Is regulatory capital pro-cyclical?
A macroeconomic assessment of Basel II

(preliminary version)

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1 Introduction

Capital requirements play a prominent role in international banking regulation, not only since the Basel Capital Accord has been introduced in 1998. Regulatory capital charges usually require banks to hold sufficient capital against their risk-weighted assets as a buffer for future unexpected loss. From a microeconomic reasoning their justification lies in the presence of some sort of market failure, resulting, for example, from explicit or implicit state guarantees for banks. According to this view, minimum capital requirements prevent banks from holding excessive amounts of risky assets.

On the other hand, by influencing overall loan supply, capital requirements have important macroeconomic implications. However, microeconomic benefits and macroeconomic risks of regulatory regimes are difficult to assess the financial sector and the real sector are interconnected.

In terms of risks the danger is that banks react to external developments in the same way at the same time - even if this behaviour is rational or prudential from a microeconomic perspective - thereby creating or reinforcing destabilizing trends. This problem has come only more to the fore since the Basel Committee on Banking Supervision has announced plans to revise the existing accord. The existing accord has been widely criticized because it did not properly reflect the inherent risks of the banks' assets. It is said that this has lead to distortions in capital markets, because banks have since moved to riskier business.

The objective of Basel II is to reduce the incentive for capital arbitrage by increasing the risk sensitivity of regulatory capital charges. However, ncreased risk sensitivity of capital charges may lead to an unwarranted pro-cyclical effect, if the quality of the banks' assets is closely in line with the business cycle. This could then counteract capital regulation's original goal to enhance financial stability not only of individual banks but of the entire financial system.

The procyclical effects of capital regulation can manifest itself in two ways. First, as regards the financial sector, capital charges will be possibly subject to large swings if asset risk or the perception of asset risk moves in sync with business fluctuations. This can eventually lead to an increased volatility of asset prices or loan interest rates with the potential of creating dangerous boom-and-bust cycles in credit markets.

Second, increased volatility of the financial sector may spill over to the real sector. As banks are required to hold more capital against increased credit risk in an economic downturn, they will partly pass on their increased costs of capital to their borrowers. Faced with higher interest rates and lacking alternative sources of finance, firms will cut back on investment spending thereby aggravating the downturn.

It is especially this latter scenario which may be more damaging to the economy than the purely financial scenario. While the volatility of regulatory capital may be partly offset by banks holding an extra buffer of own capital, economic losses of the second scenario are difficult to avoid as we shall show in this analysis.

Though there exists some empirical which analysis fluctuations in ratings over time, only few papers discuss the issue of procyclicality on a deeper level. By invoking the concept of macroeconomic multiplier Blum and Hellwig (1995) argue in a theoretical paper that (flat) capital ratios have a signifant pro-cyclical effect on the real economy. Estrella (2001) shows that if regulatory capital is based on the value of risk, the implied short-sightedness will lead to increased volatility of the financial sector.

In this paper we try to estimate the impact of capital adequacy rules on the volatility of the financial and the real sector. The empirical problem which we have to solve is, that we do not have the data to compare two different regulatory regimes in a direct way. Even with regard to the current Basel accord, time series are not long enough to obtain stable results. We therefore propose a different methodology. In the first part of the paper we present a theoretical model for the banking industry, which is based on the concept of economic capital under regulatory constraints. In doing so, we derive the sensitivity of loan supply with respect to interest rates and regulatory capital ratios. To some extent this model can be tested against regulatory and balance sheet data of German banks.

In a second step we estimate the impact of business fluctuations on the probability of default of German firms again by using German banks' balance sheet data. By combining both results we are able to assess the impact of risk sensitive capital ratios as those envisaged by Basel II both on actual capital and on the real economy.

2 The model

We consider a simple macroeconomic model, which is composed of two parts: the real sector and the financial sector of an economy. The financial sector consists of banks, which extend loans to firms. As borrowers might default on their debt obligations banks themselves are subject to credit risk. We therefore assume that banks maximize expected profits under the constraint that their probability of default is not larger than some pre-specified value. One could think of that value as determined by a rating the bank tries to achieve. Furthermore, the bank faces regulatory capital adequacy rules as an additional constraint. Capital adequacy rules are such that the ratio of own equity to loans must exceed a certain lower bound. In our model a bank defaults when its capital falls below the regulatory capital ratio.

In the sequel, we consider a time horizon of only one period. We assume that the bank's own capital is exogenously given. Besides own capital E the bank holds debt at the riskless rate r. The bank decides to what extent it will invest its funds into loans L at rate ρ. In doing so it takes account of the fact that at the end of the period it will have to write off an uncertain rate s of its loans. Hence, its economic profit barring its own default is given by $(\rho - s - r)L$. Given its target for the probability of default (PD) the bank's maximization problem is as follows:[1]

$$\max \; E\left[(\rho - s - r)L\right] \quad \text{s.t.} \quad \text{Prob}\left(\frac{E + (\rho - s - r)L}{L} < a\right) \leq p \tag{1}$$

where a is the regulatory capital ratio.

Since the profit function is monotone, the constraint in (1) is binding. Let F be the cumulative distribution function of the random variable s and let $e = E/L$. In the optimum

[1] We use the reduced form of the profit function which takes into account that the expected cash-flow $(\rho - s)L - r(L - E)$ must exceed in equilibrium the opportunity cost of capital $r\,E$.

the bank will ex ante exactly match its target PD. Therefore

$$\text{Prob}\left(\frac{E + (\rho - s - r)L}{L} < a\right) = p \tag{2}$$

$$\Leftrightarrow \text{Prob}(s > e + \rho - r) = p \tag{3}$$

$$\Leftrightarrow 1 - \text{F}(e + \rho - r) = p \tag{4}$$

$$\Leftrightarrow e = \alpha + \rho - r + a \tag{5}$$

where $\alpha = F^{-1}(1 - p)$

Sometimes it may be appropriate to distinguish between *expected losses* and *unexpected losses*. In standard notation expected loss is defined by the mean of s, the unexpected loss by its standard deviation σ. Suppose that the distribution of s is stable in the sense that the distribution function of the standardized random variable $\frac{s-\bar{s}}{\sigma}$ is fixed. In this case one derives:

$$e \quad = \alpha + \rho - \bar{s} - r + a \tag{6}$$

where $\alpha = F^{-1}(1 - p)\,\sigma$.

Equation (6) makes strong predictions about the capital a bank wants to hold. In absolute terms, the elasticity of e with regard to interest rates and expected loss is equal equal to 1 regardless of the distribution of the loss rate. The *level* of e, of course, does depend on the distribution (and on the unexpected loss). We will test those findings against German banks balance sheet in section 3.

Equation (6) also determines loan supply of an individual bank:

$$L^s(\rho, r, \bar{s}, \sigma, a) = e^{-1}((\rho, r, \bar{s}, \sigma, a) \cdot E \tag{7}$$

As we want to focus on the investment behaviour of banks, we do not explicitly model loan demand but just assume that it is equal to

$$L^d = L^d(\rho, y) \tag{8}$$

where y is total real income. Suppose for the moment, that L^d is independent of ρ. This is, of course, a simplification, which is only justified if the income effect is much larger than the price effect. Furthermore assume that there is only one bank. Then we can determine the impact of a on the equilibrium loan interest rate be equating L^s and L^d

and differentiating the equation with respect to a:

$$\begin{aligned} e^{-1}(\rho, a) \cdot E &= L^d(y) \\ -e^{-2}\,(e_\rho\,\rho_a + e_a) &= 0 \\ \rho_a = -e_a/e_\rho &= 1 \end{aligned}$$

Therefore, we have a relatively strong impact of regulatory capital on interest rates. Note, however, that we assumed own capital to be fix in the short run. On the other hand if we assumed banks to be able to acquire additional own equity at expected rate r any solution of equation (1) must be such that profits are equal to zero (otherwise the maximization problem has no finite solution). Simple transformations show that in this case:

$$\begin{aligned} \rho &= (r + s) + r\,e \\ &= (r + s) + r\,(\alpha + \rho - s - r + a) \end{aligned} \tag{9}$$

The first term is well known from the expectation theory of interest rates as it states that the spread of the loan interest rate must at least cover the expected loss. The second term reflects the cost of holding economic or regulatory capital against unexpected loss. Equation (9) predicts the elasticity with respect to a being equal to r, which is much smaller than 1. We should therefore refer to the first case as the short term effect on interest rates, whereas the second case holds in the medium and long run.

We now turn to the real sector of the economy. Since our main focus is on business fluctuations we assume prices and supply to be fixed in the short run. For simplicity, we model total real demand as a function of income and interest rates only. Furthermore, we presuppose the riskless rate to be exogenously set by monetary policy (we could, of course, easily extend the model to include short term interest rates, but that would only complicate the presentation of the model). Therefore, in equilibrium output is given by

$$y = y^d(\rho, r, y) + \varepsilon \tag{10}$$

Here, the parameter ε denotes an unexpected demand shock. In this framework, we can assess fluctuations by the demand multiplier which is calculated by differentiating equation (10) with respect to ε :

$$y_\varepsilon = (1 - y^d_y - y^d_\rho\,\rho_y)^{-1} \tag{11}$$

Under the usual assumptions y_ε is positive and larger than 1.

How will the multiplier react if we changed regulatory capital? If it increased, we would validate the findings of Blum and Hellwig who maintained that fluctuations would increase. In our model regulatory capital influences output through the elasticity of interest rates. From

$$L^s(\rho, a) = L^d(\rho, y) \tag{12}$$

we get

$$\rho_y = \frac{L_y^d}{1 - L_\rho} \tag{13}$$

Furthermore, assume that cross elasticities of real demand are equal to zero, which, on the aggregate level, does not seem to be a very strong assumption. In this case ρ_y does not depend on the level of a at all. Therefore, at least for small changes, regulatory capital does not have any impact on business fluctuations. The picture changes if we allow the capital ratio to depend on y. Of course, a direct link between a and y is unrealistic. However, as Basel II is concerned, the capital ratio is a function of the probability of default of the bank's loans, which itself depends on the state of the economy. So let us assume that a is a function of y:

$$a = a(y) \tag{14}$$

with a_y being negative. That means that a increases in an economic downturn and decreases in an upturn. Therefore, from a financial point of view, regulatory capital is pro-cyclical. We do not want to further question this hypothesis but just presuppose its validity. In this case, differentiating equation (12) with respect to y yields

$$\rho_y = (1 - L_\rho^d)^{-1}(L_y + a_y) \tag{15}$$

By inserting (15) this into equation (11) we obtain

$$y_\varepsilon = \left(1 - y^d - y_\rho^d(x_1 + x_2)\right)^{-1} \tag{16}$$

where

$$\begin{aligned} x_1 &= \tfrac{L_y^d}{1-L_\rho^d} \\ x_2 &= \tfrac{a_y}{1-L_\rho} \end{aligned}$$

Under reasonable assumption on the elasticities of loan demand, x_2 is negative. Since y_ρ can be assumed to be negative as well, we derive that the multiplier is the larger the larger is a_y in absolute terms. Consequently, we have also shown in a formal way that pro-cyclical capital ratios have also a pro-cyclical effect on output. To what extent largely depends on the elasticity of real demand with respect to interest rates and on the elasticity of regulatory capital with regard to output. In the following sections we shall try to estimate the magnitude of this effect.

3 Estimation of loan supply

Instead of directly estimating loan supply directly, we have seen in the previous section that it suffices to estimate the banks target capital. In doing so, we have to be aware of the fact that the capital ratio may not be totally flexible in the short run. Besides our previously made assumption that total capital is fix in the short run banks may not be able to swiftly reduce its stock of loans (though they may increase it by granting new loans). In the medium run, however, downward flexibility is feasible as old loans expire. Thus, the capital ratio of equation (6) should be regarded as the optimum, which only holds in the medium run. Suppose that in the medium term the bank tries to achieve a capital ratio given by equation (6), which we shall denote by e^*. Furthermore assume that the stock of loans is partially inflexible. In this case, we can expect that the bank sets its capital ratio in the following way:

$$e_t(\rho, r, a) = \begin{cases} e_t^*(\rho, r, a) & \text{if} \quad e_t^* \leq e_{t-1} \\ e_{t-1} & \text{otherwise} \end{cases} \tag{17}$$

Hence, we should expect on average the short capital ratio e_t to be a weighted mean of $e*$ and the capital ratio of the previous period. At least, the elasticity of e with respect to interest rates should be significantly less than 1 and the elasticity of e_t with respect to e_{t-1} should be larger than zero . Table 3 shows the result of the regression for medium run capital ratios.

Estimation was based on reported capital ratios of German banks as of December from 1993 to 2001, respectively. To derive the respective parameters we used the dynamic panel estimator of Arellano and Bond. Clearly, all parameters have the expected sign. The coefficients of the interest rates are relatively large, they are even large than expected by equation (6). Furthermore, the coefficients of the loan rate and the riskless rate are

Table 1: Estimation of medium term target capital ratio

e_t	Coef.	Std. Err.	P-value	95 % Conf. Interval	
e_{t-1}	.032	.107	.003	.0112	.053
ρ	-2.172	.133	.000	-2.433	-1.911
r	2.453	.169	.000	2.123	2.784
const.	.325	.031	.000	.265	.386

Table 2: Estimation of short term target capital ratio

e_t	Coef.	Std. Err.	P-value	95 % Conf. Interval	
e_{t-1}	.608	.024	.000	.561	.655
ρ	-.255	.0245	.000	-.304	-.207
r	.130	.0247	.000	.081	.178
const.	.020	.002	.000	.016	.023

of the same magnitude in absolute terms. At the same time, the impact of the previous year's capital ratio is very small, though significantly positive (as we should see if some persistence prevails also in the medium term).

Running the regression for monthly data the magnitude of the estimated coefficients changes (Table 3). As expected, there is a strong impact of the previous month's capital on the current capital ratio. Interest rates effect the capital ratio much less than we have seen for the yearly data.

Summing up, the results of the regression are broadly in line with predictions of equations (6) and (17). Of course, a complete validation could not be achieved, and one should not have expected that in the first place. It goes without saying that the model of the banking sector is rather crude. Besides many other points we totally neglected the quality distribution of loans and the differences in corresponding interest rates. Furthermore, we did not properly account for the banks's funding as capital is not fully inflexible even in the short run and the cost of funding varies across banks.

4 Estimating the probability of default

There exists abundant work on the estimation of the probability of default for various classes of borrowers. Most of the estimation was carried out with logit regression techniques or related models. However, relatively little has been done to assess the impact of business fluctuations on PDs. Although it is well known that public ratings vary significantly over time, the influence of the business cycle is rather difficult to assess.

In this paper we suggest a different approach. From each bank's balance sheet we can derive the default rate of its loan portfolio. It seems not unreasonable to assume that the average PD is equal to the current default rate. Although Basel II requires bank's to forecast the probability of default with a lead time of one year, projections tend to be extrapolations of current default rates. Analysing the individual banks' loan default rates has the advantage of making direct use of the banks' actual loan portfolios. Previous research relied heavily on simulated portfolios or any other sample portfolio, which might not have been representative.

Of course, the risk weight function of Basel II is not linear and we do not know the exact quality distribution of the banks' loan portfolio. However, it is not unreasonable to assume that the bulk of loans have similar ratings. Therefore, we may approximate regulatory capital by inserting the average PD into the risk weight function of Basel II. From the benchmark risk weight function for corporate exposures which was published in the second consultative paper of the Basel Committee the regulatory capital ratio can be derived as being equal to

$$100^{-1} \cdot a = 0.08 \cdot 976.5 \cdot N(1.118 \cdot N^{-1}(PD) + 1.288) \cdot (1 + .047 \cdot (1 - PD)/PD^{.44} \tag{18}$$

From the data the average default rate is approximately 1.1 %, which corresponds to a risk weight of 99.8 %. A 6 % rise in the default rate will increase the corresponding risk weight to 104.2 %. Table 3 shows the development of regulatory capital under Basel II from 1993 to 2001 under the assumption that default rate were equal to the average PD. In this period capital ratios would have fluctuated between 7.3 % and 9.2 % and annual changes of regulatory capital between -5 % and 7 %. Furthermore, a correlation coefficient of -33 % between GDP on the one hand and default rates and regulatory capital ratios on the other indicates some degree of pro-cyclicality.

However to fully assess the effect of business fluctuations we need to build an econometric model which links default rates to a set of macroeconomic variables. One major problem with any regression analysis is the restricted availability of data for the banks' balance sheets, which, for most banks, is collected only on a yearly basis. Furthermore, a

Table 3: Simulated capital ratios

Year	Default rate	Capital ratio	Annual changes of capital
1994	1.21	8.6	
1995	1.33	9.2	7.0
1996	1.25	8.8	-4.3
1997	1.16	8.3	-5.4
1998	1.08	7.9	-5.4
1999	1.01	7.5	-5.0
2000	0.98	7.3	-1.9
2001	1.07	7.8	7.0

complete and reliable data set is only available from 1993. This renders standard time series regression based on aggregate data impossible. Instead, we will apply panel regression techniques to exploit all useful information of the disaggregated data set.

The goal of the regression analysis is to explain new loan loss provisions (LLP) per year mainly by current macroeconomic variables and balance sheet information of the previous years. To this end, we used the following regression equation:

$$\lambda_{it} = \beta_1 \, \lambda_{i,t-1} + \beta_2 \, \lambda_{i,t-2} + \beta_3 \, \Delta L_{it} + \beta_4 \, \Delta GDP_t + \beta_5 \, yield_t + \mu_i + \varepsilon_{it} \tag{19}$$

where the subscript i denotes an individual bank and t denotes time (in years)

The dependent variable is given by a non-linear transformation of LLP to account for the fact that LLP is always positive and the right side of the equation may become negative. More specifically λ_{it} is given by

$$\lambda_{it} = \frac{DR_{it}}{1 - DR_{it}} \tag{20}$$

and DR_{it} being the default rate in banks i loan portfolio at time t. The explanatory variables are given by

ΔL_{it} the percentage increase in loans

ΔGDP_t the growth rate in GDP

$yield_t$ the short term interest rates

Table 4: Default rates of banks' loan portfolio

λ_{it}	Coef.	Std. Err.	P-value	95 % Conf. Interval	
$\lambda_{i,t-1}$	.351	.040	.000	.272	.430
$\lambda_{i,t-2}$	.110	.024	.000	.062	.157
ΔGDP_t	-.062	.012	.000	-.086	-.039
$yield_t$	.104	.019	.000	.068	.140
ΔL_{t-1}	-.003	.001	.000	-.004	-.002
const	-.007	.005	.185	-.017	.0003

μ_i the individual effect and

ε the error term.

For the estimation we used balance sheet information of the total set of savings banks (approximately 600 banks) from 1993 to 2001. The regression was carried out with the dynamic panel estimator of Arellano and Bond. Standard analysis has been carried out as regards the specification of the model and its stability. The results are listed in table 4. The important variable is ΔGDP. The estimation shows that a fall of 1 % in GDP approximately results in a 6 % increase in the loans' default rate.

Combining this result with equation (18) we can show that a 1 % decrease in GDP may lead to an average increase of 4.4 % of the regulatory capital ratio, or -starting from a benchmark level of 8% - to an increase of 0.4 percentage points. In the period from 1980 to 2001, yearly differences in GDP growth rates were between -3 % and 3 %. Supposing our assumptions were true, we would have seen regulatory capital changes of $\pm$8%. Therefore, with regard to regulatory capital, the pro-cyclical effect is significant.

Against these findings one could maintain, that, although regulatory capital may be relatively volatile, actual capital may be much less so, since banks intend to hold some extra capital in order not to fall below required capital. However, inspection of equation (17) shows that this might not be the case. Quite to the contrary, higher default rates during an economic downturn may lead the bank to hold additional capital on top of the buffer it already holds on average on regulatory capital. Of course, the positive effect on capital ratios might be partly mitigated by the negative effect of spread changes, which tend to increase during economic downturns.

Table 5: VAR(1) estimation of the German economy

	ΔGDP$_t$	Δyield$_t$
ΔGDP$_{t-1}$	.377	-.007
	(.159)	(.083)
	[2.37]	[-0.09]
Δyield$_{t-1}$	-.842	.197
	.257	).135)
	[-3.27]	[1.45]
const	1.375	.000
	(.475)	(.249)
	[2.90]	[-.00]
Δmoney	.283	.359
	(.129)	(.068)
	[2.20]	[5.31]

5 Assessing pro-cyclicality for the real economy

The previous chapter has shown that risk sensitive capital ratios such as those of Basel II are likely to lead to a significant effect on both regulatory and actual capital. However, to fully assess pro-cyclicality one must also analyse the effect of those changes on the real economy. In section 2 we already gave theoretical reasons why we also expect a procyclical effect on GDP. In this section we shall give an appraisal of the severity of such effect. Of course, it will be impossible to provide precise numbers since the necessary data will be available only years after the new accord has been implemented. Instead, we will try to simulate a model of the economy with some paramaters being estimated or calibrated by available data, others being exogenously set. For this purpose we estimated a very simple VAR model of the macroeconomy with GDP and the average yield of corporate bonds as endogenous variables. The 3-month money market was introduced as an exogenous variable to account for monetary policy of the central bank. Regression results are displayed in table 5.

All parameters of the lagged variables have the expected signs. Ignoring for the moment that GDP is explained by lagged variables we deduce from the regression results that y_ρ is approximately equal to 1. The results also show that the ρ_y is not significantly different

Table 6: Simulation results

Year	Scenario 0	Scenario 1	Scenario 2
1	1.96	5.05	5.05
2	2.13	3.29	3.29
3	2.19	2.63	4.35
average growth	2.09	3.65	4.23

from zero (Remember that short term interest rates are exogenous). To evaluate the multiplier in this dynamic model, we simulated a shock in the first year (Table 6. The benchmark case of the first columns displays hypothetical economic growth under the assumption that no shock occurs. In the second column we assumed a shock of 3.03 % in first year or - equivalently - an average shock of 1 % over three years. Instead of growing, on average, with a rate of 2.1 % the economy will grow with a rate of 3.6%. Therefore, in terms of growth, the multiplier is 1.5.

In the third column, we simulated the same shock while we changed the elasticity of interest rates with regard to GDP. The change was calculated according to equation (16), i.e.

$$\Delta\rho_y = \frac{a_y}{1 - L_y^d} \tag{21}$$

While we may infer a_y from our results of section 2, L_ρ^d is unknown. We therefore simulated the economy for different values of L_ρ^d. In the third column of table 6 we depicted the case of L_ρ^d being equal to zero. Obviously, the pro-cyclical effects on the real economy are significant. An unexpected average increase of 1 % in GDP, which under the original scenario increased average GDP growth rate to 1.6 % will, under the second scenario, increase the GDP growth rate to 2.1 %. Therefore the multiplier in this scenario is 2.1 - 40 % larger than under scenario 1.

6 Conclusion

In this paper we have analyzed the effects of different regulatory capital regimes on the volatility of banks actual capital and on real output. As opposed to what has been maintained elsewhere our theoretical model does not suggest an increased volatility of output under the current Basel Accord. As Basel II is concerned, however, an increased volatility is likely both for actual capital and real output. The increase is significant and depends on the sensitivity of regulatory capital with respect to the probability of default.

At this point we want to make some qualifying remarks concerning these findings. First, we do *not* say that increased volatility must be avoided by all means. A certain degree of pro-cyclicality may be acceptable considering the advantages of a more risk sensitive capital regimes. For example, the current Accord may have led to distortions in the credit market, therefore having caused potentially severe efficiency losses. Furthermore, from the modelling point of view we may have exaggerated the pro-cyclical effects since we assumed that, in the short run, banks cannot increase their capital. We concede, that this is not a realistic assumption for the medium term horizon. In this case, that the banks can vary their capital, the impact of regulatory capital on interest rates may be much less than stated above.

References

[1] Basel Committee on Banking Supervision, *International convergence of capital measurements and capital standards,*, July 1988.

[2] ______, *A new capital adequacy framework,*, July 1999, Consultative Document.

[3] Jürg Blum and Martin Hellwig, *The macroeconomic implications of capital adequacy requirements for banks*, European Economic Review **39** (1995), 739–749.

[4] Arturo Estrella, *The cyclical behavior of optimal bank capital*, 2001, Discussion papier.