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Abstract

Policy discussions on the recent financial crisis feature widespread calls to address the pro-cyclical effects of regulation. The main concern is that the new risk-sensitive bank capital regulation (Basel II) may amplify business cycle fluctuations. This paper compares the leading alternative procedures that have been proposed to mitigate this problem. We estimate a model of the probabilities of default (PDs) of Spanish firms during the period 1987-2008, and use the estimated PDs to compute the corresponding series of Basel II capital requirements per unit of loans. These requirements move significantly along the business cycle, ranging from 7.6% (in 2006) to 11.9% (in 1993). The comparison of the different procedures is based on the criterion of minimizing the root mean square deviations of each adjusted series with respect to the Hodrick-Prescott trend of the original series. The results show that the best procedures are either to smooth the input of the Basel II formula by using through-the-cycle PDs or to smooth the output with a multiplier based on GDP growth. Our discussion concludes that the latter is better in terms of simplicity, transparency, and consistency with banks' risk pricing and risk management systems. For the portfolio of Spanish commercial and industrial loans and a 45% loss given default (LGD), the multiplier would amount to a 6.5% surcharge for each standard deviation in GDP growth. The surcharge would be significantly higher with cyclically-varying LGDs.

Keywords: Bank capital regulation, Basel II, Pro-cyclicality, Business cycles, Credit crunch.

JEL classification: E32, G28.

1 Introduction

The 1988 Basel Accord consolidated capital requirements as the cornerstone of bank regulation. It required banks to hold a minimum overall capital equal to 8% of their risk-weighted assets. As all consumer and business loans were included in the full weight category, 8% became the universal capital charge for household and corporate lending, while for mortgages the capital requirement was 4%.

Following widespread criticism about the risk-insensitiveness of these requirements [Jackson (1999)], the Basel Committee on Banking Supervision (BCBS) approved in 2004 a reform, known as Basel II, whose primary goal was "to arrive at significantly more risk-sensitive capital requirements" [BCBS (2006), par. 5]. Basel II introduced a menu of approaches for determining capital requirements. The *standardised approach* uses external ratings to refine the risk weights of the 1988 Accord (henceforth, Basel I), but leaves the capital charges for loans to unrated companies essentially unchanged. The *internal ratings-based* (IRB) approach allows banks to compute the capital charges for each exposure from their own estimate of the probability of default (PD) and, in the advanced IRB approach, the loss given default (LGD) and the exposure at default (EAD); see Box 1.

As a result of this risk-sensitiveness, a widespread concern about Basel II is that it might amplify business cycle fluctuations, forcing banks to restrict their lending when the economy goes into recession. Even in the old Basel I regime of essentially flat capital requirements, bank capital regulation had the potential to be pro-cyclical because bank profits may turn negative during recessions, impairing banks' lending capacity [Borio, Furfine and Lowe (2001); Gambacorta and Mistrulli (2004)].[1] Under the IRB approach of Basel II, capital requirements are an increasing function of the PD, LGD and EAD parameters estimated for each borrower, and these inputs are likely to rise in downturns. For example, using the formula in Box 1 one finds that an increase in the PD from 1% to 3% (something in line with US experience[2]) increases the capital requirement for corporate exposures from 6.21% to 9.32%.[3] Clearly, a jump of 50% in required capital would not be easy to accommodate in the middle of a recession. So concerns about Basel II are stronger than those regarding Basel I because the worsening of borrowers' creditworthiness in recessions will significantly increase the requirement of capital for banks and might lead to a severe contraction in the supply of credit.[4] At the same time, there is the complementary concern that the lower capital requirements in expansions may contribute to the emergence of credit and asset price bubbles.[5]

The recent financial crisis, with its boom and bust lending cycle, has brought to the forefront the need to address the potential pro-cyclical effects of risk-sensitive bank capital regulation. The idea is to devise procedures that correct the bias towards exacerbating the inherent cyclicality of lending, and consequently distorting investment decisions, either by restricting access for some agents to bank finance or, in the opposite direction, by fuelling credit booms.

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1. In fact, there is a debate in the literature on whether the implementation of the Basel I capital requirements in the US might have brought about a credit crunch in the early 1990s; see Bernanke and Lown (1991), Berger and Udell (1994), Hancock and Wilcox (1994), Hancock, Laing and Wilcox (1995), and Peek and Rosengren (1995a and b).

2. See the discussion in Appendix B in Repullo and Suárez (2009).

3. Assuming a constant LGD of 45% and a maturity, M, of 1 year.

4. These concerns would be exacerbated by mark-to-market accounting, which increases the cyclical movements in banks' capital, and consequently has the potential to amplify the pro-cyclical effects of bank capital regulation.

5. See Panetta and Angelini (2009) for an extensive discussion of the literature on pro-cyclicality in the financial sector.

Multiple committees, institutions, central banks and supervisory authorities all over the world are working on mechanisms to abate this pro-cyclicality. To name a few, the G-20 at the summit held in Washington [G-20 (2008)] requested Finance Ministers to formulate specific recommendations, among others, on mitigating pro-cyclicality in regulatory policy. The Basel Committee [BCBS (2008)] in its comprehensive strategy to address the lessons of the banking crisis also highlights the need to dampen the pro-cyclicality in the financial system. The European Union (EU, press release July 2009) created a working group to address pro-cyclicality issues by analysing potential policy responses to reduce their impact. Furthermore, the G-20 at the Pittsburgh summit [G-20 (2009)] called on Finance Ministers and Central Bank Governors to reach agreement on an international framework of reform in four critical areas, the first one being "building high-quality capital and mitigating pro-cyclicality." The Financial Stability Board (FSB) issued in April 2009 a series of reports covering different areas of interests in response to the current crisis, recommending that the Basel Committee should monitor the impact of the Basel II framework and make appropriate adjustments to dampen the excessive cyclicality of the minimum capital requirements; see FSB (2009). The EU Economic and Financial Committee working group on pro-cyclicality (2009) finds that there is a host of potential elements that can contribute to reducing the pro-cyclical effects on the financial system, including counter-cyclical capital requirements.

Both Treasury Secretary Geithner (2009) and Chairman Bernanke (2009) advocate that capital regulation should be revisited to ensure that it does not induce excessive pro-cyclicality. In the same vein, Adair Turner (2009) proposes the need for regulatory approaches to capital regulation to avoid unnecessary pro-cyclicality in capital adequacy requirements.

One can conclude that there is widespread agreement that something must be done. The devil is, of course, in the details. How should the pro-cyclicality problem be tackled without throwing out the risk-sensitiveness of the new capital regulation regime? This is what this paper is about.

We present, analyse, and discuss the leading alternative procedures that have been proposed to mitigate the pro-cyclicality of the Basel II capital requirements. As a first step, we show that capital requirements under Basel II move significantly along the business cycle. The analysis is based on the results of the estimation of a logistic model of the one-year-ahead probabilities of default (PDs) of Spanish firms during the period 1987-2008. The database includes all commercial and industrial loans granted in Spain during this period, and comes from the Credit Register of the Bank of Spain. The dependent variable is a binary variable that takes value one when a firm defaults in the course of a year on its outstanding loans at the end of the previous year, and zero otherwise. The explanatory variables comprise characteristics of the firm (industry, location, age, credit line utilization, and previous delinquencies and loan defaults), characteristics of its loans (size, collateral, and maturity), characteristics of the banks from which the firm borrows (distribution of exposures among lenders and changes in the main provider of finance), and macroeconomic controls (the rate of growth of the GDP, the rate of growth of bank credit, and the return of the stock market).

The empirical model provides an estimate of the *point-in-time* (PIT) PDs of the loans in the entire portfolio of commercial and industrial loans of the Spanish banks over the sample period, so using the Basel II formula we can compute the corresponding aggregate capital requirements per unit of loans. We find that Basel II capital requirements increase more than 50% from peak to trough, which is a very significant change compared with the flat requirements of Basel I.

We next consider the effect of different procedures to mitigate the cyclicality of these requirements over the business cycle. According to Gordy and Howells (2006) there are two basic alternatives: one can smooth the input of the Basel II formula, by using some sort of *through-the-cycle* (TTC) adjustment of the PDs, or smooth the output by using some adjustment of the Basel II capital requirements computed from the PIT PDs.[6] We analyze both approaches. Following the work of Saurina and Trucharte (2007) on mortgage portfolios, we first construct TTC estimates of the PDs by setting the value of the macroeconomic controls at their average level over the sample period, and then compute the corresponding Basel II capital requirements. Second, we analyze different adjustments to the PIT capital requirements based on aggregate information (the rate of growth of the GDP, the rate of growth of bank credit, and the return of the stock market) and individual bank information (the rate of growth of banks' portfolios of commercial and industrial loans). The comparison of the different procedures is based on the criterion of minimizing the root mean square deviations of each smoothed series with respect to the trend of the original series. This trend is computed by applying the Hodrick-Prescott (HP) filter, which is the procedure customarily used by macroeconomists to separate cycle from trend. Thus, our approach aims at smoothing just the cyclical component of the Basel II capital requirements.

The results show that the best procedures in terms of approaching the HP trend are either to smooth the input of the Basel II formula using TTC PDs, or to smooth the output with simple multiplier of the PIT capital requirements that depends on the deviation of the rate of growth of the GDP with respect to its long-run average. Our discussion of the pros and cons of these two procedures concludes that the latter is better in terms of simplicity, transparency, low cost of implementation, and consistency with banks' risk pricing and risk management systems.

The remainder of the paper is structured as follows. Section 2 provides a broader perspective of the rationale for the approach developed in the paper. Section 3 presents the empirical model of probabilities of default (PDs) using data from the Credit Register of Bank of Spain on commercial and industrial loans for the period 1987-2008. In Section 4 we use the estimated PDs to compute the corresponding Basel II capital requirements and its trend using the Hodrick-Prescott (HP) filter, and then compare different smoothing procedures using root mean square deviations from the HP trend. Section 5 contains our discussion of these results. Section 6 extends the analysis to adjustments using individual bank data and to the case where the loss given default moves along the business cycle, and also considers the cyclical adjustment of expected losses. Section 7 concludes. The Appendix contains the tables with the estimation results and the analysis of performance of the empirical model.

6. See also the discussion in Committee of European Banking Supervisors (2009).

2 Dealing with the pro-cyclicality of Basel II

In approaching the issue of how to deal with the pro-cyclical effects of Basel II it is important to stress that this regulation is not derived from a framework in which the costs and benefits of bank capital regulation are traded-off. Instead, Basel II is derived from an ad hoc requirement that capital must cover credit losses with a confidence level of 99.9%, where the underlying probability distribution of loan losses is computed using a particular credit risk model. Thus there is no presumption that the resulting requirement is "optimal" from a social welfare perspective.

Of course, designing optimal capital requirements is not an easy task, because one would require a proper economic model of the above-mentioned trade-off. A simple starting point could be the conceptual framework put forward by Kashyap and Stein (2004). In this framework, bank capital regulation is justified by the externalities associated with bank failures (losses to the deposit insurer, break-up of lending relationships, disruption to other players in the financial system, etc.). Bank capital regulation may serve to correct this externality, but if it is expensive for banks to raise and/or hold capital this will have a cost in terms of a reduction in the funding of positive Net Present Value (NPV) projects. Optimal regulation would trade-off the reduction in the social costs of bank failures against the underinvestment of bank-dependent borrowers.

Using this framework, Kashyap and Stein (2004) argue that if the shadow value of bank capital is low in expansions and high in recessions, optimal capital charges for each type of risk should depend on the state of the business cycle. Without such adjustments, capital requirements would be too low in expansions, when bank capital is relatively plentiful and has a low shadow value, and too high in recessions, when the shadow value of bank capital goes up, leading to the amplification of business cycle fluctuations. They conclude that optimality would require a family of capital charge curves, with each curve corresponding to a different shadow value of bank capital. In this way, the cross-sectional dimension of Basel II (that is, that riskier exposures carry a higher capital charge) would be maintained, but without undesirable side-effects in the time series dimension.

One important issue that is not addressed in Kashyap and Stein (2004) is whether in the presence of risk-sensitive capital regulation banks have an incentive to build sufficient capital buffers (capital in excess of regulatory requirements) that could neutralize the effect of the cyclical variation in capital requirements. This was the view of many regulators before the onset of the current crisis. For example, Greenspan (2002) noted that "the supervisory leg of Basel II is being structured to supplement market pressures in urging banks to build capital considerably over minimum levels in expansions as a buffer that can be drawn down in adversity and still maintain adequate capital."

To address this issue, Repullo and Suárez (2009) construct a model that shows that banks have an incentive to hold capital buffers, but that the buffers maintained in expansions are typically insufficient to prevent a contraction in the supply of credit to bank-dependent borrowers at the arrival of a recession. They also show that Basel II leads to a substantial increase in the pro-cyclicality induced by bank capital regulation, with credit rationing at the beginning of a recession jumping from 1.4% to 10.7% on average in the baseline scenario. Finally they show that some simple cyclical adjustments in the 99.9% confidence level used to derive the Basel II capital requirements may significantly reduce its pro-cyclical effects.

In contrast with the normative approach of Kashyap and Stein (2004), the approach of Repullo and Suárez (2009) is positive. They take as given the Basel II regulation, and compute the associated costs in terms of credit rationing in different states of the credit cycle. This paper follows the latter approach. In particular, we do not attempt to provide a social welfare rationale for the various ad hoc adjustments that we compare, although we think that they could be related to the arguments in Kashyap and Stein (2004). Our focus is on how counter-cyclical regulation should be implemented in practice.

It could be argued that these adjustments should be left to the discretion of supervisors, in the context of the so-called "supervisory review process" (Pillar 2) of Basel II. However, we believe that having a rule for counter-cyclical adjustments is better from the perspective of ensuring a level-playing field at the international level, and also for correcting possible biases in the objective function of supervisors, who would normally put extra weight on the avoidance of bank failures at the expense of the funding of positive NPV projects.

The rules that we consider imply changing the Basel II capital requirement k_{jt} for bank j at date t to a cyclically-adjusted capital requirement $\hat{k}_{jt}$. The objective would be to remove the cyclical component of k_{jt} using a simple procedure that would be applied to all the banks (as opposed to using a different procedure for each bank). The natural benchmark for doing this adjustment is the trend of the k_{jt} series, which we compute by applying the Hodrick-Prescott filter. The comparison of the different procedures is conducted in Section 4 for a single fictional bank that aggregates all commercial and industrial loans in Spain, although in Section 6 we test the robustness of our results using individual bank data.

Summing up, this is not a paper about how optimal bank capital regulation should deal with business cycle fluctuations. It is a paper that considers fixing in an ad hoc manner an ad hoc regulation. Nothing can be done on the latter: risk-based regulation à la Basel II is already in place. And we think that the former is very important from a policy perspective, because Basel II has the potential to induce severe contractions in the supply of credit in downturns. Not surprisingly, discussions on pro-cyclicality are at the centre of the ongoing regulatory review process.

3 Empirical model of firms' probabilities of default

Empirical model

To compute how Basel II capital requirements would evolve over the business cycle we estimate a model of default for the firms that borrowed from Spanish banks over the period 1987-2008. The model provides estimates of the probabilities of default (PDs) for each firm and year, which are used to compute the corresponding Basel II capital charges.

This procedure, although in line with other recent approaches,[7] is obviously subject to the Lucas' critique. Had Basel II been in place, banks' decisions over lending, and consequently the pool of borrowers, might have been different. However, the dominant role of universal banks in the Spanish financial system, the limited role of securitization, as well as the tight model of supervision implemented by the Bank of Spain, suggest that composition effects may not be very significant.

Based on direct information on firms' economic and financial conditions, banks grant loans with very different characteristics. Some of these differential features are, directly or indirectly, contained in the information included in the Credit Register of the Bank of Spain and constitute the basis for our empirical analysis.

The Credit Register also provides information on the default status of each loan. This allows us to construct the dependent variable for the regression (logit) model, y_{it+1}, which is a dichotomous (zero-one) variable that takes value 1 if borrower i defaults in year $t + 1$, and 0 otherwise.[8] A borrower is considered to have defaulted if it is 90 days overdue failing to meet its financial obligations on a certain loan or if, with a high probability, it is considered to be unable to meet its obligations. If a borrower has several loans, failure to meet payments on any of them means that the borrower is in default. The default event is conditional, requiring that a firm defaulting in a certain year shall not have defaulted during the previous year.

The next step is to specify the explanatory variables, all dated in year t, that include variables that describe the characteristics of the borrower and its risk profile, as well as macroeconomic controls and regional (Spanish province in which the firm is registered) and industry (NACE code) dummies.

$COLLATERAL_{it}$ represents the average (weighted by the size of the exposures) of the proportion of guarantees in a firm's borrowing.[9] The empirical evidence [Berger and Udell (1990); Jiménez, Salas and Saurina (2006)] shows that banks ask for collateral to those firms perceived as riskier. $MATURITY_{it}$ represents the proportion of long-term exposures (more than one year) over total exposures. The longer the maturity of a loan, the more thorough will be the screening process of the quality of the borrower. Riskier borrowers will probably be granted only short-term loans. AGE_{it} tries to approximate the age of each firm, with the idea of capturing that firms of recent creation are more prone to disappear than older ones. Thus, higher rates of default are expected during the first years of activity. As the relationship is not likely to be linear, we have constructed a set of dummy variables each accounting for the number of years (one,

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7. See, for example, Committee of European Banking Supervisors (2009), Kashyap and Stein (2004), and Saurina and Trucharte (2007).

8. This definition is similar to that established in Basel II; see BCBS (2006, par. 452).

9. Clearly, some of the explanatory variables (such as collateral) may be endogenous, but this is not a problem for our empirical model since we are interested in predicting default, not in estimating causal effects.

two, three, and four or more) a borrower has been reporting to the Credit Register. $FIRM\_SIZE_{it}$ stands for the total amount of bank borrowing, and proxies for the size of each firm. The variable has been deflated by the consumer price index, and enters the model in logarithmic terms.

We also include in the model the variable $NUMBER\_BANKS_{it}$, representing the number of banks that have granted a loan to firm *i* in year *t*. We hypothesize that the more banks a firm is related to, the more constrained it may be in terms of liquidity and thus the higher its probability of default. We expect a non-linear relationship between this variable and the default event, so it enters the equation in logarithmic terms. We have also included a variable that accounts for the number of times a firm changes its main lender, $MAIN\_LENDER\_CHANGE_{it}$. It indicates the frequency with which a firm changes the bank that provides the largest amount of funding. High values of this variable imply high rates of rotation and hence possible constraints or even difficulties in securing finance, which suggest low creditworthiness. $UTILIZATION_{it}$ is the ratio between the amount of credit drawn by a borrower and the total available amount (credit line). For various reasons, firms extensively use credit line facilities where they can withdraw funds at any time. Collateral required, if any, remains pledged to the credit line. The rationale for this variable is that the more a borrower withdraws, the more liquidity constrained it may be. The empirical evidence in Jiménez, López and Saurina (2009a) shows that firms that eventually default draw down more intensely their credit lines.[10]

$HISTORIC\_DELINQUENCY_{it}$ represents the borrowers' record of overdue loans that have been paid before the 90-day threshold (that is, before having defaulted) measured as the number of years in which the firm has been delinquent divided by the number of years it has been reporting to the Credit Register. The problems behind overdue loans are sometimes "technical", spanning only a few days as a result of mismatches in cash flows, but in other cases they are good predictors of future defaults. $HISTORIC\_DEFAULT_{it}$ is another risk profile variable that captures whether a certain borrower defaulted in the past.[11] As in the case of the delinquency variable, this variable is defined as the number of years in which the firm has been in default divided by the number of years it has been reporting to the Credit Register.[12]

The macroeconomic controls are the rate of growth of the gross domestic product, GDP_GROWTH_t, the rate of growth of the commercial and industrial loans in the Credit Register, $CREDIT\_GROWTH_t$, and the return of the Spanish stock market index, $STOCK\_MARKET\_RETURN_t$. These variables proxy macroeconomic activity factors that affect credit risk, an essential ingredient for our analysis of the cyclical implications of Basel II.

Data

The database used in the estimation of the model of PDs is the Credit Register of the Bank of Spain (CIR). This Register records monthly information on all credit operations granted by all credit institutions operating in Spain for a value of over €6,000. The data distinguishes between loans to firms and to households. CIR includes information on the characteristics of each loan, including the following: instrument (trade credit, financial credit, leasing, etc.), currency denomination, maturity, existence of guarantees or collateral, type of guarantor, coverage of the guarantee, amount drawn and undrawn of a credit commitment, and whether the loan is current in payment or past due, distinguishing in turn between delinquency and default status. CIR also

10. In fact, utilization ratios are significantly different for defaulted and non-defaulted firms well in advance of the date of default (even 4 or 5 years before).

11. The dates have to be $t - 1$ or earlier to be consistent with the definition of default: failing to meet its financial obligations in year $t + 1$ given that it was not in default in year t.

12. Jiménez, López and Saurina (2009a) show that these two variables are good proxies for firms' financial condition. When they replace them by balance sheet and profit and loss data there is no significant change in the fit of the empirical model.

includes information on the characteristics of borrowers: province of residence and, for firms, the industry in which they carry out their main economic activity.

Our analysis focuses on loans to firms. The sample period goes from 1984 to 2008, although for estimation purposes and to use explanatory variables such as age or historic delinquency and default it spans from 1987 to 2008. It should be noted that this time span includes the recession of the early nineties and the subsequent upturn during the late nineties and the first years of the current decade. The database contains a vast amount of information (about 10 million observations). To facilitate the analysis we have randomly selected a 10% sample, which leaves us with about 1 million observations. The main statistics of the sample (and in particular those referred to the default condition of borrowers) perfectly match those of the entire population.

Results

Table A in the Appendix presents the results of the estimation of the model. The results show that firms that post collateral when granted a loan have higher probabilities of default (PDs). Lenders try to mitigate risks by requiring collateral to those firms that they consider riskier. Longer maturities are associated with lower default rates, and this is also the case for the age of the borrower. Big firms are safer than smaller ones. Firms that are two or three years old have, on average, lower credit quality, and as they grow older their default rate decreases. The more lenders a firm has and the higher rotation of its main lender the higher its PD. The higher the utilization of credit lines the higher the PD, so liquidity constraints also seem to play a role in firms' default. Regarding risk-profile variables, past overdue and past default events are a signal of future defaults. Finally, the macroeconomic controls show that firms' defaults increase during downturns, proxied by low GDP growth, credit growth, and stock market returns.

Tests of stability have been carried out by estimating the model without some of the variables, which does not change the signs and statistical significance of the remaining variables, and by omitting some years of the sample period, which leads to very small changes in the estimated coefficients. The model classifies correctly approximately 70% of the defaulted and non-defaulted firms in the sample (see Table B in the Appendix).[13] Finally, we tested the predictive power of the model by using a second 10% sample of the population. The parameters estimated with the original sample were used to predict defaults in the validation sample. The results show that 68% of defaulted and 71% of non-defaulted firms were correctly classified.

13. Alternative performance measures confirm the predictive power of the model. In particular, the area under the ROC curve is over 76% which results in an Accuracy Ratio (AR) of 52%. These results are in line with those in the related literature; for example, Chava and Jarrow (2004) obtain an AR of 53%.

4 Cyclical adjustment of Basel II capital requirements

Point-in-time (PIT) capital requirements

The results reported in Section 3.3 allow us to compute the *point-in-time* (PIT) capital requirements k_{it} for each borrower and each year using the Basel II formula for corporate exposures [BCBS (2006), par. 272] included in Box 1, the estimated probability of default PD_{it}, and assuming a loss given default (LGD) of 45% (as in the foundation IRB approach of Basel II),[14] and a 1 year maturity. We then compute the aggregate PIT capital requirements per unit of loans for each year, that is

$$k_t = \frac{\Sigma_i k_{it}}{\Sigma_i l_{it}}, \quad (1)$$

where l_{it} denotes the value of the loans to firm *i* at the end of year *t*.

Figure 1 shows how aggregate PIT capital requirements per unit of loans would have evolved in Spain during the sample period had Basel II been in place, together with the Spanish GDP growth rate. Both series are highly negatively correlated (the correlation is −0.80), which suggests that GDP growth rates may be useful to mitigate the pro-cyclicality of Basel II. It is important to note that this result is not due to the fact that GDP growth is one of the explanatory variables in our empirical model. We also run cross-section regressions for each year of the sample (thus excluding the macroeconomic controls) and computed the PDs and the corresponding Basel II capital requirements, obtaining a cyclical profile very similar to that in Figure 1 (the correlation between both series was 0.94).

There is a very significant cyclical variation of the Basel II capital requirements when they are calculated with PIT PDs. In 1993, at the worst point in the business cycle, they would have been 11.9%, falling to around 8% at the peak of the cycle (8.07% in 2005, 7.63% in 2006, and 8.06% in 1986, three years of strong economic expansion). The variability of 57% in Basel II capital requirements from peak to trough contrasts with the flat 8% requirements of Basel I.[15]

It should be noted that the average capital requirement over the sample period is 9.37%, higher than the 8% of Basel I,[16] but this has little significance because we are only looking at the portfolio of commercial and industrial loans that typically bears higher capital charges than other important parts of banks' portfolios such as mortgages. In fact Basel II was calibrated so that banks would hold total capital equivalent to at least 8% of their risk-weighted assets.

The Hodrick-Prescott benchmark

To identify a trend in the PIT capital requirements series we apply a Hodrick-Prescott (HP) filter with a smoothing parameter $\lambda = 100$ (annual data).[17] Figure 2 shows the HP trend in dashed

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14. Section 5.2 analyses the case where LGDs vary over the business cycle.

15. It can be argued that this result is only for a specific portfolio (of loans to firms). However, Saurina and Trucharte (2007) show that PIT capital requirements also fluctuate significantly for mortgage portfolios in Spain. Loans to firms and mortgages represent close to 90% of total loan portfolios of Spanish banks.

16. The actual capital requirement would have been 8%, since loans to firms had a 100% risk-weight under Basel I.

17. The choice of the smoothing parameter λ depends on the purpose of the exercise. Using the standard value for annual data ($\lambda = 6.25$) produces a trend that follows more closely the series and consequently leaves smaller cyclical variations of capital requirements. However, a number of people criticised this feature and suggested to us using a flat benchmark (see lines. As expected, the trend filters out the cyclical movements in the capital requirement series, being below the series in bad times and above the series in good times, but maintains the risk-sensitiveness of the capital requirements along the business cycle (i.e. they increase in downturns and decline in upturns). The purpose of computing this trend is to provide a benchmark for the comparison of different alternatives proposed in the literature to mitigate the cyclicality of the Basel II requirements.

Adjusting the input of the Basel II formula: TTC capital requirements

The first procedure that we analyze is to smooth the PD input of the Basel II formula by using *through-the-cycle* (TTC) PDs. To estimate these PDs we follow the idea in Saurina and Trucharte (2007) of replacing the current values of the macroeconomic controls by their average values over the sample period. We then compute the capital requirements for each borrower and each year using the Basel II formula for corporate exposures, the estimated TTC PDs, a loss given default (LGD) of 45%, and a maturity of 1 year. Figure 3 shows the TTC capital requirements per unit of loans for each year of the sample.

In comparison with the PIT capital requirements, the cyclical variability of the TTC capital requirements series declines significantly. The maximum is reached in 1991, two years before the recession, at the level of 10.8%, while the minimum is 8.8% in 2005. The change in capital requirements from peak to trough goes down to 25%, which is less than half of the 57% figure obtained for the PIT series. Alternatively, the standard deviation of the TTC series is 0.62, while for the PIT series was 1.27. Figure 3 also shows that TTC PDs would have produced capital levels above those corresponding to PIT PDs during the boom of 2003-2007, with a very significant increase in 2005 and 2006.

Adjusting the output of the Basel II formula

The second procedure to adjust the Basel II capital requirements that we analyze is to apply to the PIT series a *business cycle multiplier* of the form:

$$\hat{k}_t = \mu_t k_t \tag{2}$$

where k_t is the original PIT capital requirements series, computed using the Basel II formula in Box 1, and $\hat{k}_t$ is the adjusted series. A convenient functional form for the multiplier μ_t is:

$$\mu_t = \mu(g_t, \alpha) = 2N\left(\frac{\alpha(g_t - \overline{g})}{\sigma_g}\right) \tag{3}$$

where g_t is the growth rate of some indicator variable of the business cycle, $\overline{g}$ its long-run average, σ_g its long-run standard deviation, $N(\cdot)$ is the standard normal cumulative distribution function, and α is a positive parameter. The multiplier μ_t in (3) has several key features: it is continuous and increasing in the proxy for the business cycle g_t, so capital requirements would be increased in good times and reduced in bad times, it is equal to 1 when $g_t = \overline{g}$, so there would be no adjustment at the average of the business cycle indicator, and it is bounded, so capital requirements do not increase without bound or become negative. The normalisation of the business cycle indicator allows us to express changes of capital requirements (surcharges) in

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Section 6.3). For this reason, we chose to work with $\lambda = 100$. Nevertheless, the qualitative results are not very sensitive to the choice of λ.

terms of standard deviation movements with respect to the average value of the indicator. Any functional form with these features could be an alternative, but (3) is a particularly simple one.

Two issues related to the proposed adjustment have to be addressed. First, what is the variable that should be chosen as indicator of the business cycle? Second, how does one choose parameter α? With respect to the first issue, we consider the three macroeconomic controls used in the empirical model, namely the rate of growth of the GDP, the rate of growth of bank credit, and the return of the stock market. With respect to the second, we propose as criterion for the choice of α (for each proxy for the business cycle) to minimise the root mean square deviations (RMSD) of the adjusted series with respect to the HP trend. In other words, we choose the value of α that is best in terms of smoothing the cyclical component of the PIT capital requirements series.

The results obtained are as follows. When the variable selected as indicator of the business cycle is the rate of growth of the GDP we get α (GDP) = 0.081; when the variable is the rate of growth of bank credit we get α (credit) = 0.075; and when the variable is the return of the stock market we get α (stock market) = 0.038.

Figures 4, 5 and 6 show the adjustment of the PIT capital requirements for the three indicators of the business cycle and the optimally chosen values of parameter α, together with the HP trend. It can be readily seen that the stock market indicator does very poorly in terms of approaching the HP benchmark, while the other two are much better.

An alternative procedure to adjust the output of the Basel II formula is to follow the proposal of Gordy and Howells (2006) to use an autoregressive filter of the form

$$\hat{k}_t = \hat{k}_{t-1} + \phi(k_t - \hat{k}_{t-1}) \tag{4}$$

where k_t is the original PIT capital series and $\hat{k}_t$ is the adjusted series, and ϕ is a positive parameter. As in the case of parameter α, we propose as criterion for the choice of ϕ to minimise the RMSD of the adjusted series with respect to the HP trend, which gives $\phi = 0.306$.

Figure 7 shows the autoregressive adjustment of the PIT capital requirements for the optimally chosen value of ϕ, together with the HP trend. As expected, this adjustment follows the original series with a lag. The results in Repullo and Suárez (2009) suggest that this is a significant shortcoming, especially in downturns, when capital requirements should be brought down in order to reduce the likelihood of a credit crunch. Another disadvantage of the autoregressive adjustment, noted by Gordy and Howells (2006), p. 415, is that "it 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."

Comparing the different smoothing procedures

In line with the proposed HP benchmark, we compare the different smoothing procedures by computing the root mean square deviations (RMSD) of the adjusted series with respect to the HP trend. Table 1 shows the results, together with the estimated values of parameters α and ϕ . It also shows a performance indicator given by the percentage reduction in the RMSD of the original series with respect to the HP trend that is achieved by each procedure (so the indicator would be 100% if the adjusted series coincided with the HP trend). Two procedures are clearly dominated according to this criterion, namely adjusting the output of the Basel II formula with a credit growth multiplier and with a stock market returns multiplier. The other three procedures are very similar in terms of RMSD. We have argued that there are good reasons to discard the autoregressive adjustment, so the final choice is between smoothing the input of the Basel II formula with TTC PDs and smoothing the output with a GDP growth multiplier. The discussion of the pros and cons of these two procedures is contained in the next section

It is interesting to note in Figure 5 the early tightening in the last years of the sample of the series adjusted with the credit growth multiplier. For this reason, we also tried a multiplier that used as inputs both GDP growth and credit growth. The results were only marginally better than those obtained with the GDP growth multiplier, with a RMSD of 0.0052 and a performance indicator of 39.6%. The disappointing result, together with the additional complexity involved, led us to discard this procedure.

Table 1. Root mean square deviations from Hodrick-Prescott trend for different adjustment procedures

Type of adjustment	α or ϕ	RMSD	Performance
TTC PDs	–	0.0055	35.6%
GDP growth	0.0810	0.0054	37.6%
Credit growth	0.0745	0.0066	23.5%
Stock market return	0.0382	0.0081	5.3%
Autoregressive	0.3062	0.0054	36.9%

Notes: This table compares the performance in terms of root mean square deviations (RMSD) from the Hodrick-Prescott (HP) trend of the following adjustment procedures: Through-the-cycle (TTC) PDs, multipliers based on GDP growth, credit growth, and stock market returns, and autoregressive adjustment. It also shows the relative performance of each procedure, measured by the reduction in the RMSD of the original series with respect to the HP trend, and the value of parameter α for the multipliers based on GDP growth, credit growth and stock market return, and of parameter ϕ for the autoregressive adjustment.

Source: Authors' calculations.

Given the functional form (3) of the multiplier μ_t, the value α (GDP) = 0.081 implies that capital requirements should be increased in expansions and reduced in recessions by approximately 6.5% (since $\mu_t = 2N\,(0.081) = 1.065$) for each standard deviation in GDP growth. The relatively low value of α (GDP) also implies that multiplier is almost linear for reasonable values of GDP growth. In particular, we have $\mu_t = 1.13$ for two standard deviations and $\mu_t = 1.19$ for three standard deviations in GDP growth. This is a convenient property that allows to easily translate changes in the business cycle indicator into capital surcharges.

It is important to note that during the second half of 1989 and the entire 1990 there were binding credit growth limits in Spain. Those limits were an extraordinary measure to complement conventional monetary policy tools during a period in which inflation was hard to control. In order to avoid any potential bias in our results against the credit growth multiplier, we have rerun the whole exercise from 1991 onwards. RMSDs show almost no change. GDP growth is still better than credit growth, although now the TTC PDs adjustment is slightly better than the GDP growth adjustment.

It should be noted that the methodology presented in this paper may be used to assess other proposals to mitigate the pro-cyclicality of Basel II. For instance, it could be argued that one should focus on proxies for the business cycle that are more closely related to banks' business activity, such as loan losses or profitability. However, in both cases the results are disappointing. The RMSD corresponding to a multiplier based on the ratio of loan loss provisions to total loans is 0.0077,[18] while the RMSD corresponding to the multipliers based on ROA (return on assets) and ROE (return on equity) are 0.0075 and 0.0070, respectively, which are much higher than the figures in Table 1 for the GDP growth multiplier.[19]

Recently, macro-variables such as the ratio of credit to GDP have been proposed as a possible indicator to deal with the pro-cyclicality of capital requirements [see, for example, Borio and Drehmann (2009), and Committee of the Global Financial System (2010)]. The idea behind the use of this ratio is that increases in the value of the credit to GDP ratio are associated with higher leverage levels in the economy and could also imply lowering lending standards and thus higher credit risk. As the risk increases during rapid credit growth episodes (relative to the expansion of the economic activity), so should capital requirements. Jiménez and Saurina (2006) provide robust empirical evidence for the Spanish banking system of a close relationship between credit expansion and risk taking by banks. However, we are not convinced that the ratio of credit to GDP is the best variable to carry out the adjustment of the pro-cyclicality of capital requirements. First, this ratio is a variable thatnormally shows an increasing trend along time. In particular, in bad times the reduction in GDP will continue pressing the ratio upwards providing the wrong signal in terms of the required adjustment. Second, the performance of a multiplier based on the credit to GDP ratio is even worse than the multiplier based on the stock market return, with a RMSD of 0.0085.

Finally, some people have argued that the adjustment could be done using forward-looking credit market variables such as credit default swaps (CDS) indices or corporate bond spreads [see, for example, Gordy and Howells (2006)]. However, it is not possible to find such variables for the Spanish market during the whole period under analysis. Even in the last few years, there is only a small number of Spanish non-financial companies for which CDS are traded, and there is not much information about the liquidity of those contracts (to figure out how reliable prices could be). A similar remark applies to corporate bond spreads.

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18. We are using specific loan loss provisions, that is, provisions that cover individually identified losses.

19. At any rate, we would be rather sceptical about making regulation contingent on a variable that may be easily manipulated by the regulated. See Beatty, Chamberlain and Magliolo (1995), Ahmed, Takeda and Thomas (1999), and Pérez, Salas-Fumás and Saurina (2008), among many others.

5 Discussion

What is the best procedure?

Our previous results show that the best procedures for mitigating the pro-cyclicality of the Basel II capital requirements are either to adjust the input of the Basel II formula using through-the-cycle (TTC) PDs or to adjust the output with a multiplier based on GDP growth.

The use of TTC PDs has been criticized by Gordy and Howells (2006), pp. 414-415, on the grounds that "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." They also point out that "through-the-cycle ratings are less sensitive to market conditions than point-in-time ones, (so) they are less useful for active portfolio management and as inputs to ratings-based pricing models." Finally, they add (p. 406) that "despite the ubiquity of the term 'trough-the-cycle' in descriptions of rating methods, there seems to be no consensus on precisely what is meant."

As noted in Financial Services Authority (2009), p. 89, adjusting PDs so that they reflect "an average experience across the cycle" involves a very significant challenge, since it requires "the ability to differentiate changes in default experience that are due entirely to the economic cycle from those that are due to a changing level of non-cyclical risk in the portfolio." As a result, they observe that "in general firms have not developed TTC ratings systems whose technical challenges are typically greater than those of PIT approaches." The UK Financial Services Authority has been working with the industry to develop a so-called "quasi-TTC" rating approach, based on adjusting the PIT PDs by a cyclical scaling factor. However, calibrating such factor seems a difficult task. From this perspective, doing the scaling with the output of the Basel II formula, along the lines that we have proposed above, seems much easier.

The difficulty in making precise the notion of TTC ratings implies that this adjustment procedure would be implemented very differently across banks in a single jurisdiction, and especially across banks in different jurisdictions, so level-playing field issues are likely to emerge. These issues would be particularly difficult to resolve because of the lack of transparency of the procedure. From this perspective, it also seems better do the adjustment with a single (and fully transparent) macro multiplier.

Finally, it has been argued that using one-year-ahead PDs is not appropriate for loans with longer maturities, and that for this reason a TTC procedure would be more appropriate. The reply to this objection is three-fold. First, the share of long term loans in non-mortgage portfolios is relatively small.[20] Second, even for longer-term loans, a correct assessment of their risk should be done conditional on the state of the economy, not in an unconditional manner. Doing the latter, which is in the spirit of TTC ratings, contradicts the Basel II requirement of using "all relevant and material information in assigning ratings" [BCBS (2006), par. 426]. Third, one should remember that the Basel II formula incorporates a maturity adjustment factor that is supposed to take care of possible downgrades during the life of the loan.

The distinction between conditional and unconditional assessments of risk deserves a further discussion. To make it more precise, consider an economy with two aggregate states, expansion (denoted by *h)* and recession (denoted by *l).* Let p_h and p_l denote the representative

20. For example, the proportion of loans in our sample with an initial maturity over one year is only 28%.

PDs in the two states, with $p_h < p_l$, and let q_{ij} denote the transition probability from state i to state j. From the transition probabilities one can derive the unconditional probabilities, q_h and q_l, of being in each state, which gives the unconditional probability of default $\overline{p} = q_h p_h + q_l p_l$. Now suppose that the economy is in an expansion state, and that we want to price a one-year loan. Clearly we should use the PIT p_h rather than the TTC $\overline{p}$. Similarly, for a two-year loan we should use p_h for the first year, and (if the loan does not default during the first year) $q_{hh}p_h + q_{hl}p_l$ for the second year. If q_{hh} is sufficiently high, i.e. if expansions have a long duration, then this PD will be close to p_h, so using the (conditional on the state) one-year-ahead PD would be approximately correct for pricing purposes. And so on for longer maturity loans. The conclusion is that cyclically adjusting the PDs produces a distortion in the correct measurement of risk that makes them inadequate for risk pricing and risk management purposes.

This is especially relevant in the light of the requirements on the use of internal ratings specified by the BCBS (2006), par. 444: "Internal ratings and default and loss estimates must play an essential role in the credit approval, risk management, internal capital allocations, and corporate governance functions of banks using the IRB approach."

The preceding arguments suggest that adjusting the input of the IRB formula by using through-the-cycle (TTC) PDs has many shortcomings. The alternative procedure, to adjust the output with a multiplier based on GDP growth, is much better in terms of simplicity, transparency, low cost of implementation, consistency with banks' risk pricing and risk management systems, and even consistency with the idea of a single aggregate risk factor that underlies the capital requirements of Basel II [see Gordy (2003)].

Alternative forms of the multiplier

The proposed multiplier could be adjusted in several ways. For example, the range of μ_t in (2) goes from 0 (when $g_t \to -\infty$) to 2 (when $g_t \to \infty$), but one could easily introduce alternative lower and an upper bounds so that $1-\Delta \leq \mu_t \leq 1+\Delta$. Alternatively, the multiplier could be redefined so that $\overline{g} = g_{\min}$ where $g_{\min}$ is the lowest value of GDP growth in the sample. In this way, it would be possible to generate a positive buffer of regulatory capital, so minimum capital requirements would be cyclically adjusted but would never be below the level specified by the Basel II formulas with PIT PDs.

Application to international banks

The procedure of adjusting the Basel II capital requirements with a multiplier based on GDP growth would be applied in each national jurisdiction, possibly with different multipliers for different portfolios, and only for banks that are under the IRB approach of Basel II, on the grounds that the standardised approach is only minimally risk-sensitive. The procedure is very simple, since it only requires a readily available macroeconomic variable such as the rate of growth of the GDP, and very transparent, since it would be possible to ask the banks to report the unadjusted capital requirements (and the corresponding risk-weighted assets). It would of course imply to have different capital requirements for different jurisdictions, but this is an inevitable feature of any procedure designed to correct the effect of the business cycle on risk-sensitive capital requirements. It should also be noted that with the increasing correlation in international business cycles these differences should not be very significant.

The procedure would involve some complexity in its application to international banks, especially those that have significant cross-border lending activities. To limit the possibility of regulatory arbitrage, which could lead to a concentration of lending from the jurisdiction with the lowest multiplier, some general criterion should be establish. A possible approach would be to base the calculation of capital requirements on the geographic location of the credit exposures.

The final requirement would be computed by adding all the adjustments in the jurisdictions in which the bank has a significant exposure. As commented above, the methodology is very simple and transparent and the required data are easily accessible in all countries.

GDP revisions

One relevant issue about the cyclical adjustment of capital requirements using a multiplier based on GDP growth is the fact that in many countries GDP statistics are usually revised, sometimes by significant amounts. The revisions are obviously more important for the quarter-on-quarter data, rather than the year-on-year data, so we would favour using the latter. We would also favour using the latest data corresponding to the second to last quarter, without making any subsequent adjustments in the multiplier. For example, in the US the Bureau of Economic Analysis (BEA) releases three quarterly GDP reports: the advance report that comes out within one month after the end of the quarter, the second report (formerly called the preliminary report) that comes out within two months after the end of the quarter, and the third report (formerly called the final report) that comes out within three months after the end of the quarter. Thus for the US we could use the final data for second to last quarter (for example, the end-of-2009 multiplier could have been set with the third quarter data released on December 22), so the problem of revisions would not arise. Even when this is not the case, leaving unchanged the multiplier after revisions in GDP data should not generate significant deviations with respect to its final "correct" value. For example, for α (GDP) = 0.081 a revision amounting to 0.25 standard deviations of GDP growth would have a maximum impact on the multiplier of 1.6% (since $2N(0.081/4) = 1.016$).

How would banks react to the adjustment?

The potential pro-cyclical effects of bank capital regulation depend not only on the design of the minimum capital requirements but also on the endogenous response of banks to the regulation, in terms of the characteristics of their portfolio and the incentives to hold capital above the minimum required by regulation. Repullo and Suárez (2009) analyse the effect on capital buffers of modifying the cyclical profile of the 99.9% confidence level of Basel II, and hence the corresponding capital requirements, so that they are lower in recessions and higher in expansions. The results show that this policy changes the cyclical behaviour of the capital buffers in a direction that partly offsets its intended effect (reducing them in expansions and increasing them in recessions), but the net effect is a significant reduction in the pro-cyclicality of the regulation.

Contingent capital: Is it an alternative?

Contingent capital has recently emerged in policy discussions as an instrument that could be useful to deal with the pro-cyclicality problem.[21] Contingent capital is a debt instrument with the potential of converting into common equity during periods of financial strain. This property effectively helps banks to weather recession periods without having to resort to issuing equity in unfavourable conditions. At the same time, it could be a cost-effective way for banks to reduce their capital holdings, and hence its costs, in normal times. From a regulatory perspective there are two problems with using contingent capital as part of the regulatory framework. First, a number of important design issues should be resolved, especially in connection with the trigger points for conversion.[22] Second, there is the view that the new capital regulation should focus on core capital, playing down the role of hybrid securities such as subordinated debt.[23] The

21. See, for example, Kashyap *et al.* (2008) and Flannery (2009).

22. As noted recently by Sundaresan and Wang (2010), the proposal for banks to issue contingent capital that is forced to convert into common equity when stock prices fall below a certain specified low threshold does not in general lead to a unique equilibrium, which opens the door to price manipulation.

23. See, for example, Basel Committee on Banking Supervision (2009).

proposal of strengthening the current definition of capital could be blurred if a new hybrid instrument is brought into the picture. However, contingent capital could be useful as an instrument outside of the regulatory framework for banks to manage their capital over the business cycle. Design issues would be addressed by private contracting, and regulators would be able to focus on core capital. Obviously, the availability of such instrument would alter banks' incentives to hold capital buffers, but this would not probably change the amplification effects of risk-sensitive capital regulation à la Basel II. This is an interesting topic that should be pursued in future work.

6 Extensions

Adjustments using individual bank data

The results obtained in Section 4 are based on an adjustment calibrated for the entire banking system, but they would be applied to individual banks. Therefore it is important to check the performance of the different procedures with individual bank data. In addition, this extension allows us to assess the performance of adjustments based on disaggregated data such as the credit growth of each bank.

In particular, we have chosen five Spanish banks that have opted for the IRB approach of Basel II, and that are currently calculating their minimum capital requirements using the IRB formulas. We compute the point-in-time (PIT) capital requirements per unit of exposure for each of these five banks and for each year of the sample using the estimated PDs, a loss given default (LGD) of 45%, and a 1 year maturity.

The results show that there is significant heterogeneity across our sample of five banks, despite the fact that they all operate at the national level (i.e., there are no regional banks). The average value over the sample period of their Basel II capital requirements ranges from 4.5% to 8.2%, and the range of variation from peak to trough is between two and three times higher than the 57% figure obtained for the aggregate data. The significant heterogeneity among these banks makes the comparison of the different adjustment procedures much more interesting.

The analysis is carried out with the PIT capital requirements series data of the five selected banks plus a sixth fictitious bank that comprises all the other banks in the system. To provide a benchmark for the comparison of the different procedures, we compute for each of these six banks the HP trend of each capital requirements series.

Following the steps in Section 4, we first consider adjusting the PD input of the Basel II formula by using through-the-cycle (TTC) PDs estimated by replacing in the regression model the current values of the macroeconomic controls by their average values over the sample period. In this way we get the TTC capital requirements for each of the six banks. Second, we apply to the PIT series of each bank the business cycle multiplier (3), where the value of parameter α (for each proxy for the business cycle) is chosen to minimise the sum for the six banks of the root mean square deviations (RMSD) of the adjusted series with respect to the HP trends.[24] As proxies for the business cycle, we use the rate of growth of the GDP, the rate of growth of the credit of each bank, and the return of the stock market. Finally, we also compute for each bank the autoregressive adjustment (4), where the value of parameter ϕ is chosen to minimise the sum for the six banks of the RMSDs of the adjusted series with respect to the HP trends.

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24. Although parameter α could be estimated for each bank, we restrict attention to multipliers that have the same α for all banks within a jurisdiction.

Table 2. **Root mean square deviations from Hodrick-Prescott trend for different adjustment procedures using individual bank data**

Type of adjustment	α or ϕ	RMSD	Performance
TTC PDs		0.0048	52.0%
GDP growth	0.1237	0.0066	33.8%
Individual credit growth	0.0796	0.0091	9.2%
Stock market return	0.0239	0.0098	1.8%
Autoregressive	0.3654	0.0070	29.6%

Notes: This table compares the performance of the adjustment procedures in terms of the sum for six banks (five banks that have opted for the IRB approach of Basel II plus a sixth fictitious bank which is the aggregate of all the other banks in the system) of the root mean square deviations (RMSD) from the Hodrick-Prescott (HP) trend of each bank's series. It also shows the relative performance of each procedure, measured by the reduction in the sum of RMSDs of the original series with respect to their HP trends, and the value of parameter α for the multipliers based on GDP growth, individual credit growth and stock market return, and of parameter ϕ for the autoregressive adjustment.

Source: Authors' calculations.

In line with this approach, we compare the different procedures in terms of the sum for the six banks of the RMSDs of the adjusted series with respect to their HP trends. Table 2 shows the results, together with the estimated values of parameters α and ϕ. It also shows a performance indicator given by the percentage reduction in the sum of RMSDs of the original series with respect to the HP trends that is achieved by each procedure (so the indicator would be 100% if all adjusted series coincided with their HP trends). The best procedure is now to adjust the input of the Basel II formula with TTC PDs, with the procedure based on a GDP growth multiplier coming second, and the autoregressive procedure coming third. The other two procedures are clearly dominated, including the one based on individual credit growth. In fact, comparing Tables 1 and 2 we conclude that the relative performance of the credit growth multiplier worsens when moving from aggregate to disaggregated data. Thus, our results raise doubts about the proposal of Goodhart and Persaud (2008) to adjust Basel II capital requirements "by a ratio linked to the growth of the value of bank assets, bank by bank." The values of parameters α and ϕ in Table 2 are broadly in line with those in Table 1, although interestingly α (GDP) jumps from 0.081 to 0.124. This implies an increase in the corresponding multiplier from 6.5% to 9.8% (since $2N(0.124)=1.098)$ for each standard deviation in GDP growth.

The superiority of the TTC PDs procedure may be explained by the fact that it approaches more closely the characteristics of the portfolio of each bank, instead of using a common adjustment for all banks. However, despite its better statistical performance, we believe that the arguments in Section 5 are sufficiently strong to favour using the multiplier based on GDP growth.

To the extent that GDP data could be available at the (domestic) regional level, it would be possible to compute regional multipliers, with a treatment of national banks similar to that proposed for international banks in Section 4. However, we would not favour this approach because the high correlation in regional business cycles does not justify the additional complexity that would be introduced in the regulation of bank capital.

Cyclically-varying LGDs

We have assumed so far a constant LGD fixed at the 45% level specified in the foundation IRB approach of Basel II. However, banks in the advanced IRB approach must input their estimated LGDs, which clearly vary over the business cycle (they are typically higher in recessions when asset prices are depressed than in expansions).[25] This means that for those banks there is further cyclicality of the PIT capital requirements.

A problem to assess the impact of cyclically-varying LGDs on the procedures to smooth the Basel II capital requirements is that we do not have data on the LGDs of the loans in our sample. For this reason, in what follows we simply postulate a linear relationship between LGD_t and PD_t with the same slope as in Altman *et al.* (2005) and with an intercept such that when the PD is at its average level over the sample period then the LGD equals the reference value of 45%,[26] that is:

$$\text{LGD}_t = 0.45 + 2.61(\text{PD}_t - \overline{\text{PD}}) \tag{5}$$

where PD_t is the weighted average PD in year *t* (with weights equal to the borrowers' exposures), and $\overline{\text{PD}}$ is the average of PD_t over the sample period. Figure 8 represents the values of weighted average PDs and cyclically varying LGDs. The fluctuation in LGDs ranges between 40% and 55%.

Figure 9 shows PIT capital requirements when LGDs vary over time in this manner and PIT capital requirements calculated using a fixed 45% LGD. The cyclicality of capital requirements increases significantly. From peak to trough, they range from almost 7% to more than 14%, which is twice the variation that we had before.

With this data we proceed to perform the same analysis as in Section 4, comparing the different procedures by computing the root mean square deviations (RMSD) of the adjusted series with respect to the HP trend. The results in Table 3 show that the best procedures are either to smooth the input of the Basel II formula with TTC PDs (and a constant 45% LGD) or to smooth the output with a GDP growth multiplier. The performance of the autoregressive adjustment worsens relative to the case with a fixed 45% LGD, while as before the other two procedures are clearly dominated.

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25. For example, Altman *et al.* (2005) show that that there is a positive relationship between PDs and LGDs. In particular, they regress average bond recovery rates (1 – LGD) on average bond default rates (PD), obtaining a slope coefficient of –2.61.

26. There is not much justification in the literature for this assumption. Araten, Jacobs and Varshney (2004) estimate LGDs in the interval between 39.8% and 50.5%, while Gupton (2000) estimates LGDs between 30.5% and 47.9%. Frye (2000) finds similar results for senior secured corporate loans. Data collected during the calibration processes leading to Basel II (Quantitative Impact Studies or QIS exercises) do not settle the question because those exercises were carried out under benign economic conditions. Thus it is not unreasonable to take the 45% benchmark set by the Basel Committee for the IRB foundation approach.

Table 3. Root mean square deviations from Hodrick-Prescott trend for different adjustment procedures using cyclically-varying LGDs

Type of adjustment	α or ϕ	RMSD	Performance
TTC PDs		0.0086	42.7%
GDP growth	0.1330	0.0084	43.8%
Credit growth	0.1329	0.0108	27.8%
Stock market return	0.0489	0.0146	2.6%
Autoregressive	0.2984	0.0095	37.0%

Notes: This table compares the performance in terms of root mean square deviations (RMSD) from the Hodrick-Prescott (HP) trend of the adjustment procedures when LGDs are a linear function of weighted average PDs according to equation (5) in the text. It also shows the relative performance of each procedure, measured by the reduction in the RMSD of the original series with respect to the HP trend, and the value of parameter α for the multipliers based on GDP growth, credit growth and stock market return, and of parameter ϕ for the autoregressive adjustment.

Source: Authors' calculations.

Thus, the introduction of cyclically-varying LGDs does not affect the relative performance of the different procedures to adjust the Basel II capital requirements. However the value of the multipliers is higher. In particular, the jump in the value of α (GDP) from 0.081 to 0.133 implies an increase in the corresponding multiplier from 6.5% to 10.6% (since $2N(0.133)=1.106)$ for each standard deviation in GDP growth.

Obviously, these results should be taken with care, since they are based on the ad hoc linear relationship between LGDs and PDs postulated in (5). On the other hand, there is an additional factor that increases the sensitivity of PIT capital requirements to the business cycle, namely that exposures at default (EADs) also move in parallel with PDs [see, for example, the evidence in Jiménez, López and Saurina (2009b)]. It is not easy to simulate the impact of EADs on capital requirements, so we will not pursue this here. But the fact that EADs vary over the business cycle makes the proposed cyclical adjustment of capital requirements even more compelling.

A flat benchmark

It could be argued that our results might depend on the filtering procedure used. Although the HP filter is the standard procedure used by macroeconomists to separate cycle from trend, to check the robustness of our results we tried an alternative benchmark, namely a constant requirement at the average level of the estimated PIT capital requirements over the sample period, which is 9.37%. We then perform the same analysis as in Section 4 with a flat benchmark replacing the HP trend.[27]

For this benchmark the best adjustment is obtained with the autoregressive procedure, because starting at the 9.37% level and setting the autoregressive parameter ϕ equal to zero we get a zero RMSD. However, risk-sensitivity is completely eliminated by making the capital requirement equal to the flat benchmark. This is effectively throwing out the baby with the bath water, and adds to the previous drawbacks noted in Section 4.4. As for the other procedures, smoothing the input of the Basel II formula with TTC PDs dominates the adjustment based on GDP growth (RMSD = 0.0066 and 0.0074, respectively), which in turn is better than the adjustments based on credit growth and stock market returns (RMSD = 0.0085 and 0.012, respectively). The main conclusion from this exercise is that the performance of the different

27. One way to rationalize this filter is to think of it as Basel I-type benchmark.

procedures does not seem to depend on the selected benchmark, but on their ability to smooth cyclical patterns in the original PIT capital requirements series.

Adjustment of expected losses

Regulatory capital under Basel II is set aside to cover unexpected losses, while expected losses must be covered with loan loss provisions. Assuming an LGD of 45%, our empirical model allows us to compute the expected losses for each borrower and each year of the sample. From here we may obtain an estimation of the expected losses per unit of loans for each year of the sample. Figure 10 shows expected losses and capital requirements per unit of loans over the sample period. Both series exhibit a very similar pattern, driven by the cyclical behaviour of PDs. It is also worth noting that the average level of expected losses (2%) is significantly lower than the average level of capital requirements (9%). This means that in order to mitigate the pro-cyclical effects of regulation, acting on the capital requirements front is much more important than acting on the expected losses front.

As a response to the current financial crisis, there is a growing consensus among academics and policy makers about the need to build buffers in good times that can be drawn down when conditions deteriorate.[28] One way to build up these buffers would be to implement an explicit cyclical adjustment of loan loss provisions similar to the adjustment of capital requirements discussed above. For example, a multiplier of expected losses based on GDP growth could be designed to smooth the provisioning requirements over the business cycle. Thus, during expansion phases, when expected losses are below their cyclically adjusted value, the buffer would be built up, while in recessions, when the opposite obtains, the buffer would be drawn down. This Economic Cycle Reserve [Turner Review (2009)], could be implemented by either adjusting the P&L figures (as in the case of the Spanish dynamic provisioning system[29]) or by restricting distributable profits. The choice between these two alternatives would require an agreement between prudential and accounting regulators.

28. See, for example, Brunnermeier *et al.* (2009) and the G20 Leaders' Declaration on Strengthening the Financial System of 2 April 2009.

29. Jiménez and Saurina (2006) explain the rationale for anti-cyclical or dynamic provisions. Such provisions were introduced in Spain in 2000, and were adjusted in 2005 when the International Financial Reporting Standards (IFRS) came into effect.

7 Conclusion

This paper provides clear evidence that Basel II capital requirements based on point-in-time (PIT) probabilities of default (PDs) move significantly along the business cycle. According to our results, from peak to trough capital requirements for loans to firms may vary by more than 50%, a figure that could reach 100% with cyclically-varying losses given default (LGDs). This variation in capital requirements could lead to a significant amplification of business cycle fluctuations. Therefore, a very important question that is in the front line of current discussions among policy makers is: How should the pro-cyclical effects of risk-sensitive bank capital regulation à la Basel II be mitigated? To the best of our knowledge this is the first paper that presents a framework to address this issue.

We propose a benchmark for comparing different procedures and apply it to the adjustment of the estimated Basel II capital requirements for commercial and industrial loans in Spain over the period 1987-2008. The comparison is based on the minimization of the root mean square deviations of each adjusted series with respect to the trend of the original series computed by applying the Hodrick-Prescott (HP) filter.

The results show that adjusting the output of the Basel II formula with a credit growth multiplier (based on aggregate or individual bank data) or with a stock market return multiplier is suboptimal, as it is also the case when the multiplier is based on profits (e.g., ROA, ROE) or specific loan loss provisions. The autoregressive adjustment performs better, but we argue that its lagged response is an important shortcoming, especially in downturns. Consequently, the final choice is between smoothing the input of the Basel II formula by using through-the-cycle (TTC) PDs or smoothing the output with a multiplier based on GDP growth. Our discussion of the pros and cons of these two procedures concludes that the latter is better in terms of simplicity, transparency, low cost of implementation, and consistency with banks' risk pricing and risk management systems.

We also show that for the portfolio of commercial and industrial loans in Spain and for banks using the foundation IRB approach (with an LGD set at 45%), the multiplier would amount to a 6.5% surcharge for each standard deviation in GDP growth. The surcharge would be significantly higher for banks using cyclically-varying LGDs. Applying these results to the current crisis, where GDP growth in many countries is 3 or more standard deviations below its long-run average, would imply a reduction in capital requirements of the order of at least 20%. The analytical framework presented in the paper could also be applied to expected losses, so it can be used to calibrate economic cycle reserves or dynamic provisions.

To conclude, it is important to stress that the proposed adjustment maintains the risk-sensitivity of the Basel II capital requirements in the cross-section, so banks with riskier portfolios would bear a higher capital charge, but a cyclically-varying scaling factor would be introduced to increase capital requirements in good times and to reduce them in bad times. Such changes should contribute to reduce the incidence and magnitude of both credit bubbles and credit crunches.

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Box 1. Key features of the Basel II framework

In June 2004 the Basel Committee on Banking Supervision released the revised capital adequacy framework, commonly referred to as Basel II, with the aim of a better alignment of capital requirements to banking risks.[30] In other words, the idea was to improve on the relatively risk-insensitive framework of Basel I, by requiring higher capital charges to riskier borrowers.

Basel II adopts a three-pillar structure: Pillar 1 requires banks to maintain a minimum amount of capital for credit, market, and operational risks. It sets out the quantitative and qualitative requirements and algebraic formulae to calculate capital for the different types of asset classes identified. Pillar 2, devoted to the supervisory review process, is intended to ensure that banks possess adequate capital for the full range of risks they run. In doing this, banks should develop their own risk management techniques to contribute to the overall assessment of their capital levels under the monitoring of the supervisory authorities. Pillar 3 aims to bolster market discipline to complement the other two pillars by setting out disclosure requirements applicable to banks in areas such as required capital, risk exposures, and risk assessment procedures.

Focusing on Pillar 1, and in particular on credit risk, Basel II provides a menu of approaches to calculate the minimum capital requirement according to the sophistication of a bank's activities and its internal risk management capabilities. The three approaches are:

- The standardised approach.

The foundation internal ratings-based approach.

The advanced internal ratings-based approach.

The standardised approach is based on external credit assessments, when they are available, and if they are not exposures require the same capital charge as in Basel I (8%). The main principle behind the internal ratings-based (IRB) approaches is that banks assign exposures to different asset classes and, within them, banks assign different internal rating grades according to the their credit quality (creditworthiness).[31] In particular, banks estimate, for each borrower or homogenous groups of them, a series of credit risk drivers that determine the corresponding capital charges. These drivers are:

- The one-year ahead probability of default (PD).
- The loss given default (LGD).
- The exposure at default (EAD).[32]
- The maturity (M) of the exposure.

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30. In June 2006 the Basel Committee released a final comprehensive version that included the 2004 Capital Accord, the elements of the 1988 Capital Accord that were not revised during the Basel II process, and the 1996 Amendment incorporating market risks.

31. Broadly speaking asset classes are divided into two main categories: corporate and retail exposures. Retail exposures are in turn divided into residential mortgages exposures, qualifying revolving exposures, and other retail exposures. Securitisations are treated separately.

32. For on-balance sheet items this parameter will be the amount of the exposure. For off-balance sheet items, credit conversion factors are used to obtain credit equivalent amounts.

In the advanced approach banks are required to compute all four drivers, whereas in the foundation approach they are only required to estimate the PD and rely on supervisory estimates for the others. These parameters are then plugged into a formula that gives the capital requirement corresponding to each exposure.

The Basel II formula is derived from the requirement that capital must cover losses in a particular credit risk model with a confidence level of 99.9% [see Gordy (2003), for details). For example, in the case of corporate exposures the capital requirement *k* per unit of exposure is:

$$k = LGD \times \left[N\left(\frac{N^{-1}(PD) + \sqrt{\rho}\, N^{-1}(0.999)}{\sqrt{1-\rho}} \right) - PD \right] \times \frac{1+(M-2.5)b}{1-1.5b} \times 1.06 \tag{B1}$$

where $N(\cdot)$ is the standard normal cumulative distribution function,

$$\rho = 0.12\left(\frac{1-e^{-50PD}}{1-e^{-50}} \right) + 0.24\left(1 - \frac{1-e^{-50PD}}{1-e^{-50}} \right) \tag{B2}$$

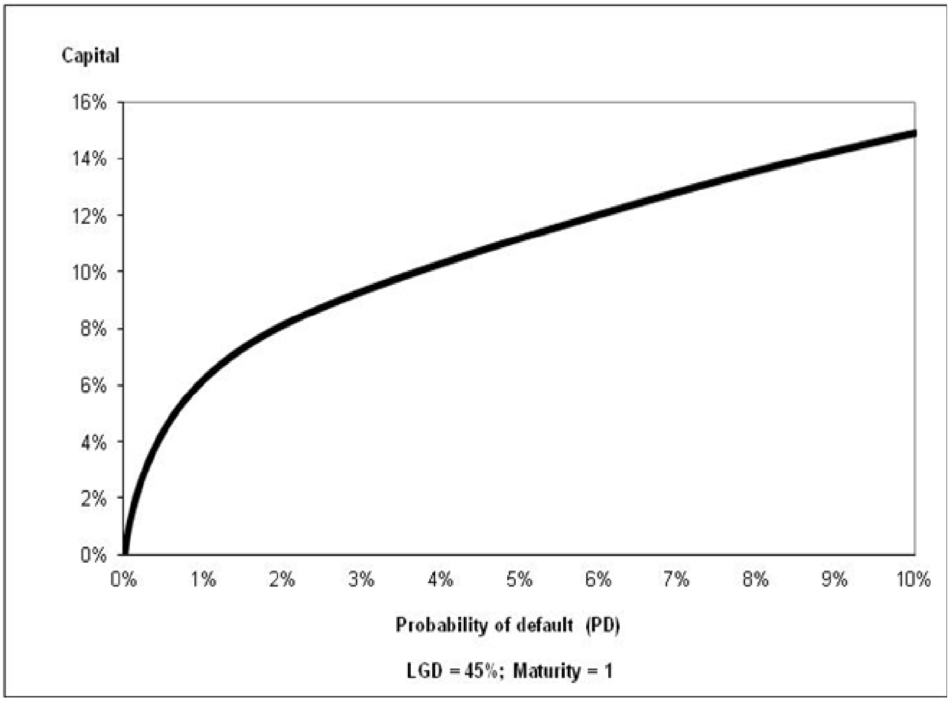
and

$$b = \left[0.11852 - 0.05478 \times \ln(PD) \right]^2 \tag{B3}$$

Thus the capital requirement is the LGD multiplied by three terms. The first one, within square brackets, is the 99.9% percentile of the distribution of the losses of a large portfolio of loans with a probability of default PD minus the expected losses (that are supposed to be covered with loan loss provisions). The second term is a maturity adjustment that is increasing in the maturity M of the loan, and equal to 1 for M = 1 year. The term ρ in the formula is a parameter intended to capture the extent of correlation in defaults in the loan portfolio. It is decreasing in PD, so riskier loans are supposed to be less correlated —in terms of the credit risk model they have higher idiosyncratic risk. The third term is a scaling factor that increases the capital requirement by 6%. This factor was computed using quantitative impact studies data to broadly maintain the aggregate level of the capital requirements.

Figure B1 plots the relationship between the capital requirement *k* and the PD, for LGD = 45% and M = 1. The function is increasing (for the relevant range) and concave in PD, so increases in the probability of default translate into less than proportional increases in the capital requirement.

Figure B1. The Basel II capital charge curve for corporate exposures



This figure shows the Basel II capital requirement for corporate exposures as a function of the probability of default (PD) assuming a loss given default (LGD) of 45%, and a maturity M = 1 year.

Source: Authors' calculations

Appendix A: Empirical results

Table A1. Estimation results

Dependent variable (0/1): Borrowers' default in $t + 1$	Coefficient*	S.E.
Borrower variables (*t*)		
COLLATERAL	0.169	0.017
MATURITY	-0.251	0.016
AGE dummy 2	0.868	0.023
AGE dummy 3	0.756	0.024
AGE dummy 4	-0.100	0.023
FIRM_SIZE	-0.254	0.005
NUMBER_BANKS	0.488	0.013
MAIN_LENDER_CHANGE	0.660	0.029
UTILIZATION	2.655	0.034
HISTORIC_DELINQUENCY	2.133	0.024
HISTORIC_DEFAULT	2.858	0.058
Macro variables (*t*)		
GDP_GROWTH	-0.148	0.005
CREDIT_GROWTH	-1.596	0.087
STOCK_MARKET_RETURN	-0.248	0.023
Control_Variables (*t*)		
Regional_dummies	Yes	
Industry_dummies	Yes	
Constant	-4.829	0.046
Number of observations	996,885	
Sample period (annual)	1987-2008	
Pseudo R2	10.28%	
Log pseudolikelihood	- 145,548.960	
LR chi2(47)	33,349.380	
Prob > chi2	0.000	

Notes: This table reports the estimation of the logistic model of firms' default. The dependent variable takes value 1 if borrower *i* defaults in year $t + 1$, and zero otherwise. $COLLATERAL_{it}$ represents average (weighted by the size of exposures) of the proportion of guarantees in a firm's borrowing. $MATURITY_{it}$ represents the proportion of long-term exposures (more than one year) over total exposures. AGE_{it} accounts for the number of years a borrower has been reporting to the Credit Register. $FIRM\_SIZE_{it}$ is the log of a firm's borrowing deflated by the consumer price index. $NUMBER\_BANKS_{it}$ is the number of banks with which a firm has lending relationships. $MAIN\_LENDER\_CHANGE_{it}$ indicates the frequency with which firms change the bank which provides them with the largest amount of funding. $UTILIZATION_{it}$ is the ratio between the amount of credit drawn by a borrower and the total available amount (credit line). $HISTORIC\_DELINQUENCY_{it}$ is the number of years in which a firm has been delinquent divided by the number of years it has been reporting to the Credit Register. $HISTORIC\_DEFAULT_{it}$ is the number of years in which a firm has been in default divided by the number of years it has been reporting to the Credit Register. GDP_GROWTH_t is the rate of growth of the gross domestic product, $CREDIT\_GROWTH_t$ is the rate of growth of the commercial and industrial loans in the Credit Register, and $STOCK\_MARKET\_RETURN_t$ is the rate of change of the Spanish stock market index.

*All coefficients are statistically significant at the 99% level.

Source: Authors' calculations.

Table A2. Model performance

Classification Power	Classification Table In-sample model		Classification Table Out-of-sample model	
	Predicted Defaults	Predicted Non-Defaults	Predicted Defaults	Predicted Non-Defaults
Observed defaults	68.01%	30.27%	68.05%	29.54%
Observed non-defaults	31.99%	69.73%	31.95%	70.46%
	Area under ROC curve = 0.76 Accuracy ratio = 52%		Area under ROC curve = 0.76 Accuracy ratio = 52%	

Notes: This table reports the performance of the estimated logit model for an in-sample (a random 10% of the population) and an out-of-sample set of observations (another random 10% of the population) in terms of observed and predicted defaults, areas under the Receiver Operating Characteristic (ROC) curve, and Accuracy Ratios (AR).[33]

Source: Authors' calculations.

33. The AR measure determines the performance enhancement over the random model. For references on these performance statistics see, for example, Sobehart, Keenan and Stein (2000), Sobehart and Keenan (2001), and Engelmann, Hayden and Tasche (2003).

Figures

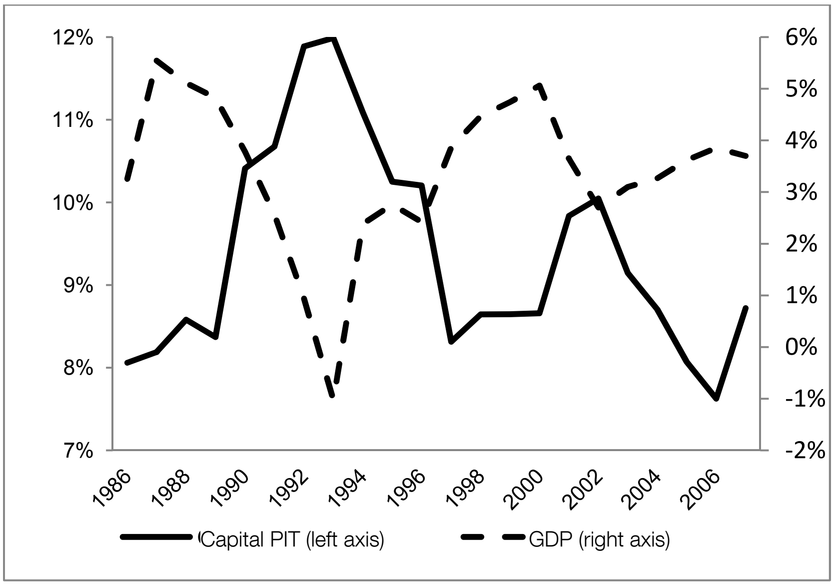


Figure 1. PIT capital requirements and GDP growth

Notes: This figure shows the aggregate point-in-time (PIT) Basel II capital requirements per unit of loans for the portfolio of commercial and industrial loans of Spanish banks, together with the Spanish GDP growth rate.

Source: Authors' calculations (capital), Instituto Nacional Estadística, INE, (GDP growth).

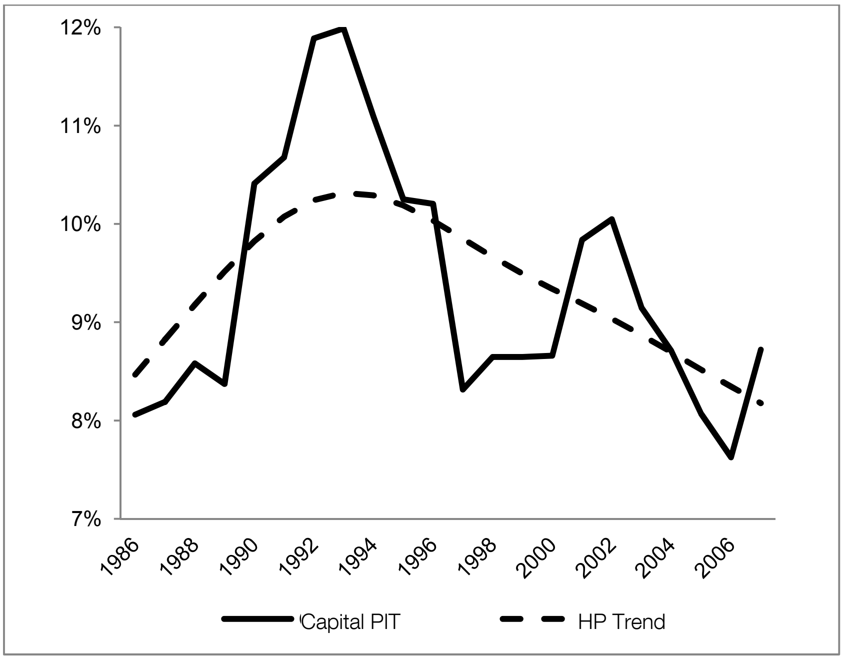


Figure 2. PIT capital requirements and HP trend

Notes: This figure shows the aggregate point-in-time (PIT) Basel II capital requirements per unit of loans for the portfolio of commercial and industrial loans of Spanish banks, together with the Hodrick-Prescott (HP) trend.

Source: Authors' calculations.

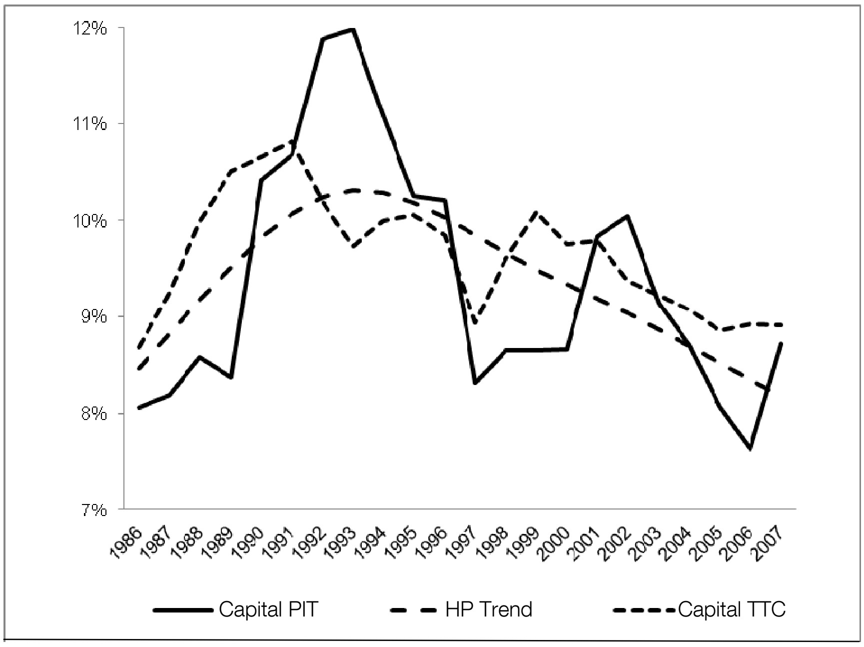


Figure 3. PIT and TTC capital requirements and HP trend

Notes: This figure shows the aggregate point-in-time (PIT) and through-the-cycle (TTC) Basel II capital requirements per unit of loans for the portfolio of commercial and industrial loans of Spanish banks, together with the Hodrick-Prescott (HP) trend of the PIT series.

Source: Authors' calculations.

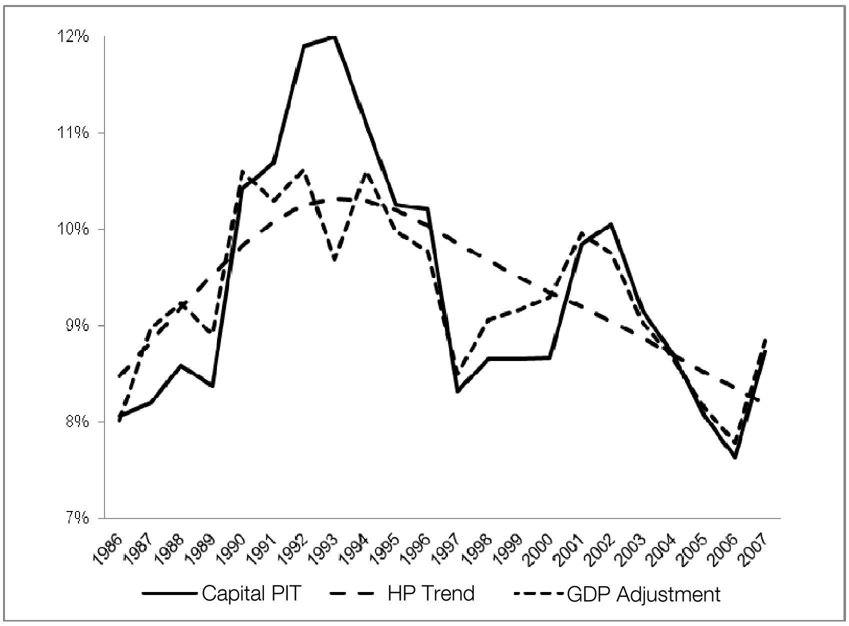


Figure 4. PIT capital requirements, GDP adjustment, and HP trend

Notes: This figure shows the aggregate point-in-time (PIT) Basel II capital requirements per unit of loans for the portfolio of commercial and industrial loans of Spanish banks, the adjustment using a multiplier based on GDP growth, and the Hodrick-Prescott (HP) trend of the PIT series.

Source: Authors' calculations.

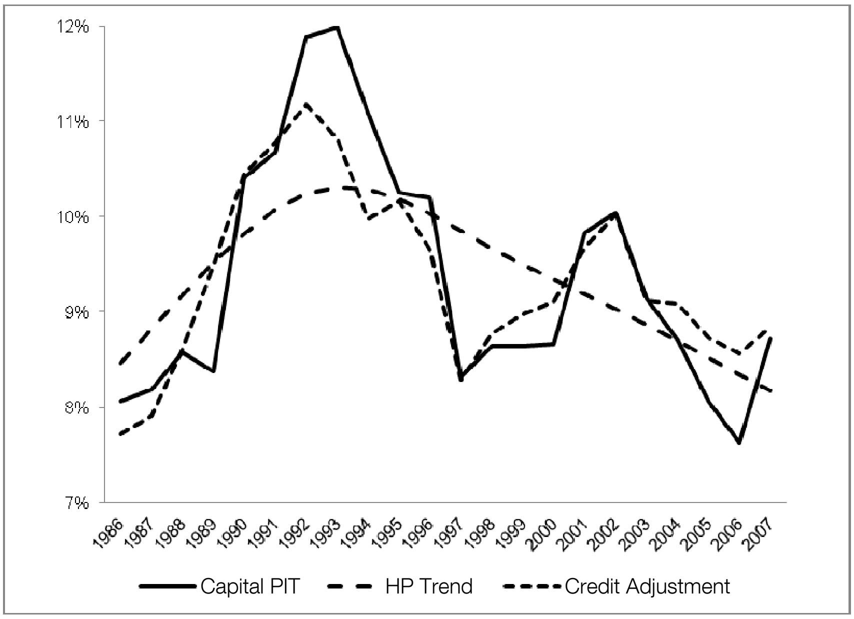


Figure 5. PIT capital requirements, credit adjustment, and HP trend

Notes: This figure shows the aggregate point-in-time (PIT) Basel II capital requirements per unit of loans for the portfolio of commercial and industrial loans of Spanish banks, the adjustment using a multiplier based on credit growth, and the Hodrick-Prescott (HP) trend of the PIT series.

Source: Authors' calculations.

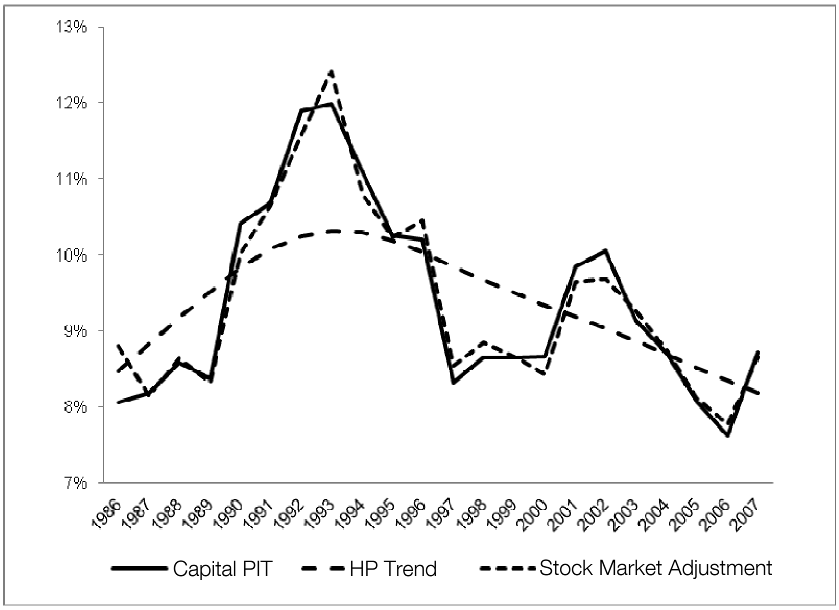


Figure 6. PIT capital requirements, stock market adjustment, and HP trend

Notes: This figure shows the aggregate point-in-time (PIT) Basel II capital requirements per unit of loans for the portfolio of commercial and industrial loans of Spanish banks, the adjustment using a multiplier based on the return of the Spanish stock market, and the Hodrick-Prescott (HP) trend of the PIT series.

Source: Authors' calculations.

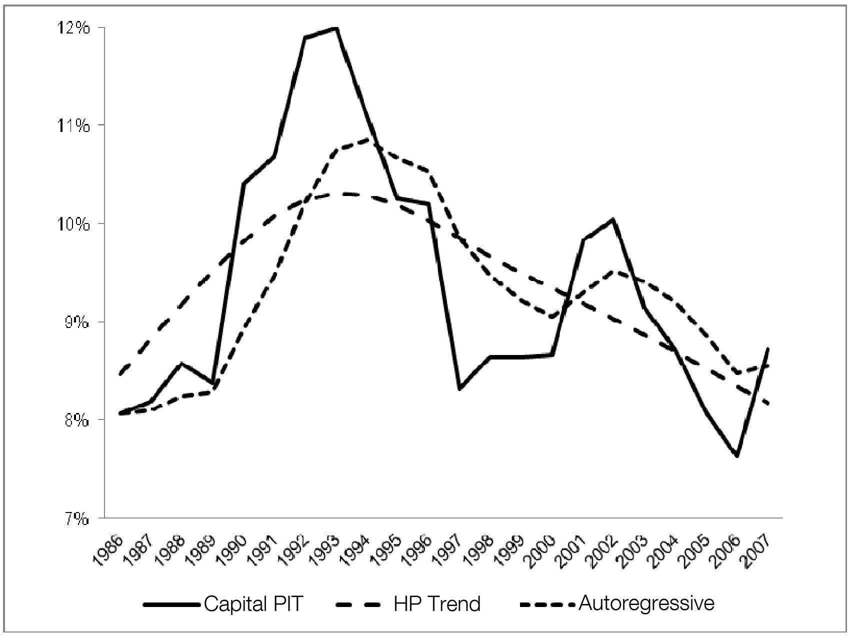


Figure 7. PIT capital requirements, autoregressive adjustment, and HP trend

Notes: This figure shows the aggregate point-in-time (PIT) Basel II capital requirements per unit of loans for the portfolio of commercial and industrial loans of Spanish banks, the autoregressive adjustment, and the Hodrick-Prescott (HP) trend of the PIT series.

Source: Authors' calculations**.**

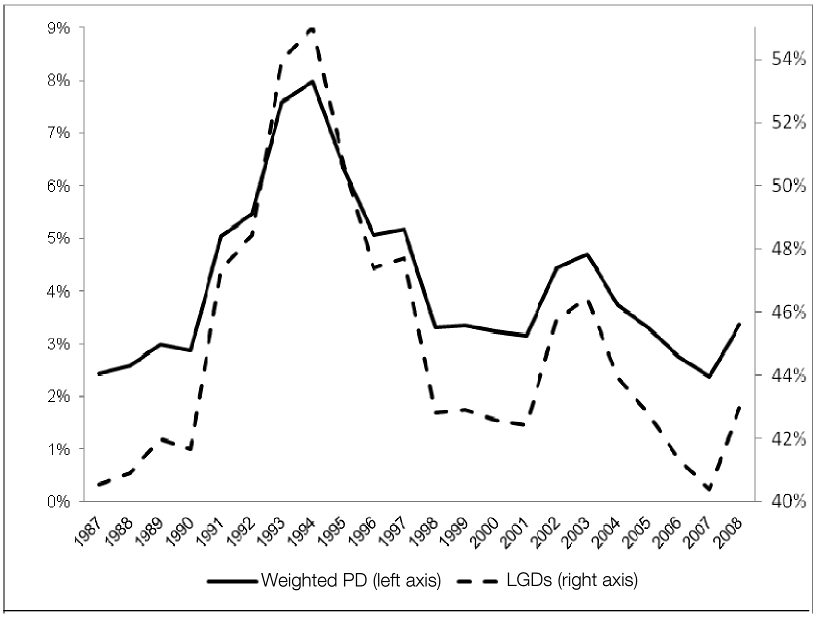


Figure 8. Weighted average PDs and cyclically-varying LGDs

Notes: This figure shows the average (weighted by the size of the exposures) probability of default (PD) for the portfolio of commercial and industrial loans of Spanish banks, and the cyclically-varying loss given default (LGD) computed by assuming that it is increasing in PD according to equation (5).

Source: Authors' calculations.

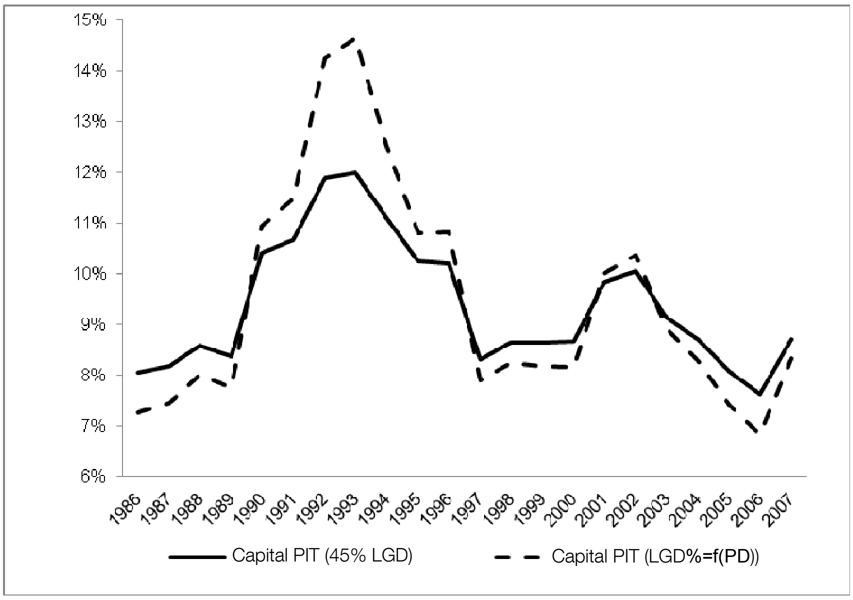


Figure 9. PIT capital requirements with and without variable LGDs

Notes: This figure shows the aggregate point-in-time (PIT) Basel II capital requirements per unit of loans for the portfolio of commercial and industrial loans of Spanish banks using a 45% loss given default (LGD) and a cyclically-varying LGD.

Source: Authors' calculations

Figure 10. PIT expected and unexpected losses

Notes: This figure shows the aggregate point-in-time (PIT) Basel II capital requirements per unit of loans for the portfolio of commercial and industrial loans of Spanish banks using a 45% loss given default (LGD), and the corresponding expected losses per unit of loans computed by multiplying the LGD by the average (weighted by the size of the exposures) probability of default (PD).

Source: Authors' calculations.

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