for cross-jurisdiction comparison of disclosed regulatory capital ratios. Our simulation strategy is especially well-suited to evaluating the costs and benefits of competing proposals under a wide variety of model assumptions.

Consider the New Accord as an engineering system. If we are concerned about excess volatility, where do we place the dampening filter? Some proposals call for dampening the inputs (that is, the PDs), some call for modifying the machinery (that is, by flattening the capital formula), and some call for dampening the outputs (that is, by loosening the relationship between the IRB capital formula and the required regulatory minimum). Our simulations confirm our intuitions on the strengths and drawbacks associated with each class of proposals. Dampening the inputs to

[22] Peura and Jokivuolle (2004) cite similar motivations for their own simulation-based approach to assessing procyclicality in the New Accord.

the IRB capital formula by adopting through-the-cycle rating methodologies effectively reduces capital volatility, but at great cost. Changes in a bank's capital requirements over time would be only weakly correlated with changes in its economic capital, and there would be no means to infer economic capital from regulatory capital. Thus, Pillar 3 disclosures would fail to help market participants monitor banks over time. Furthermore, as through-the-cycle ratings are less sensitive to market conditions than point-in-time ratings, they are less useful for active portfolio management and as inputs to ratings-based pricing models such as Jarrow et al. (1997). Not surprisingly, most large banks in the US seek to rate in a point-in-time fashion (Treacy and Carey, 1998).

Dampening inside IRB's "black box" by flattening the capital formula poses the opposite trade-off. So long as the flattening is modest and uniform across loan types, the information value in regulatory capital is preserved, but relatively little dampening is achieved. Heavy-handed flattening of the capital formula might better succeed in dampening procyclicality, but also would distort relative capital charges across loans (and do so at every point in the business cycle). This would pave the way for continued regulatory capital arbitrage.

If we dampen only the outputs, we can reduce volatility in capital requirements without distortion to Pillar 3 disclosures and without inducing capital arbitrage. So long as the dampening rule is public and applied only at the level of aggregate portfolio capital requirements, then the unsmoothed portfolio capital requirement can be inferred by market participants—no information is sacrificed. We consider two different smoothing rules. The autoregressive (AR) rule smooths required capital independently for each bank using a time-series filter. Intuitively, the AR smoothing rule causes the regulatory capital requirement to adjust slowly over time to a shock today in the bank's economic capital requirement. The counter-cyclical (CC) indexing rule applies a time-varying multiplier to the IRB formula. The multiplier is large (over one) in good times and small (under one) in bad times. It is announced in each period by the national regulator, and applied to all banks under its jurisdiction.

The AR and CC rules appear to be comparable in how well they dampen capital volatility and in how well changes in the regulatory minimum would track changes in the undampened IRB capital requirement for the portfolio. Neither would impose additional operational burden on banks. However, they would differ significantly in implementational challenges. The great advantage to the autoregressive rule is that it is decentralized. Because it depends only on the bank's own time-series of IRB capital requirements, it does not disadvantage banks operating in local markets with business cycles distinct from the overall national market. Furthermore, the regulator is a passive observer of the smoothing, and is not called upon to make judgments about the state of the macroeconomy that may be hard to defend empirically or politically. The disadvantage is that it implicitly assumes that the bank's lending strategy is stationary. A weak bank would have the incentive to ramp up portfolio risk rapidly, because required capital would catch up only slowly.

The counter-cyclical indexing rule is robust to changing business mix at the individual bank level, which is important in markets in which large flows of financial assets can move between regulated banks and unregulated financial firms. As business cycles need not be well-synchronized across the major markets, each national regulator would require some degree of control over the multiplier to be applied with its own jurisdiction. To mitigate concerns that such a provision would be abused to "tilt the playing field" to national advantage, each national regulator would need to make transparent the rule by which it determines the multiplier. For several of the largest markets, a formula for the multiplier could be based on traded credit default swap indices.[23] In markets where banks hold the overwhelming share of total corporate debt, the multiplier could be tied to a moving average of the aggregate default rate for bank commercial borrowers. In our view, counter-cyclical indexing should be favored wherever data on the state of national credit markets are available and reliable.

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References

Altman, E.I., Rijken, H.A., 2004. How rating agencies achieve rating stability. J. Banking Finance 28 (11), 2679–2714.
Basel Committee on Bank Supervision (BCBS), 2001. The New Basel Capital Accord. Second consultative paper. Bank for International Settlements.
Basel Committee on Bank Supervision (BCBS), 2004. International convergence of capital measurement and capital standards: A revised framework. Publication No. 107. Bank for International Settlements.
Bassett, W.F., Zakrajšek, E., 2003. Recent developments in business lending. Fed. Reserve Bull. December, 477–492.
Berger, A.N., Udell, G.F., 2004. The institutional memory hypothesis and the procyclicality of bank lending behavior. J. Finan. Intermediation 13 (4), 458–495.
Berger, A.N., Espinosa-Vega, M.A., Frame, W.S., Miller, N.H., 2005. Debt maturity, risk, and asymmetric information. J. Finance 60 (6).
Borio, C., Furfine, C.H., Lowe, P., 2001. Procyclicality of the financial system and financial stability: Issues and policy options. Working paper No. 1. BIS.
Cantor, R., 2001. Moody's Investor Services' response to the consultative paper issued by the Basel Committee on bank supervision: A new capital adequacy framework. J. Banking Finance 25, 171–185.
Cantor, R., Mann, C., 2003. Are corporate bond ratings procyclical? Special comment. Moody's Investor Services.
Carey, M., Hrycay, M., 2001. Parameterizing credit risk models with rating data. J. Banking Finance 25, 197–270.
Carey, M., Post, M., Sharpe, S.A., 1998. Does corporate lending by banks and finance companies differ? Evidence on specialization in private debt contracting. J. Finance 53 (3), 845–878.
Catarineu-Rabell, E., Jackson, P., Tsomocos, D., 2005. Procyclicality and the New Basel Accord—Banks' choice of loan rating system. Econ. Theory 26 (3), 537–557.
Christensen, J., Hansen, E., Lando, D., 2004. Confidence sets for continuous-time rating transition probabilities. J. Banking Finance 28 (11), 2575–2602.
Cosandey, D., Wolf, U., 2002. Avoiding pro-cyclicality. Risk 15 (10), S20–S22.
Decamps, J.-P., Rochet, J.-C., Roger, B., 2004. The three pillars of Basel II: Optimizing the mix. J. Finan. Intermediation 13 (2), 132–155.
Ervin, D.W., Wilde, T., 2001. Pro-cyclicality in the new Basel Accord. Risk 14 (10).
Estrella, A., 2004. The cyclical behavior of optimal bank capital. J. Banking Finance 28 (6), 1469–1498.
Gordy, M.B., 2000. A comparative anatomy of credit risk models. J. Banking Finance 24 (1–2), 119–149.
Gordy, M.B., 2003. A risk-factor model foundation for ratings-based bank capital rules. J. Finan. Intermediation 12 (3), 199–232.
Gordy, M.B., 2004. Granularity adjustment in portfolio credit risk measurement. In: Szegö, G.P. (Ed.), Risk Measures for the 21st Century. Wiley.
Gupton, G.M., Finger, C.C., Bhatia, M., 1997. CreditMetrics—Technical Document. J.P. Morgan & Co., New York.
Heitfield, E., 2006. On the role of internal rating systems in credit-risk management. Unpublished working paper.
Jarrow, R., Lando, D., Turnbull, S., 1997. A Markov model for the term structure of credit risk spreads. Rev. Finan. Stud. 10, 481–523.
Jordan, J., Peek, J., Rosengren, E., 2003. Credit risk modeling and the cyclicality of capital. Working paper. Federal Reserve Bank of Boston.

[23] Recent years have seen the emergence of highly liquid markets for trading in CDS indices such as the DJ CDX indices for North America and the iTraxx indices for Europe and Asia.

Kalkbrenner, M., Overbeck, L., 2002. The maturity effect on credit risk capital. Risk 15 (7), 59–63.

Kashyap, A.K., Stein, J.C., 2003. Cyclical implications of the Basel-II capital standards. Working paper. University of Chicago.

Kashyap, A.K., Stein, J.C., 2004. Cyclical implications of the Basel-II capital standards. Fed. Reserve Bank Chicago Econ. Perspect. First Quater, 18–31.

Löffler, G., 2004. An anatomy of rating through the cycle. J. Banking Finance 28 (3), 695–720.

Löffler, G., 2005. Avoiding the rating bounce: Why rating agencies are slow to react to new information. J. Econ. Behav. Organ. 56 (3), 365–381.

Merton, R.C., 1974. On the pricing of corporate debt: The risk structure of interest rates. J. Finance 29, 449–470.

Pennacchi, G.G., 2005. Risk-based capital standards, deposit insurance, and procyclicality. J. Finan. Intermediation 14 (4), 432–465.

Peura, S., Jokivuolle, E., 2004. Simulation based stress tests of banks' regulatory capital adequacy. J. Banking Finance 28 (8), 1801–1824.

Purhonen, M., 2002. New evidence of IRB volatility. Risk 15 (3).

Rösch, D., 2002. Mitigating procyclicality in Basel II: A value at risk based remedy. Working paper.

Study Group on Subordinated Notes and Debentures, 1999. Using subordinated debt as an instrument of market discipline. Staff Study 172. Federal Reserve System.

Treacy, W.F., Carey, M.S., 1998. Credit risk rating at large US banks. Fed. Reserve Bull. 84 (11), 897–921.