The impact of loan loss provisioning on bank capital requirements☆,☆☆

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Abstract

This paper shows that the revised loan loss provisioning based on the International Financial Reporting Standards (IFRS) and the Generally Accepted Accounting Principles (GAAP) implies a reduction of Tier 1 capital which levies an additional burden on banks. The paper finds in a counterfactual analysis that these changes are more severe (i) during economic downturns, (ii) for credit portfolios of low quality, (iii) for banks that do not tighten capital standards during downturns, and (iv) under a more lenient definition of significant increase in credit risk (SICR) under IFRS. Hence, the provisioning rules further increase the procyclicality of bank capital requirements. Adjustments of the SICR threshold or capital buffers are suggested as ways to mitigate a regulatory pressure that may emerges due to the reduction of regulatory capital.

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1. Introduction

Loan loss provisioning has historically been based on the incurred loss model and increases following economic downturns (Laeven and Majnoni (2003) and Bikker and Metzemakers (2005)). Gunther and Moore (2003), Fonseca and González (2008) and Cummings and Durrani (2016) find that this approach has led to a non-transparent management of loss reserves and income smoothing. Hence, the International Accounting Standards Board (2014) and the Financial Accounting Standards Board (2016) decided to replace the existing standards with a more forward looking approach based on expected losses of financial instruments. The International Financial Reporting Standards 9 (IFRS 9) and Generally Accepted Accounting Principles Topic 326 (GAAP 326) thereby contribute to a more adequate recognition of economic values. The new standards are intended to ensure more transparency and less procyclicality (§ BC 16 and § BC 79 of International Accounting Standards Board (2011) and Financial Accounting Standards Board (2011)).

On the other hand, Basel's *regulatory capital requirements* under pillar I are designed to cover unexpected losses because expected losses have been recognized by loan loss provisioning and hence deducted from bank capital. The Basel Committee on Banking Supervision (2011, 2015) acknowledges that the computation of risk measures differ in the regulatory and accounting definition. Basel defines loan loss provisions as the 12-month expected losses, whereas IFRS 9 defines loan loss provisions as the 12-month expected loss for unimpaired assets and as expected losses for the entire remaining lifetime for financial instruments that have experienced a significant increase in credit risk (SICR). GAAP 326 applies the expected lifetime loss concept to all assets regardless of whether they have experienced significant changes in credit risk. Furthermore, Basel excludes macroeconomic risk factors, while IFRS 9 and GAAP 326 consider the current economic state and forecasts of future states for the instruments that have experienced a SICR.

The European Banking Authority (2016) and the European Commission (2016) expect a decrease of the Core Tier 1 capital (CET 1) ratio due to IFRS 9 and GAAP 326 and propose in accordance with the Basel Committee on Banking Supervision (2017) a transition phase of five years to lower the additional burden on banks. The Basel Committee on Banking Supervision (2016b) points to the volatility of the new provisioning approach. This paper quantifies the magnitude of Tier 1 capital changes and the cyclicality of capital.

The paper offers the following contributions. First, it shows the link between IFRS 9 and GAAP 326 loan loss provisioning and Basel bank capital regulation.[1] Second, the impact on the eligible regulatory capital of IFRS 9 and GAAP 326 is analyzed in a counterfactual analysis by studying the IFRS 9 and GAAP 326 rules for US American bonds between 1991 and 2013, it being a period in which these rules were not applied. The analysis includes different economic periods, portfolio credit qualities, SICR thresholds as well as reinvestment strategies.

The paper explores the procyclical reduction of Tier 1 capital levels due to loan loss provisioning and how institutions might mitigate the impact in dependence of several factors: (i) portfolio quality, (ii) portfolio reinvestment strategy, and (iii) SICR criterion. The paper further analyzes how regulators may assist banks in these efforts.

The remainder of the paper is organized as follows. Section 2 describes theoretical requirements of IFRS 9 as well as GAAP 326 and the regulatory handling of provisions. Section 3 provides the data description. Section 4 estimates probabilities of default (PD) and loss rates given default (LGD) and computes 12-month expected losses as well as lifetime expected losses. A formula for the lifetime expected loss is developed and requirements on the SICR criterion are discussed. Finally, Section 5 shows the impact of expected loss based loan loss provisioning on the eligible regulatory capital and discusses implications for institutions, regulators and supervisors.

2. Capital requirements and provisioning

This paper analyzes the interaction between loan loss provisioning and bank capital. Figure 1 shows that financial institutions hold loan loss provisions for expected credit

[1] We focus on institutions that use the internal ratings-based (IRB) approach. The framework for institutions using the standardized approach is different and will be revised in the future as discussed by the Basel Committee on Banking Supervision (2016b, 2017).

losses and capital for unexpected losses, i.e., the difference between the 99.9 % Value at Risk and the expected losses.

[Insert Figure 1 here]

2.1. Accounting provisions

The International Accounting Standards Board (2011) and the Financial Accounting Standards Board (2011) propose to replace the incurred loss model for loan loss provisioning by an approach that recognizes expected losses to reflect the economic value of financial instruments. Two basic accounting regimes exist: The International Financial Reporting Standards (IFRS) and the United States Generally Accepted Accounting Principles (GAAP).

The International Accounting Standards Board (2014) introduces IFRS 9 and stipulates a three-stage model that will be mandatory from 2018 on. Financial instruments generally start in Stage 1 where the required provision is based on the 12-month expected loss, i.e., "the expected credit losses that result from default events on a financial instrument that are possible within the 12 months after the reporting date" (§ 5.5.5 and p. 53 IFRS 9). If the instrument's credit risk for the remaining lifetime significantly increases since initial recognition, it will be classified in Stage 2. Section 4.3 discusses the criterion for a significant increase in credit risk (SICR). In this second stage, the provision is calculated by the lifetime expected loss that is given by the "expected credit losses that result from all possible default events over the expected life of a financial instrument" (§ 5.5.3 and p. 56 IFRS 9). If an instrument becomes credit-impaired (i.e., is in default), it will be assigned to Stage 3 where the lifetime expected loss must also be recognized (p. 191 IFRS 9). If the conditions of Stage 2 or 3 are no longer met an instrument shifts back to Stage 1.

The Financial Accounting Standards Board (2016) updates GAAP on Topic 326 (GAAP 326). Thereby, institutions are obliged from 2020 on to recognize the "current estimate of all expected credit losses" (p. 3 GAAP 326) which is consistent with the lifetime expected loss of IFRS 9 in Stage 2. The board rejected the three-stage model of IFRS 9 due to lack of clarity of the SICR criterion, concerns about different measurements of identical instruments and potential for earnings management as well as cliff effects (p. 250 GAAP 326).

2.2. Basel expected loss and capital requirements

As mentioned above, Basel assumes that provisions cover expected losses whereas the required regulatory capital covers unexpected losses. The loan loss provisioning of IFRS 9 and GAAP 326 is based on expected loss computations which differ from the expected loss amount under the Basel regulation for a number of reasons. First, the time horizon differs on which possible losses need to be considered. The Basel framework is based on a 12-month horizon (e.g., § 285 Basel II, see Basel Committee on Banking Supervision (2006)) whereas accounting standards consider the entire remaining lifetime of at least some or even all financial assets. Second, economic conditions are differently treated. § 5.5.17 of IFRS 9 and § 20-30-9 of GAAP 326 oblige institutions to account for current economic conditions. In contrast, in the Basel regulation loan loss provisions are considered to abstract from macroeconomic risk. This section analyzes the implications of a difference between expected loss based provisions and the Basel expected loss on the calculation of the eligible regulatory capital.

The required regulatory capital under pillar I is based on unexpected credit losses that are caused by the credit risk on the asset side for a 12-month horizon and does not depend on current economic conditions. Any provisioning directly lowers the Common Equity Tier (CET) 1 on the liability side. However, the Basel Committee on Banking Supervision (2011, Basel III) makes an adjustment for possible shortfalls in provisioning. If the Basel expected loss is higher than the provisions, the difference must be deducted from the eligible CET 1 (§ 73 Basel III). The exact amount of provisions does not affect the eligible regulatory capital as long as there is a shortfall. The excess directly lowers the eligible CET 1 if provisions exceed Basel expected losses.[2] This case mainly occurs in recessions due to higher provision levels. As a result, the new accounting standards

[2]The excess may be added up to an amount of 0.6 % in terms of risk weighted assets (RWA) to Tier 2 capital (§ 61 Basel III).

may require additional Core Tier 1 capital during downturns which we empirically study in Section 5.

Table 1 shows the treatment of shortfalls and excesses in the calculation of regulatory capital. The Basel framework distinguishes between three levels of capital that are built on each other: Core Tier 1 (CET 1), CET 1 capital plus additional Tier 1 capital, Tier 1 capital plus Tier 2 capital. Let the regulatory expected loss in both cases be 200 monetary units. The provisions for financial instruments may be 150 in an economic upturn, i.e., 50 less than required by Basel. The provisioning level in a downturn may be 250, i.e., 50 units more than required by Basel.

[Insert Table 1 here]

The example assumes that the initial CET 1 before the deduction of provisions is 1,000. The remaining CET 1 after provisioning is 850 (shortfall) in an economic upturn and 750 (excess) in an economic downturn. In the first case, the deficit of 50 must be deducted so that the eligible CET 1 amounts to 800 and is equal to the initial capital minus the Basel expected loss. However, an excess of the provisions directly lowers the eligible CET 1 to 750.

The additional Tier 1 capital is not affected by provisions and exemplary amounts to 100. Let the initial Tier 2 capital also be 100. The excess in provisions (which was deducted from CET 1) is added to Tier 2 capital. Whilst the total regulatory capital (Tier 1 plus Tier 2) equals in both cases (1,000) the composition differs.

In summary, the amount of the required regulatory capital does not depend on a shortfall or excess of the provisions, whereas the amount of eligible CET 1 does.

Financial institutions generally need to hold in relation to the risk weighted assets 4.5 % CET 1, 6 % Tier 1 capital and 8 % Tier 1 plus Tier 2 capital. In addition to these requirements, institutions must provide three additional CET 1 buffers that are currently phased in: capital conversion buffer (2.5 percentage points), countercyclical capital buffer (0 - 2.5 percentage points, depending on the current economic state) and systemic risk buffer (0 - 3.5 percentage points, depending on the institution's systematic relevance). The results of Carlson et al. (2013) and Repullo (2013) show the need of cyclical capital adjustments due to procyclical effects of Basel regulatory capital requirements on lending. We contribute to this discussion by clarifying the role of future provisioning.

In summary, IFRS 9 and GAAP 326 may increase the pressure to raise high-quality capital for banks. Since the upcoming regulatory capital buffers are currently introduced, the new accounting standards may strengthen the existing pressure to raise high-quality capital.

3. Data

Our credit risk models are estimated using the Moody's Default and Recovery Database and macroeconomic risk factors provided by the FRED database from the Federal Reserve Bank in St Louis. US American bonds with issuance after 1990 are selected and a yearly panel dataset is set up, covering all years until 2013. After removal of observations with missing information in any of the variables used in this study 181,066 bond-years remain including 35,300 bonds and 1,419 defaults.

Figure 2 shows in the upper panel the empirical distribution of the expected loss rate at default (LGD) that is computed by one minus the ratio of the bond price 90 days after default and the par value. The mean and the median LGD are 61.69 % and 70.00 % and indicate a left-skewed distribution with a standard deviation of 27.82 %. Consistent with Chava et al. (2011) and Altman and Kalotay (2014) we transform the LGD (that is a rate) by the inverse Gaussian cumulative distribution function Φ^{-1} to provide a dependent variable on the full range of the OLS model (lower panel of Figure 2).

[Insert Figure 2 here]

3.1. Issuer- and bond-specific covariates

We account for several issuer- and bond-specific covariates that are shown in Table 2 with corresponding means of realized LGDs and yearly default rates. Moody's long-term ratings are included as key proxies for default and loss risk and are categorized into four groups, i.e., Aaa - Baa for investment grade bonds, Ba, B, and Caa - C. The historical default rate increases when creditworthiness decreases, e.g., from 0.02 % for investment grade to 13.16 % for the lowest ratings. This tendency can also be observed for the loss severity of speculative grade ratings with mean LGDs of 47.97 % - 65.63 %. The lower number of investment grade defaults of 25 limits the interpretation of LGD for this category.

[Insert Table 2 here]

Moody's rating adjustments are caused by significant changes in a bond's credit risk and may indicate a significant increase in credit risk (SICR) for IFRS 9. Following a downgrade, the default rate of a bond increases from 0.43 % to 2.44 %. Thus, we include a downgrade dummy variable that equals one if there was a downgrade of at least one notch in Moody's granular ratings in the past.

The seniority characterizes the position in a bond's post default order of payments. Senior secured bonds are first repaid and have a first lien on collateral and have lowest mean LGDs of 48.36 %. They are then followed by senior unsecured, senior subordinated, and subordinated bonds that result in a loss of 79.33 %. Default rates are driven by other issuer- and bond-specific information next to seniority and security.

Industries have been identified as key credit risk drivers (Acharya et al. (2007)). The default rate is lowest for the Utilities sector with 0.08 % and highest for Media & Publishing with 1.96 %. The loss rate varies between 21.29 % for Utilities and 72.72 % for Banking.

The credit risk of a bond generally depends on two time components that are particularly relevant in the context of lifetime expected losses: (i) the total maturity that is the timespan from issuance to maturity date, and (ii) the stage in the life of a financial instrument. First, we split the sample into three categories of total maturity: short-term (up to three years), medium-term (more than three but less than or equal to ten years) and long-term (more than ten years). The lowest default rate is realized by short-term bonds with 0.19 % in contrast to 1.00 % of medium-term bonds and 0.67 % for long-term bonds. The LGD varies between 31.54 % (short-term) and 66.40 % (long-term).

We take into account a possible term structure of credit risk by the inclusion of the remaining time to maturity (TTM) that is given by the time in years from the beginning of the observation year up to the last day of maturity. As the given metrics are conditional, i.e., given a bond does not default prior to the observation year, the credit risk seems to decrease with maturity. In other words, surviving bonds have lower default rates and LGDs at the end of their maturity.

3.2. Cyclical behavior

In addition to issuer- and bond-specific covariates, macroeconomic conditions affect credit risk. Figure 3 shows the cyclical behavior of yearly default rates and LGDs over time. The shaded areas indicate economic downturns as indicated by the National Bureau of Economic Research. Defaults are clustered in the crisis of 2001 and the Global Financial Crises (2008/2009).

[Insert Figure 3 here]

The computation of provisions requires estimates of the expected loss based on the current economic state (§ 5.5.17 and § B5.5.49 IFRS 9, § 20-30-9 GAAP 326). This approach is also known as Point-in-Time (PIT) rating philosophy.[3] In contrast, the Basel Committee on Banking Supervision (2006) aims to avoid procyclical patterns of regulatory requirements. The risk parameters of the Basel formula under Pillar 1 must be modeled using the Through-the-Cycle (TTC) philosophy (§ 447 Basel II). This implies the exclusion of macroeconomic risk factors. The remaining time-variation of risk is exclusively driven by time-varying idiosyncratic risk factors and changes in the risk population.

As the requirements for the computation of expected losses differ with respect to the inclusion of macroeconomic variables, we distinguish between a PIT and a TTC model. We study the impact of several macroeconomic variables in order to provide a PIT model as required for accounting purposes. Macroeconomic information of the financial year is used to estimate the expected loss for IFRS 9 and GAAP 326.

The literature proposes a variety of macroeconomic variables for modeling credit risk. Economic upturn (downturn) conditions result in lower (higher) default rates and LGDs.

[3]The rating philosophies Point-in-Time and Through-the-Cycle are commonly used terms for the handling of macroeconomic conditions in credit risk models. This paper follows the classification of the International Accounting Standards Board (2014), the Financial Accounting Standards Board (2016) and the Basel Committee on Banking Supervision (2015, 2016c).

This paper investigates the role of the growth in gross domestic product (GDP), the historic default rate (of the total dataset without timely restriction), the TED spread (difference between three-month LIBOR and three-month US trasury bill), US treasury rates for the one year and ten year horizon, the treasury term spread between both treasury rates, the unemployment rate and the CBOE volatility index VIX. Appendix A shows descriptives statistics. The suitability of the variables is mentioned in Section 4.1.

Appendix A discusses descriptives and the suitability of those macroeconomic variables (for the latter see also Section 4.1).

4. Loan loss provisioning

4.1. 12-month expected loss for Basel and IFRS 9 (Stage 1)

We model the risk parameters probability of default and loss rate given default for a 12-month horizon for Basel and accounting purposes.

Probability of default (PD)

The default behavior of financial instruments was considerably investigated by the Z-score of Altman (1968), the firm value model of Merton (1974) and the categorical default model as discussed in Campbell et al. (2008) and Hilscher and Wilson (2016) amongst others. In accordance with these approaches, we model the PD by a Probit model which follows, e.g., Puri et al. (2017).[4] The regression equation for the PD of a bond i in year t is given by

$$\mathrm{PD}_{it} = \mathrm{P}(\mathrm{D}_{it} = 1|x_{it-1}) = \Phi(x_{it-1}\beta), \tag{1}$$

where x_{it-1} is the vector of covariates (including an intercept) of the previous year and unknown parameter vector β. The default indicator D_{it} equals one for defaults and zero for non-defaults. We estimate this model with two different sets of variables in order to meet the different requirements of accounting standards and the Basel framework. In a first setting, we include all issuer- and bond-specific information in order to provide

[4] We also tested several accelerated-failure-time (AFT) models for PD estimation with very similar results for the predicted PDs. The predictions of the best performing AFT model (with log-normal distribution) have a correlation of more than 99.9 % with the estimated PDs of the Probit model. We thank an anonymous referee for the suggestion.

a TTC approach for Basel purposes. The PIT model for provisioning is extended by including macroeconomic information.

[Insert Table 3 here]

Table 3 shows the parameter estimates for the PD models. The PDs increase with credit ratings from Aaa-Baa to Caa-C. A downgrade of at least one rating notch significantly increases the PD.

The issuer's industry affiliation captures industry-specific effects. Although parameter estimates are not statistically significantly different from zero, the corresponding variables increase the goodness of fit. The Utilities sector implies the lowest PDs else being equal. In contrast, the Transportation sector leads to the highest PDs.

The total length of maturity and the remaining time to maturity affect the PD. Corporates with high creditworthiness generally issue bonds with longer maturities due to the higher trust of lenders. Risky borrowers are generally forced to issue bonds with shorter maturities. The default risk declines over time and is particularly low in the year prior to maturity.

We test several macroeconomic variables for inclusion in the PIT model of accounting standards (see Appendix A). We do not include more than one macroeconomic variable because correlations between variables are high and the marginal improvement of the fit is low while the complexity of forecasting multiple variables for multiple periods and hence the model risk is substantially greater. Bloom (2009) and Jo and Sekkel (2017) show that the VIX predicts future economic states. Consistent with this literature, the PDs increase with VIX. This study empirically identifies that the VIX has the highest goodness of fit for the PD model. In comparison to the TTC model, the Accuracy Ratio (McFadden's adjusted R^2) increases from 82.85 % (28.96 %) to 87.29 % (32.82 %).

[Insert Figure 4 here]

Figure 4 shows the mean estimated PD for each year. The PIT model provides more cyclical PD estimates than the TTC model as it includes a macroeconomic variable, next to idiosyncratic risk factors and changes in the population over time. The remaining variation is caused by the changing composition of the dataset.

Loss rate given default (LGD)

Acharya et al. (2007), and Jankowitsch et al. (2014) amongst others use OLS regression models for recovery and LGD models. Consistent with Chava et al. (2011) and Altman and Kalotay (2014), we transform the LGD (that is rate) by the inverse Gaussian cumulative distribution function Φ^{-1} to provide a dependent variable on the full range of the OLS model. The regression equation of a bond i in year t is given by

$$\Phi^{-1}(\mathrm{LGD}_{it}) = z_{it-1}\gamma + \varepsilon_{it}, \qquad \varepsilon_{it} \sim N(0, \sigma^2), \tag{2}$$

with a covariate vector z_{it-1} that includes an intercept and information of the previous year. The unknown components of the model are the parameter vector γ and the standard deviation σ.

Similar to the PD modeling we consider a TTC and a PIT model for Basel and accounting requirements. Table 4 shows the corresponding estimation results. Covariate effects on LGDs are generally consistent with the ones of PDs.

[Insert Table 4 here]

The seniority determines the order of the borrower's payments after default and has a significant effect on LGDs. The results show higher losses for lower seniority and security levels. Industry-specific effects are significant in comparison to the reference group Banking that provides the highest LGDs. The Utilities sector shows the lowest loss rates in addition to the lowest default risk. The total length of maturity does not cause significant variation in recoveries. LGDs significantly decrease over lifetime due to survivorship.

A high uncertainty—measured by an increased VIX—strengthens loss severity. The advantages of the VIX for inclusion in the LGD model in terms of goodness of fit is discussed in greater detail in Appendix A. The PIT model shows an adjusted R^2 of 25.36 % and dominates the TTC model with an adjusted R^2 of 21.74 %.

[Insert Figure 5 here]

Figure 5 shows the mean estimated LGDs for each year. The PIT model shows procyclical patterns whereas the TTC model does not.

4.2. Lifetime expected loss for GAAP 326 and IFRS 9 (Stage 2)
Macroeconomic forecasts

Lifetime expected losses for GAAP 326 and IFRS 9 (Stage 2) must contain information on the current economic state, which changes over the remaining lifetime of an instrument and multi-period forecasts are necessary (§ B5.5.49 IFRS 9 and § 20-30-9 GAAP 326). This paper uses an autoregressive (AR) process for forecasting.

[Insert Figure 6 here]

Figure 6 shows the time-series plot of the VIX in the upper panel. The autocorrelation and the partial autocorrelation function (lower panel) suggest an AR process of order one. Hence, the difference of the VIX in year t to the mean φ_0 is modeled by

$$\mathrm{VIX}_t - \varphi_0 = \varphi_1(\mathrm{VIX}_{t-1} - \varphi_0) + \epsilon_t, \qquad \epsilon_t \sim N(0, \sigma_\epsilon^2), \tag{3}$$

with unknown parameters φ_0, φ_1 and σ_ϵ. Note that AR processes converge to the long run mean over time. Table 5 shows the estimation results.

[Insert Table 5 here]

The estimated long-run average of the VIX is 20.07 percentage points. The AR parameter estimate for the lag amounts to 0.5580. It is statistically significantly different from zero and indicates stationarity. The forecast of the VIX for s years ahead given a realization in year t is given by

$$\widehat{\mathrm{VIX}}_{t+s} = (1 - \hat{\varphi}_1^s)\hat{\varphi}_0 + \hat{\varphi}_1^s \, \mathrm{VIX}_t, \tag{4}$$

where $\hat{\varphi}_1^s$ is the s-th power of the estimated AR parameter.

Prediction of lifetime expected losses

The upcoming accounting standards require the computation of 12-month and lifetime expected losses. Both measures must account for current economic conditions. Hence, we use risk parameters based on PIT models to provide accounting expected losses.

In Stage 1 of IFRS 9, provisions are given by the 12-month expected loss. If the time to maturity of an instrument is less than 12 months, the remaining lifetime is crucial for the computation (§ B5.5.43 IFRS 9). The expected loss of a regular bond is principally given by the product of the PD and the LGD.[5] We denote the information that is available up to year t by $\mathcal{F}_t$. Hence, the estimated Stage 1 expected loss of instrument i for year t is

$$\widehat{\mathrm{EL}}_{it}^{PIT} = \widehat{\mathrm{P}}(\mathrm{D}_{it} = 1|\mathcal{F}_t) \cdot \widehat{\mathrm{E}}(\mathrm{LGD}_{it}\,|\mathcal{F}_t) \cdot \min(1, \mathrm{TTM}_{it}), \tag{5}$$

where $\widehat{\mathrm{P}}(\mathrm{D}_{it} = 1|\mathcal{F}_t)$ is the estimated PD using Equation (1) and $\widehat{\mathrm{E}}(\mathrm{LGD}_{it}\,|\mathcal{F}_t)$ is the estimated LGD using Equation (2). Both calculations use lagged covariates, i.e., provisions in a financial year $t-1$ are based on the available information of that year and correspond to the expected loss for the following year t. TTM_{it} denotes the time to maturity that is left at the reporting date.

In GAAP 326 as well as Stage 2 of IFRS 9 the provision for an instrument shall represent the lifetime expected loss. This amount is the sum of the expected losses of all remaining years up to maturity. The loss contribution of future years must be discounted to account for the time value of money. Accounting standards require the consideration of "the contractual terms of the financial instrument" (p. 55 IFRS 9) and "the financial asset's effective interest rate" (§ 20-30-4 GAAP 326). Consistent with this we use the contractual coupon rate r_i of bond i as discount rate.

[5] The exposure of a regular bond is deterministic. For the empirical study we assume a constant exposure of one monetary unit.

Hence, the lifetime expected loss for instrument i in year t can be calculated by

$$\widehat{\mathrm{LEL}}_{it} = \sum_{\Delta t=0}^{\lfloor \mathrm{TTM}_{it} \rfloor} \Bigg[\widehat{\mathrm{P}}(\mathrm{D}_{it+\Delta t} = 1, \mathrm{D}_{it+s} = 0 \, \forall \, s \in \mathbb{Z} : 0 \leq s \leq \Delta t - 1 | \mathcal{F}_t) \cdot \frac{\widehat{\mathrm{E}}(\mathrm{LGD}_{it+\Delta t} \, | \mathcal{F}_t)}{(1+r_i)^{\Delta t}} \cdot \min(1, \mathrm{TTM}_{it} - \Delta t) \Bigg], \tag{6}$$

where $\widehat{\mathrm{P}}(\mathrm{D}_{it+\Delta t} = 1, \mathrm{D}_{it+s} = 0 \, \forall \, s \in \mathbb{Z} : 0 \leq s \leq \Delta t - 1 | \mathcal{F}_t)$ is the estimated probability that an instrument defaults in and not prior to year $t + \Delta t$. The time-varying LGDs are included by the term $\widehat{\mathrm{E}}(\mathrm{LGD}_{it+\Delta t} \, | \mathcal{F}_t)$ and again calculated by Equation (2). In contrast to the 12-month expected loss, it is essential here to use predictions for the VIX, i.e., for the Δt-th year in the future we forecast the VIX Δt years ahead by Equation (4). Furthermore, we subsequently lower the time to maturity over a bond's lifetime. Again, the last year is only partly considered by the factor $\mathrm{TTM}_{it} - \lfloor TTM_{it} \rfloor$ where $\lfloor \mathrm{TTM}_{it} \rfloor$ is the largest integer less than or equal to the remaining time to maturity at reporting date.

We replace the estimated probability that an instrument defaults in and not prior to year $t + \Delta t$ by the product of the (unconditional) survival probability prior to that year (which is the product of (conditional) survival probabilities) and the (conditional) probability of default in $t + \Delta t$, i.e.,

$$\widehat{\mathrm{LEL}}_{it} = \sum_{\Delta t=0}^{\lfloor \mathrm{TTM}_{it} \rfloor} \Bigg[\Bigg(\prod_{s \in \mathbb{Z} \, : \, 0 \leq s \leq \Delta t - 1} \big(1 - \widehat{\mathrm{P}}(\mathrm{D}_{it+s} = 1 | \mathcal{F}_t)\big) \Bigg) \cdot \widehat{\mathrm{P}}(\mathrm{D}_{it+\Delta t} = 1 | \mathcal{F}_t) \cdot \frac{\widehat{\mathrm{E}}(\mathrm{LGD}_{it+\Delta t} \, | \mathcal{F}_t)}{(1+r_i)^{\Delta t}} \cdot \min(1, \mathrm{TTM}_{it} - \Delta t) \Bigg], \tag{7}$$

where $\widehat{\mathrm{P}}(\mathrm{D}_{it+s} = 1 | \mathcal{F}_t)$ and $\widehat{\mathrm{P}}(\mathrm{D}_{it+\Delta t} = 1 | \mathcal{F}_t)$ are the estimated PDs from Equation (1). We apply the same methodology for LGD computations and aggregate PDs and LGDs for future years following Equation (6).

4.3. Significant increase in credit risk (SICR)

The classification of financial instruments in IFRS 9 depends on the credit risk at reporting date compared to the initial level. Technically, an instrument shifts from Stage 1 to Stage 2 if the default risk significantly increases (§ 5.5.9 IFRS 9). Instruments with low credit risk are excluded from this rule (§ 5.5.10 and § B5.5.23 IFRS 9). Note that this significance has to be interpreted as "substantial" as it is not applied in a statistical sense. This exception holds for investment grade bonds; for those we estimate a PD of less than 19.38 basis points. The standard suggests changes of external as well as internal ratings and economic states as SICR indicators (§ B5.5.13 IFRS 9). We define SICR based on estimated PDs (i.e., ratings, other borrower controls and macroeconomic factors).

IFRS 9 requires consideration of the same time period for the SICR evaluation (§ B5.5.13). We consider an exemplary financial instrument to clarify this requirement. Let the instrument be initially recognized in year $t_0 = 2000$ with maturity ending in year $t_0 + 10 = 2010$. The (conditional) PD for each year is assumed to be 1 %. Thus, the probability of default for the total remaining lifetime is $1 - (1 - 0.01)^{10} = 9.56\,\%$ from initial recognition, i.e., it is one minus the product of (conditional) survival probabilities For the SICR evaluation after four years, i.e., at reporting date in 2004, the probability of default for the remaining lifetime of six years might be computed as 8 % (including new information, e.g., economic conditions). The false comparison would be between the 10-year PD at initial recognition (9.56 %) and the 6-year PD after four years (8 %). Instead, from the view of the initial recognition, the 6-year PD, given no default in the first four years of the initial remaining maturity, was $1 - (1 - 0.01)^6 = 5.85\,\%$. Thus, the relevant remaining lifetime PD deteriorates by 8 - 5.85 = 2.15 percentage points, i.e., 36.71 % and indicates a risk deterioration.

Under certain conditions, IFRS 9 allows use of the 12-month PD for the SICR criterion, but only if default risk changes are comparable over time horizons. We emphasize two main aspects as to why these changes are principally not similar and, thus, bonds should be evaluated using their remaining lifetime PD. First, short-term changes (e.g., caused by macroeconomic shocks) may significantly deteriorate the 12-month PD but the influence vanishes over lifetime. A naive consideration of the 12-month horizon may thus amplify a possible procyclicality. Second, long-term changes (e.g, caused by bond- or issuer-specific fundamentals) may negligibly increase the 12-month PD but sum up over the long-term to a significant risk deterioration over lifetime. These changes may not be identified by a 12-month SICR criterion.

We call the probability of default for the remaining time to maturity the lifetime probability of default (LPD). IFRS 9 demands computation of the LPD of an instrument i from the point of initial recognition or a reporting year t_1. The crucial time horizon is starting at a reporting year $t_2 \geq t_1$ and ends with maturity. The LPD is given by one minus the (unconditional) survival probability, i.e., the product of the (conditional) survival probabilities and estimated by

$$\widehat{\mathrm{LPD}}_{it_2}(t_1) = 1 - \prod_{\Delta t=0}^{\lfloor \mathrm{TTM}_{it_2} \rfloor} \left[1 - \widehat{\mathrm{P}}(\mathrm{D}_{it_2+\Delta t} = 1 | \mathcal{F}_{t_1}) \cdot \min(1, \mathrm{TTM}_{it_2} - \Delta t) \right], \quad (8)$$

where $\widehat{\mathrm{P}}(\mathrm{D}_{it_2+\Delta t} = 1|\mathcal{F}_{t_1})$ is the estimated PD for year $t_2 + \Delta t$ using the information set of year t_1 and Equation (1). For this calculation, the VIX forecast is done $t_2 - t_1 + \Delta t$ years ahead. Again, the time to maturity is subsequently decreased and the last year only partly recognized.

At reporting date t the current estimate of the lifetime PD $\mathrm{LPD}_{it}(t)$ of instrument i must be compared to the estimated $\mathrm{LPD}_{it}(t_0)$ from the point of initial recognition t_0. The evaluation of a significant risk increase shall be made in relative terms (§ B5.5.9 IFRS 9). An asset is classified to Stage 2 under IFRS 9 (i.e., the formal SICR criterion is fulfilled) if

$$\frac{\widehat{\mathrm{LPD}}_{it}(t)}{\widehat{\mathrm{LPD}}_{it}(t_0)} - 1 \geq \alpha \quad (9)$$

with a threshold $\alpha > 0$. IFRS 9 does not suggest a specific value and leaves room for interpretation. This paper discusses three thresholds: 5 %, 20 % and 50 %, and analyzes the sensitivity to the SICR criterion.

5. Impact on regulatory capital

5.1. Stylized asset portfolios

This section discusses several portfolio qualities and reinvestment strategies to allow for a comprehensive impact study. Institutions may manage their asset portfolio risk profile based on internal ratings. We follow four different stylized portfolios of different credit qualities that are given by the rating distributions of Table 6 over time. The higher fraction of assets with a better credit rating (e.g., Aaa-Baa) and a lower fraction of assets with a lower credit rating (e.g., Caa-C) implies a better portfolio quality. Each portfolio consists of 2,000 assets (represented by bonds) and is based on representative bank data of the Federal Reserve as presented in Gordy (2000). The impact on the eligible regulatory capital of IFRS 9 and GAAP 326 is analyzed in a counterfactual analysis by studying the IFRS 9 and GAAP 326 rules for US American bonds between 1991 and 2013, which is a period where these rules have not been applied. As assets mature or default we replace these following one of five reinvestment strategies following an approach adapted from Gordy and Howells (2006).

[Insert Table 6 here]

The consideration of cyclicality leads to one of three basic strategies. The idea of the first type is to keep the average portfolio PIT PD constant and to account for current economic conditions. This 'cyclical' reinvestment strategy requires a tightening of lending standards in recessions in order to compensate for the decreasing quality of the existing portfolio. For the derivation of the corresponding ratings, we estimate PDs of all assets by the PIT model of Table 3. Then we order these risk measures to assign internal ratings. The classification follows the frequencies of Moody's ratings in the dataset: 4.76 % Aaa, 17.06 % Aa, 33.71 % A, 25.33 % Baa, 6.88 % Ba, 8.97 % B, and 3.29 % Caa - C.

The contrary 'non-cyclical' reinvestment strategy aims to keep constant the average long-run default risk. Here institutions keep the long-term risk constant and do not adapt their lending standards according to economic surroundings. This strategy uses estimated PD of the TTC model of Table 3 for the classification of internal ratings.

In practice, institutions choose a mix of both above mentioned reinvestment strategies as they tighten their lending standards during downturns. However, poor market conditions may prevent a full adjustment. This 'semi-cyclical' approach uses internal ratings that are based on the average of PIT and TTC estimates. This intermediate case is used as the base case for the empirical results. Both extreme strategies show the sensitivity and robustness of implications due to portfolio management.

Results are presented for each combination of the four different portfolio qualities and the three above mentioned reinvestment strategies. For each combination we consider

100 independent portfolios that represent 100 different banks to ensure that results do not depend on one specific choice. The procedure for one bank is as follows. The bank portfolio consists of initially 2,000 randomly chosen bonds from all bonds that are in the dataset in year 1991, clustered by ratings according to the portfolio quality in this first year. For the following years all bonds of the first year principally stay in the portfolio. The portfolio needs, however, to be actively managed over time to restore the initial portfolio size and quality. Some bonds drop out due to maturity or default.[6] In addition, bond ratings, and thus the initial portfolio quality, change. To restore the initial portfolio size and rating distribution we subsequently add and replace bonds year by year. First, bonds are randomly removed for rating classes that are over-represented due to rating migration. Second, some rating classes are under-represented over time because of bonds' default or maturity, or bonds' rating changes to other classes. Bonds for the specific year from the dataset to the portfolio are randomly added if rating classes are over-represented. These bonds also principally stay in the portfolio for following years but may be removed for further restoring. The procedure is subsequently performed year by year until 2013. This procedure is repeated for each bank separately, i.e., sampling is carried out independently. The first five years of the data are treated as a burn-in phase to setup representative portfolios. Each bond is equally weighted by the same exposure and is sampled with replacement.

This paper also considers two reinvestment strategies of Gordy and Howells (2006) for further robustness. The 'fixed' strategy does not restore the initial portfolio quality. New bonds are added from the initial distribution following default/maturity but no bond is removed due to over-representation in a rating class. In the 'passive' strategy new bonds are added each year following the current rating distribution in the portfolio for that year. Both approaches are optimized for pure simulation studies over a long time-horizon. The first years of the dataset will cause a shift in the portfolio qualities.

[6] Similar to Gordy and Howells (2006) bonds are excluded after default to analyze the impact of loan loss provisioning of non-defaulted bonds.

5.2. Significant increase in credit risk (SICR)

The instrument classification in IFRS 9 is based on the evaluation of the change in default risk. The current LPD estimate (for the remaining lifetime) must be compared to the initially estimated LPD (for the same time horizon) for each financial instrument at the reporting date.

[Insert Figure 7 here]

Figure 7 shows the mean for each portfolio quality and SICR threshold per year for the base case of a semi-cyclical reinvestment strategy. The portfolios are initialized in the financial year 1990 with reporting date 31.12.1990, i.e., starting with default risk and expected losses from 1991 on. The first five years of the data (1991 - 1995) are treated as a burn-in phase to setup representative portfolios and excluded for the results. Bonds shift over time from Stage 1 to Stage 2 due to significant increases in default risk and shift back if the SICR criterion does not longer apply. In addition, some instruments leave the portfolio due to default or maturity and new instruments are added to restore the portfolio quality and size. The minimum mean share of Stage 2 bonds in expansions is between 5 % and 15 %., e.g., in year 2005 approximately 10 % of all instruments in a portfolio with an average credit risk are in Stage 2. A lower portfolio quality is more likely to cause an exceedance of the SICR threshold and increases the share of Stage 2 instruments. The choice of α does not seem to cause differences for good economic conditions, e.g., in 2003 - 2006. Downturns increase the systematic default risk and, thus, the share of Stage 2 bonds. The maximum strongly depends on the SICR threshold and the portfolio quality. For the average credit risk the 50 % threshold leads to 39 % of bonds in Stage 2, the 20 % threshold leads to 45 % and the 5 % threshold leads to 53 %. A high portfolio quality leads to a low number of bonds in Stage 2 due to a lower risk sensitivity and the exception of low risk assets from the lifetime loss requirement. The corresponding maximum varies between 34 and 39 % depending on the threshold. In contrast, for banks with very low credit quality the maximum share is between 50 and 65 %.

In the following sections, we study the resulting impact of IFRS 9 on provisions as well as regulatory capital and compare those to GAAP 326 requirements.

5.3. Computation of Basel and accounting expected losses

After the stage classification of IFRS 9 in the previous section, the corresponding provisions can be calculated: the 12-month expected loss for Stage 1 and the lifetime expected loss for Stage 2. GAAP 326 uses the latter in all instances. The 12-month and lifetime expected losses are computed by using the PIT PD and LGD models (see Section 4). This section compares the corresponding provisions and Basel expected losses. Furthermore, Section 5.4 analyzes the impact on the eligible regulatory capital of IFRS 9 and GAAP 326 in a counterfactual analysis for the data, for which the rules have not been applied. Again, we present results for different portfolio qualities and SICR thresholds using the semi-cyclical reinvestment strategy.

The Basel expected loss is generally the product of the estimated PD and LGD of the TTC models in Table 3 and Table 4. Current information of the financial year is used and no VIX forecast is included. However, Basel requires several corrections to both risk parameters. First, the LGD must reflect economic downturn conditions (§ 468 Basel II). We account for those by the adjustment $0.08 + 0.92 \cdot \text{LGD}$ as proposed by the Board of Governors of the Federal Reserve System (2006). Second, regulators apply a floor for the parameter estimates for the internal ratings-based approach (see Basel Committee on Banking Supervision (2016a)). The PD estimate must be greater or equal to 5 basis points which affects approximately 15.6 % of all observations. In addition, the LGD parameter minimum of 25 % affects 6.7 % of all observations.[7]

For each bank, i.e., sampled portfolio, we calculate the portfolio sum of the Basel expected loss and the sum of all provisions. Figure 8 shows the time-series of means for all banks with the same portfolio quality. All measures are reported as a fraction of the portfolio exposure. We additionally consider the provisions depending on the accounting standard and the SICR threshold α for IFRS 9. The Basel expected loss (gray line) is less volatile due to the underlying TTC approach. The solid black line characterizes

[7]The proposed 25 % floor holds for unsecured bonds. As the data does not contain sufficient information on collateral we also use the 25 % floor for secured bonds. This do not affect the contributions because (i) the affected secured bonds have on average estimated LGDs of 19.0 %, and (ii) lower proposed floors lower Basel expected losses and thus even increase the impact of IFRS 9 and GAAP 326 on regulatory capital.

the PIT 12-month expected loss and is the lower bound for IFRS 9 provisioning that holds if all instruments are in Stage 1. The upper bound is given by GAAP 326 provisions (dash-dotted line) that are generally calculated by the lifetime expected loss (what equals Stage 2) and, thus, are less volatile. The corresponding provisions are on average approximately 1 % for the high portfolio quality, 2 % for the average case and up to 5 % for very risky portfolios.

[Insert Figure 8 here]

The IFRS 9 provisions (the three middle dashed and dotted lines) are by definition lower than GAAP 326 provisions. In expansions, the SICR threshold plays a minor role and overall provisions are closer to the 12-month expected losses. The IFRS 9 requirements are closer to GAAP 326 requirements in downturns and for lower SICR thresholds.

Although GAAP 326 requires more provisions in general, it is less procyclical than IFRS 9, i.e., the additional burden from upturn to downturn periods is lower in GAAP 326.

5.4. Impact on Common Equity Tier (CET) 1

The previous section shows what the provisions would have been, had the accounting standards been mandatory in the past. Here we discuss the corresponding impact on CET 1 that is directly lowered by the deduction implied by provisioning.[8] We present the deduction in regulatory capital in percentages of the exposure and the RWA. These are calculated according to the Basel II formula (§ 272) and take into account the parameter adjustments as previously mentioned for the Basel expected loss. Again, we present results for the four portfolio qualities and the three SICR thresholds using the semi-cyclical reinvestment strategy (Figure 9). We aggregate the mean capital for four time horizons: (i) through the economic cycle, (ii) for recessions as given by the National Bureau of Economic Research, (iii) expansions (times of no recession), and (iv) the Global Financial crises (GFC). Table 7 shows the mean capital deduction distinguished for portfolio qualities, accounting standards (including SICR threshold) and time horizon.

[8]This paper focuses on the impact on the higher-quality CET 1 and does not further consider the Tier 2 component as Tier 2 capital does not provide a binding constraint for most banks.

[Insert Figure 9 here]

[Insert Table 7 here]

For the average portfolio quality, the average deduction of the CET 1 ratio due to GAAP 326 is 134 bps (= 1.34 % of RWA). This is the average additional amount of CET 1 institutions need to hold due to differences between Basel expected losses and GAAP 326 provisions. Due to the risk sensitivity of the lifetime expected loss, this gap behaves procyclically. The additional requirement lowers in expansions to 126 bps but increases on up to 198 bps in recession and would have been 246 bps in the GFC. This is more than a half of the required minimum CET 1 ratio of 4.5 %.

The portfolio quality influences the capital deduction because higher risk increases lifetime expected losses. For low overall credit risk the gap decreases to 82 bps in expansions and 156 bps in the GFC. Very risky portfolios result in capital needs of 170 bps and 327 bps receptively.

IFRS 9 generally results in lower provisions due to the recognition of the 12-month expected loss for Stage 1 instruments. The lower the SICR threshold α, the more sensitive the transition from Stage 1 (12-month expected loss) to Stage 2 (lifetime expected loss) and the higher provisions and the capital deduction are. The 20 % threshold serves as a median case, where the average gap for the average portfolio quality is 66 bps of the RWA and, thus, 50.75 % less than the corresponding amount of an GAAP 326 institution.[9] The difference between both accounting standards is greater in expansions and lower in recessions. The IFRS 9 gap is with 145 bps only 26.77 % lower in recessions (than in GAAP 326) and with 221 bps in the GFC 10.16 % less than GAAP 326 requirements.

The results indicate that GAAP 326 requires more high-quality regulatory capital and burdens institutions through the economic cycle. IFRS 9 results in lower provisions and reacts with a lag to recessions and may challenge institutions substantially more in downturns due to procyclicality.[10]

[9] The survey of the European Banking Authority (2016) under European banks shows an expected capital deduction of 59 bps due to IFRS 9 and supports the findings of this empirical and more comprehensive study. It ensures robust and representative conclusions for further results

[10] In the transition from expansion to recession the additional capital deduction due to GAAP 326 was 198 - 126 = 72 bps whereas it was 145 - 56 = 89 bps. for IFRS 9 ($\alpha = 20\,\%$).

The choice of the SICR threshold affects the share of Stage 2 instruments in IFRS 9 (see Section 5.2). The effect remains for the capital deduction but to a minor extent. This is caused by instruments that are already classified in Stage 2 for high SICR thresholds and have large lifetime expected losses. The average capital deduction for the average portfolio quality is 57 bps - 80 bps for SICR thresholds between 5 % and 50 %. The gap in the GFC increases up to 202 bps - 226 bps. The lower the threshold, the higher IFRS 9 provisions are. This may stimulate institutions to non-transparent SICR management to lower provisions.

The portfolio reinvestment strategy affects provisioning and capital deduction. As previous results correspond to the representative semi-cyclical approach, we will briefly summarize the results for other strategies (see Table 8). A cyclical approach, i.e., a tightening of lending standards during downturns, results in lower gaps in general. In contrast, the non-cyclical management with constant long-term credit risk leads to higher capital gaps. For both strategies in combination with the average portfolio quality the average gap over time is 125 bps - 148 bps (GAAP 326) and 49 bps - 86 bps (IFRS 9) instead of 134 bps and 66 bps for the semi-cyclical strategy. In the GFC, this gap is 222 bps - 301 bps (GAAP 326) and 186 bps - 264 bps (IFRS 9) instead of the median case with 246 bps resp. 221 bps. In summary, institutions that tighten lending standards during downturns have to hold less capital with less procyclicality. Institutions that do not or cannot tighten lending standards during downturns have to keep more capital, which is also more sensitive to the economic cycle.[11]

We report results for the fixed and passive reinvestment strategy in Table 8. The size of the gap partly differs but the main conclusions are similar as before (with respect to CET 1 deduction, portfolio quality and procyclicality). Appendix A shows results for other macroeconomic variables. They are not able to capture cyclicality as well as the VIX.

[Insert Table 8 here]

[11] For the cyclical reinvestment strategy the additional burden due to downturns is 176 - 118 = 58 bps (GAAP 326) resp. 124 - 39 = 85 bps (IFRS 9, $\alpha = 20\,\%$). Is contrast, the non-cyclical numbers are 232 - 138 = 94 bps resp. 178 - 75 = 103 bps.

The results show that IFRS 9 and GAAP 326 loan loss provisioning that is based on expected losses causes procyclicality. We will briefly summarize the main conclusions with respect to level and procyclicality here. GAAP 326 reduces eligible regulatory CET 1 more than IFRS 9. However, the latter causes more procyclicality. The SICR criterion is subject to a trade-off effect as a conservative approach (low α) causes higher capital needs. This is particularly interesting for institutions' earnings management and transparency. Institutions with stressed portfolios are more affected by downturns, due to the higher sensitivity of eligible capital. Despite the implications for institutions, reinvestment and management decisions, the conclusions are important for regulators and supervisors. A transition phase as proposed by the European Commission (2016) may help to raise the general level of high-quality capital. However, further discussions need also to focus on procyclicality aspects and a possible adjustment of regulatory requirements with respect to the handling of provisions. Furthermore, the introduction of parameters floors in IFRS 9 and GAAP 326 consistent with Basel may reduce procyclicality and variation between institutions. Finally, the determination of the counter-cyclical capital buffer needs to account for the procyclicality of provisioning. The additional buffer for a systematically important bank might account for the accounting standard and portfolio quality of the institution.

6. Discussion

The accounting standards IFRS 9 and GAAP 326 replace the existing incurred loss model. The new approach is intended to increase transparency and reduce procyclicality. This paper discusses both standards and shows that the objectives are not fully met. A counterfactual analysis on US American bonds between 1991 and 2013 shows the impact of future loan loss provisioning and explores the cyclicality of eligible regulatory capital and net income.

For representative portfolios, we find GAAP 326 leads on average to a future deduction of CET 1 of 1.34 % in terms of risk-weighted assets (RWA) which needs to be seen in relation to the minimum required capital ratio of 4.5 %. This gap behaves procyclically and would have been 1.98 % during past recessions and 2.46 % in the Global Financial

Crisis. Due to the SICR criterion IFRS 9 leads to lower loan loss provisioning and capital deduction. For a median threshold, i.e., a significant increase in credit risk is given by a 20 % increase in default risk, the average CET 1 gap is 0.66 %. However, due to the high number of threshold excesses during downturns, IFRS 9 is more procyclical than GAAP 326 and would have led to a capital deduction of 1.45 % during past recessions and 2.21 % in the Global Financial Crisis. As banks are constrained in Tier 1 capital and required to hold even more Tier 1 capital in upcoming years IFRS 9 and GAAP 326 are highly likely to require banks to raise additional Tier 1 capital.

Finally, we discuss several aspects how future loan loss provisioning may be managed. The following factors are identified to reduce provisions in general and the procyclical impact on net income and regulatory capital deduction: (i) a portfolio with low credit risk, and (ii) a constant risk profile by tightening lending standards during economic downturns. A higher SICR threshold increases provisioning and must be viewed critically in combination with the objective to increase transparency as institutions may have incentives to lower provisions. Regulators might also take into account the following aspects for the debate on how to treat future loan loss provisioning. The variability of risk parameters due to varying statistical approaches may cause a high variation of loan loss provisioning for institutions with similar credit portfolios. In addition, regulators may dampen the additional burden during downturns by lowering counter-cyclical capital buffers in economic downturns or changing the treatment of provisioning when banks are close to failure (e.g., revert to 12-month provisioning during economic downturns).

A. The performance of macroeconomic variables

IFRS 9 and GAAP 326 require an accounting of macroeconomic information for the computation of expected losses. This appendix discusses several macroeconomic variables in order to capture the cyclicality of credit risk (see Table A.1).

[Insert Table A.1 here]

For all variables we evaluate the goodness of fit for the PD and LGD model (see Table A.2 for an in-sample analysis). Almost all variables indicate higher credit risk for poor economic surroundings. The VIX provides the best goodness of fit and shows that today's uncertainty adequately forecasts future macroeconomic conditions as discussed by Bloom (2009) and Jo and Sekkel (2017).[12] Thus, our preferred PIT model includes the VIX for presenting results in the main part (cf. Section 4.1 and Section 5).

[Insert Table A.2 here]

For a robustness analysis, we consider the variables with the next smallest goodness of fit: TED spread, 1-year treasury rate and treasury term spread. Table A.3 shows the impact of GAAP 326 and IFRS 9 provisions on regulatory capital using those macroeconomic variables for the PIT and AR model (cf. Section 5.4). The variables are not able to capture cyclicality as well as the VIX and they over- and undervalue cyclicality. These additional empirical results are biased and do not affect the main conclusions.

[Insert Table A.3 here]

[12] An out-of-sample analysis is even more meaningful for the determination of capital requirements and we are grateful to an anonymous referee for pointing this out. We also perform such an analysis with a rolling estimation window of ten years and a validation horizon of five years. The results confirm the suitability of the VIX.

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Tables and Figures

Table 1: Exemplary calculation of regulatory capital

	Eligible capital Upturn	Eligible capital Downturn	Required capital
Accounting provisions for financial instruments	150	250	
Basel regulatory expected loss	(200)	(200)	
CET 1 before provisions for financial instruments	1000	1000	
provisions for financial instruments	(150)	(250)	
CET 1 before regulatory adjustments due to provisions	850	750	
regulatory adjustments due to provisions	*(50)*	–	
CET 1 (Tier 1a)	800	750	4.5% of RWA
additional Tier 1	100	100	
Tier 1	**900**	**850**	6% of RWA
Tier 2 before regulatory adjustments due to provisions	100	100	
regulatory adjustments due to provisions	–	*50*	
Tier 2	**100**	**150**	
Tier 1 + Tier 2	**1000**	**1000**	8% of RWA

Notes: This table shows the calculation of the three regulatory capital amounts (CET 1, Tier 1, Tier 1 plus Tier 2). A positive difference between accounting provisions and the Basel expected losses (excess) leads to a deduction of the CET 1 and a potential addition to Tier 2 capital up to 0.6 % of RWA. A deficit must be deducted of the CET 1 to calculate the eligible regulatory capital.

Table 2: Descriptive statistics for issuer- and bond-specific covariates

	Default rate in %	Mean LGD in %	# obs.
Rating			
Aaa - Baa	0.02	68.14	100,549
Ba	0.41	47.97	58,339
B	2.30	61.75	16,238
Caa - C	13.16	65.63	5,940
Downgrade			
No	0.43	64.54	148,959
Yes	2.44	59.36	32,107
Seniority			
Senior Secured	0.95	48.36	13,970
Senior Unsecured	0.63	59.14	147,351
Senior Subordinated	3.85	72.69	8,827
Subordinated	0.20	79.33	10,918
Industry			
Banking	0.09	72.72	28,387
Capital Industries	1.59	67.03	22,963
Consumer Industries	1.28	63.33	18,675
Energy & Environment	0.73	61.49	14,375
Finance. Insurance & Real Estate	0.37	38.95	49,480
Media & Publishing	1.96	57.82	6,800
Retail & Distribution	1.35	63.48	7,638
Technology	1.40	72.46	13,391
Transportation	1.70	67.39	3,707
Utilities	0.08	21.29	15,650
Total maturity			
Short-term	0.19	31.54	7,711
Medium-term	1.00	58.02	73,717
Long-term	0.67	66.40	99,638
Time to maturity in years (TTM)			
$0<\text{TTM}\leq 1$	0.29	32.09	17,300
$1<\text{TTM}\leq 2$	0.64	48.07	17,078
$2<\text{TTM}\leq 3$	0.78	54.49	16,184
$3<\text{TTM}\leq 4$	0.89	55.50	15,047
$4<\text{TTM}\leq 5$	1.07	57.98	15,431
$5<\text{TTM}$	0.83	68.07	100,026

Notes: This table shows for each categorical explanatory variable the default rate, the mean realized LGD and the number of observations.

Table 3: Parameter estimates Probability of Default

	Through-the-Cycle	Point-in-Time
(Intercept)	-3.1573 ***	-4.5761 ***
	(0.2501)	(0.4601)
Ba	0.2429	0.2806
	(0.1885)	(0.1844)
B	0.8954 ***	0.9550 ***
	(0.1000)	(0.0917)
Caa - C	1.6202 ***	1.6717 ***
	(0.0961)	(0.1084)
Downgrade	0.3934 ***	0.3883 ***
	(0.1123)	(0.1069)
Capital Industries	0.2787	0.2972
	(0.2936)	(0.3124)
Consumer Industries	0.1851	0.1955
	(0.2384)	(0.2521)
Energy & Environment	0.2033	0.2224
	(0.3236)	(0.3434)
Finance, Insurance & Real Estate	0.2063	0.1772
	(0.2734)	(0.2759)
Media & Publishing	0.3599	0.3638
	(0.3077)	(0.3256)
Retail & Distribution	0.1735	0.1970
	(0.3107)	(0.3251)
Technology	0.3965	0.3810
	(0.3524)	(0.3684)
Transportation	0.4618	0.5252
	(0.3353)	(0.3500)
Utilities	-0.1991	-0.2110
	(0.3754)	(0.3846)
Short-term	0.1238	0.0746
	(0.0868)	(0.0981)
Long-term	-0.1443 ***	-0.1625 ***
	(0.0415)	(0.0471)
$0<TTM\leq1$	-0.2851 ***	-0.2907 ***
	(0.0942)	(0.1057)
$1<TTM\leq2$	-0.0279	-0.0260
	(0.0586)	(0.0632)
$2<TTM\leq3$	-0.0243	-0.0228
	(0.0671)	(0.0714)
$3<TTM\leq4$	-0.0739	-0.0787
	(0.0707)	(0.0734)
$4<TTM\leq5$	-0.0156	-0.0219
	(0.0542)	(0.0572)
VIX		0.0625 ***
		(0.0143)
Accuracy Ratio	0.8285	0.8729
McFadden's adjusted R^2	0.2896	0.3282
# observations	181,066	181,066

Notes: The table shows regression results for the PD models that are used for the computation of regulatory (TTC) and accounting (PIT) expected losses. These Probit models are based on Equation (1). Standard errors are given in parentheses and clustered for issuer- and year-specific fixed effects as proposed in Petersen (2009). The significance is indicated for the 1 % (***), 5 % (**) and 10 % (*) level.

Table 4: Parameter estimates Loss Rate Given Default

	Through-the-Cycle	Point-in-Time
(Intercept)	0.5032 ***	-0.4139 *
	(0.1139)	(0.2282)
Ba	-0.1197	-0.0740
	(0.1266)	(0.1755)
B	0.0442	0.1218
	(0.1049)	(0.0917)
Caa - C	0.2528	0.3173 **
	(0.1721)	(0.1568)
Senior Unsecured	0.4363 ***	0.3661 ***
	(0.1067)	(0.1087)
Senior Subordinated	0.7526 ***	0.6808 ***
	(0.0980)	(0.0980)
Subordinated	1.0520 ***	0.9693 ***
	(0.3091)	(0.3350)
Capital Industries	-0.4545 **	-0.5508 ***
	(0.2181)	(0.1873)
Consumer Industries	-0.6057 ***	-0.6791 ***
	(0.2144)	(0.1822)
Energy & Environment	-0.6039 **	-0.6296 **
	(0.2854)	(0.2588)
Finance, Insurance & Real Estate	-1.0137 ***	-1.1640 ***
	(0.1791)	(0.1990)
Media & Publishing	-0.5922 **	-0.6818 ***
	(0.2740)	(0.2350)
Retail & Distribution	-0.5127 **	-0.5525 ***
	(0.2282)	(0.2010)
Technology	-0.3037	-0.4221 *
	(0.2677)	(0.2330)
Transportation	-0.3688 *	-0.3156
	(0.2131)	(0.2372)
Utilities	-1.5577 ***	-1.7220 ***
	(0.3416)	(0.3127)
Short-term	0.0892	0.0696
	(0.2413)	(0.2371)
Long-term	-0.0142	-0.0133
	(0.0602)	(0.0509)
$0<\text{TTM}\leq 1$	-0.9018 ***	-0.8457 ***
	(0.1158)	(0.1176)
$1<\text{TTM}\leq 2$	-0.5174 ***	-0.4972 ***
	(0.1053)	(0.0971)
$2<\text{TTM}\leq 3$	-0.3113 ***	-0.2775 **
	(0.1177)	(0.1170)
$3<\text{TTM}\leq 4$	-0.2791 **	-0.2689 **
	(0.1130)	(0.1051)
$4<\text{TTM}\leq 5$	-0.2370 ***	-0.2155 ***
	(0.0908)	(0.0831)
VIX		0.0417 ***
		(0.0083)
Adjusted R^2	0.2174	0.2536
# observations	1,419	1,419

Notes: The table shows regression results for the LGD models that are used for the computation of regulatory (TTC) and accounting (PIT) expected losses. These OLS models are based on Equation (2). Standard errors are given in parentheses and clustered for issuer- and year-specific fixed effects as proposed in Petersen (2009). The significance is indicated for the 1 % (***), 5 % (**) and 10 % (*) level.

Table 5: Parameter estimates AR model

	VIX
$\hat{\varphi}_0$	20.0687 ***
	(2.1094)
$\hat{\varphi}_1$	0.5580 ***
	(0.1705)
AIC	142.83

Notes: The table shows regression results for the VIX model that is used for the computation of lifetime expected losses. This AR model is based on Equation (3) and estimates the variance by 22.08. Standard errors are given in parentheses. The significance is indicated for the 1 % (***), 5 % (**) and 10 % (*) level.

Table 6: Credit quality distributions of stylized portfolios

Rating	Credit quality			
	High	Average	Low	Very low
Aaa	76	58	20	10
Aa	118	100	31	21
A	585	268	74	63
Baa	758	623	331	264
Ba	382	649	761	712
B	55	222	647	740
Caa - C	26	80	136	190
Total	2,000	2,000	2,000	2,000

Notes: The paper uses these stylized portfolios for further analysis. The four cases stand for representative banks based on internal FED data and reported in Gordy (2000).

Table 7: Deduction of Common Equity Tier 1 due to provisioning

		GAAP 326 Accounting provisions – expected loss under Basel				IFRS 9 Accounting provisions – expected loss under Basel											
						SICR threshold $\alpha = 5\,\%$				SICR threshold $\alpha = 20\,\%$				SICR threshold $\alpha = 50\,\%$			
	Portfolio quality	Expansion	Average	Recession	GFC	Expansion	Average	Recession	GFC	Expansion	Average	Recession	GFC	Expansion	Average	Recession	GFC
In % of RWA	High	0.82	0.87	1.29	1.56	0.44	0.50	1.01	1.33	0.37	0.44	0.96	1.32	0.34	0.40	0.90	1.22
	Average	1.26	1.34	1.98	2.46	0.71	0.80	1.58	2.26	0.56	0.66	1.45	2.21	0.48	0.57	1.32	2.02
	Low	1.54	1.64	2.40	2.91	0.88	1.00	2.00	2.71	0.68	0.80	1.81	2.59	0.52	0.64	1.60	2.33
	Very low	1.70	1.81	2.69	3.27	0.96	1.10	2.23	3.03	0.74	0.88	2.01	2.90	0.57	0.70	1.79	2.62
In % of exposure	High	0.63	0.65	0.82	0.90	0.31	0.35	0.63	0.77	0.27	0.30	0.60	0.77	0.24	0.28	0.56	0.70
	Average	1.36	1.41	1.80	2.06	0.71	0.78	1.41	1.90	0.56	0.64	1.28	1.86	0.48	0.55	1.17	1.69
	Low	2.29	2.38	3.14	3.48	1.23	1.38	2.57	3.24	0.94	1.09	2.30	3.10	0.72	0.87	2.03	2.78
	Very low	2.72	2.85	3.85	4.32	1.46	1.65	3.15	4.00	1.11	1.29	2.81	3.82	0.85	1.03	2.51	3.46

Notes: This table shows the difference of provisions and the Basel expected losses given as share of the risk-weighted and non-weighted assets for different portfolio qualities using the semi-cyclical reinvestment strategy. A positive difference (excess) leads to a deduction of the CET 1 and addition to Tier 2 capital. A deficit must be deducted of the CET 1 to calculate the eligible regulatory capital. Each number corresponds to the average deduction over 100 sampled portfolios that represent 100 independent banks. Recession dates are those of the National Bureau of Economic Research.

Table 8: Deduction of CET 1 for different reinvestment strategies

In % of RWA		GAAP 326 Accounting provisions – expected loss under Basel				IFRS 9 Accounting provisions – expected loss under Basel, SICR threshold $\alpha = 20\,\%$			
Reinvestement strategy	Portfolio quality	Expansion	Average	Recession	GFC	Expansion	Average	Recession	GFC
Cyclical	High	0.86	0.92	1.40	1.79	0.32	0.40	1.06	1.55
	Average	1.18	1.25	1.76	2.22	0.39	0.49	1.24	1.86
	Low	1.54	1.59	2.05	2.39	0.52	0.62	1.42	1.94
	Very low	1.70	1.76	2.31	2.68	0.59	0.70	1.54	2.09
Semi-cyclical	High	0.82	0.87	1.29	1.56	0.37	0.44	0.96	1.32
	Average	1.26	1.34	1.98	2.46	0.56	0.66	1.45	2.21
	Low	1.54	1.64	2.40	2.91	0.68	0.80	1.81	2.59
	Very low	1.70	1.81	2.69	3.27	0.74	0.88	2.01	2.90
Non-cyclical	High	0.91	0.98	1.56	1.93	0.53	0.60	1.22	1.69
	Average	1.38	1.48	2.32	3.01	0.75	0.86	1.78	2.64
	Low	1.65	1.78	2.82	3.66	0.81	0.95	2.07	3.07
	Very low	1.79	1.93	3.06	3.93	0.87	1.03	2.27	3.31
Fixed	High	1.04	1.17	2.21	3.24	0.65	0.78	1.85	3.01
	Average	1.33	1.48	2.65	3.71	0.71	0.86	2.08	3.32
	Low	1.64	1.80	3.10	4.15	0.79	0.96	2.33	3.58
	Very low	1.75	1.92	3.27	4.32	0.79	0.96	2.38	3.63
Passive	High	0.97	1.10	2.17	3.22	0.53	0.65	1.67	2.67
	Average	1.07	1.21	2.31	3.37	0.58	0.71	1.77	2.79
	Low	1.18	1.32	2.45	3.51	0.62	0.76	1.85	2.89
	Very low	1.19	1.33	2.45	3.49	0.63	0.76	1.85	2.88

Notes: This table shows the difference of provisions and the Basel expected losses given as share of the risk-weighted assets for different portfolio qualities and reinvestment strategies. A positive difference (excess) leads to a deduction of the CET 1 and addition to Tier 2 capital. A deficit must be deducted of the CET 1 to calculate the eligible regulatory capital. Each number corresponds to the average deduction over 100 sampled portfolios that represent 100 independent banks. Recession dates are those of the National Bureau of Economic Research.

Table A.1: Macroeconomic variables

	Quantiles					Mean
	10 %	25 %	50 %	75 %	90 %	
GDP growth (in %)	-0.24	1.68	2.39	4.13	4.45	2.46
Historic default rate (in %)	0.19	0.28	0.56	0.95	2.36	0.80
TED spread (in %-points)	0.18	0.22	0.49	0.67	1.32	0.56
Treasury rate 1 year (in %)	0.18	1.24	3.49	5.05	5.63	3.06
Treasury rate 10 years (in %)	2.78	3.66	4.61	5.26	6.35	4.58
Treasury term spread (in %-points)	-0.08	0.57	1.63	2.60	2.79	1.46
Unemployment (in %)	4.00	4.40	5.20	7.10	9.10	5.83
Volatility index VIX (in %-points)	12.07	13.29	21.68	24.42	28.62	20.40

Notes: Macroeconomic variables are lagged one year and winsorized to the 5 % and 95 % level.

Table A.2: Regression results for additional macroeconomic variables

		Probability of Default			Loss Rate Given Default	
	Issuer- and bond-specific variables	Coefficient	Accuracy Ratio	McFadden's adjusted R^2	Coefficient	Adjusted R^2
GDP growth	✓	-0.0535 (0.0704)	0.8370	0.2921	-0.0200 (0.0334)	0.2180
Historic default rate	✓	0.1703 (0.1273)	0.8424	0.2963	0.0816 (0.0659)	0.2199
TED spread	✓	0.5447 *** (0.2090)	0.8460	0.3091	0.3542 *** (0.1341)	0.2374
Treasury rate 1 year	✓	0.1045 ** (0.0445)	0.8444	0.3060	0.0650 *** (0.0242)	0.2305
Treasury rate 10 years	✓	0.1520 ** (0.0721)	0.8375	0.3016	0.0689 (0.0474)	0.2216
Treasury term spread	✓	-0.1613 * (0.0842)	0.8447	0.3010	-0.1523 *** (0.0434)	0.2380
Unemployment	✓	-0.1058 * (0.0615)	0.8422	0.3003	-0.0534 (0.0351)	0.2223
Volatility index VIX	✓	0.0625 *** (0.0143)	0.8729	0.3279	0.0417 *** (0.0083)	0.2536

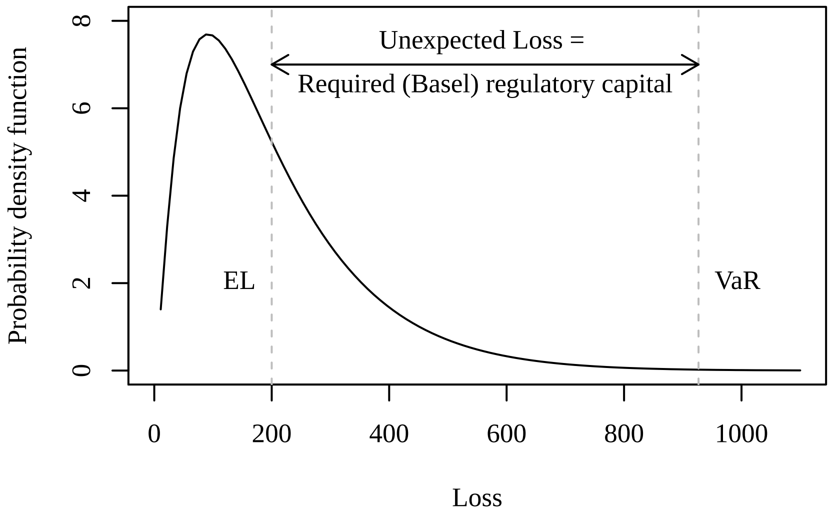
Notes: In the PIT models of the PD (Table 3) and the LGD (Table 4) we replace the VIX by the given macroeconomic variables. Each row represents one PD and one LGD model. The issuer- and bond-specific variables are included in each model but are not presented due to clarity. The table shows the parameter estimate of the corresponding macroeconomic variable and the goodness of fit. Standard errors are given in parentheses and clustered for issuer- and year-specific fixed effects as proposed in Petersen (2009). The significance is indicated for the 1 % (***), 5 % (**) and 10 % (*) level.

Table A.3: Deduction of CET 1 using alternative macroeconomic variables

In % of RWA		GAAP 326 Accounting provisions – expected loss under Basel				IFRS 9 Accounting provisions – expected loss under Basel SICR threshold $\alpha = 20\,\%$			
Macroeconomic variable	Portfolio quality	Expansion	Average	Recession	GFC	Expansion	Average	Recession	GFC
Volatility index VIX	High	0.82	0.87	1.29	1.56	0.37	0.44	0.96	1.32
	Average	1.26	1.34	1.98	2.46	0.56	0.66	1.45	2.21
	Low	1.54	1.64	2.40	2.91	0.68	0.80	1.81	2.59
	Very low	1.70	1.81	2.69	3.27	0.74	0.88	2.01	2.90
TED spread	High	1.24	1.27	1.44	1.72	0.54	0.58	0.89	1.32
	Average	1.82	1.86	2.17	2.79	0.75	0.81	1.36	2.30
	Low	2.13	2.17	2.50	3.25	0.69	0.77	1.41	2.40
	Very low	2.30	2.34	2.71	3.53	0.72	0.81	1.55	2.63
Treasury rate 1 year	High	1.40	1.39	1.28	1.24	0.76	0.75	0.62	0.65
	Average	2.06	2.04	1.91	1.92	1.07	1.05	0.90	1.09
	Low	2.42	2.39	2.15	2.05	1.14	1.12	0.91	0.88
	Very low	2.63	2.60	2.33	2.18	1.20	1.18	1.02	0.98
Treasury term spread	High	1.40	1.40	1.39	1.41	0.75	0.75	0.75	0.79
	Average	2.02	2.01	1.96	2.15	1.00	1.00	0.97	1.26
	Low	2.28	2.27	2.14	2.29	0.93	0.92	0.88	1.01
	Very low	2.47	2.45	2.30	2.43	0.98	0.98	0.99	1.11

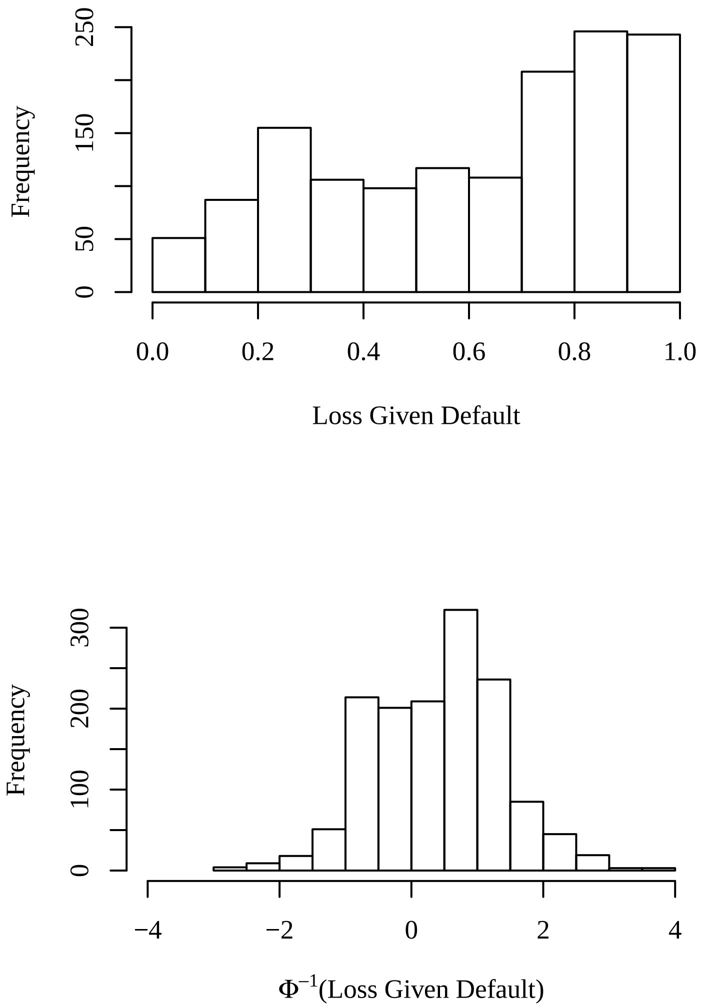
Notes: This table shows the difference of provisions and the Basel expected losses given as share of the risk-weighted assets for different portfolio qualities and macroeconomic variables using the semi-cyclical reinvestment strategy. A positive difference (excess) leads to a deduction of the CET 1 and addition to Tier 2 capital. A deficit must be deducted of the CET 1 to calculate the eligible regulatory capital. Each number corresponds to the average deduction over 100 sampled portfolios that represent 100 independent banks. Recession dates are those of the National Bureau of Economic Research.

Figure 1: The meaning behind capital and provisions



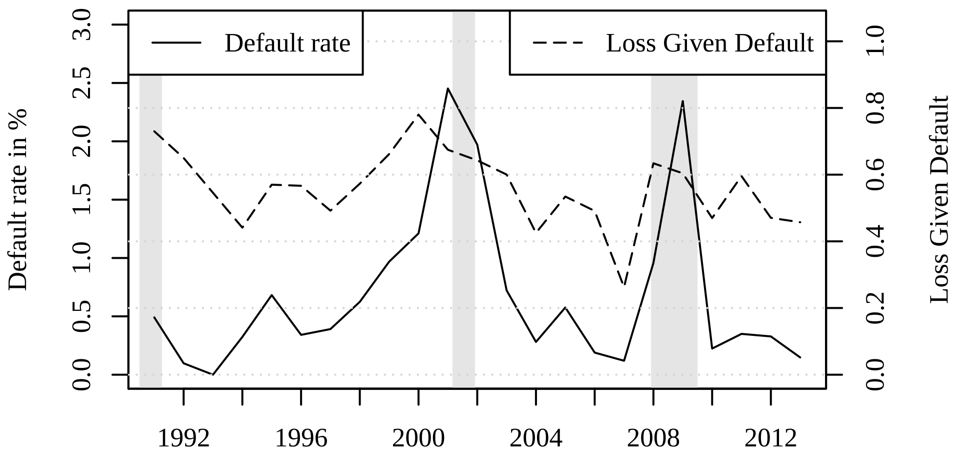
Notes: This exemplary loss distribution shows the principal links between provisions and regulatory capital. Loan loss provisioning represents the expected loss (EL) of an institution due to credit risk. Regulatory capital shall cover unexpected losses in 99.9 % of all possible future cases. The overall required amount is given by the Value at Risk (VaR).

Figure 2: Empirical distribution of Losses Given Default



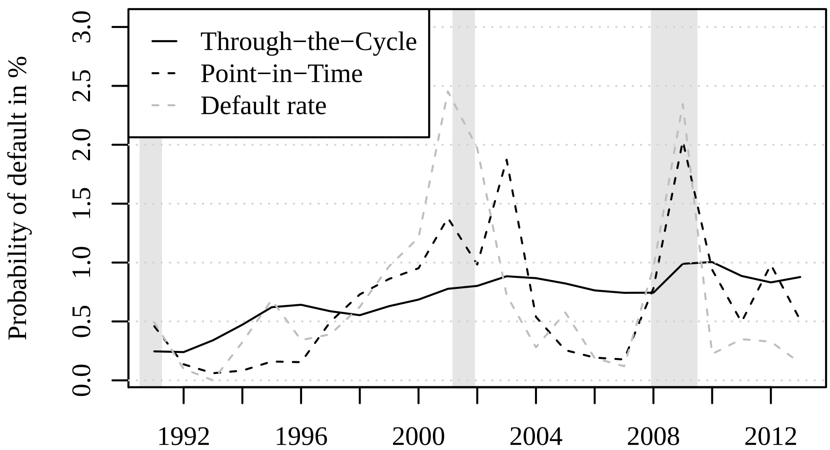
Notes: Losses given default are calculated by 1 minus the ratio of the bond price 90 days after default and the par value (left panel). These values are transformed by the inverse Gaussian cumulative distribution function Φ^{-1} for a better regression handling (right panel).

Figure 3: Default rates and mean realized Losses Given Default



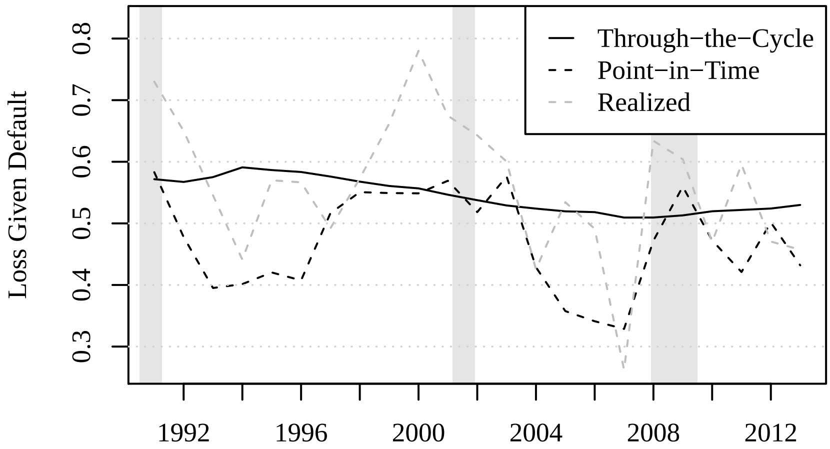
Notes: The solid line shows the default rate and the dashed line shows the mean realized LGD for each year. The shaded areas indicate recession dates of the National Bureau of Economic Research.

Figure 4: Mean predicted Probability of Default



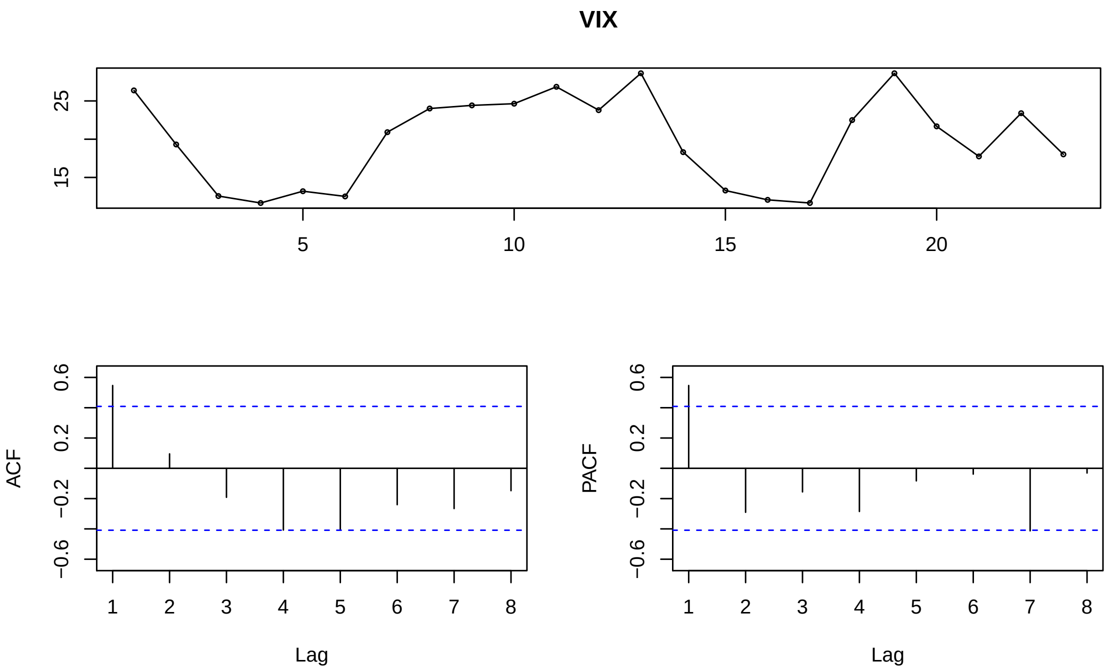
Notes: The PD for each observation is predicted by the Probit model of Table 3. The figure shows for each year the resulting mean of predictions and the corresponding realized default rate. The shaded areas indicate recession dates of the National Bureau of Economic Research.

Figure 5: Mean predicted Loss Given Default



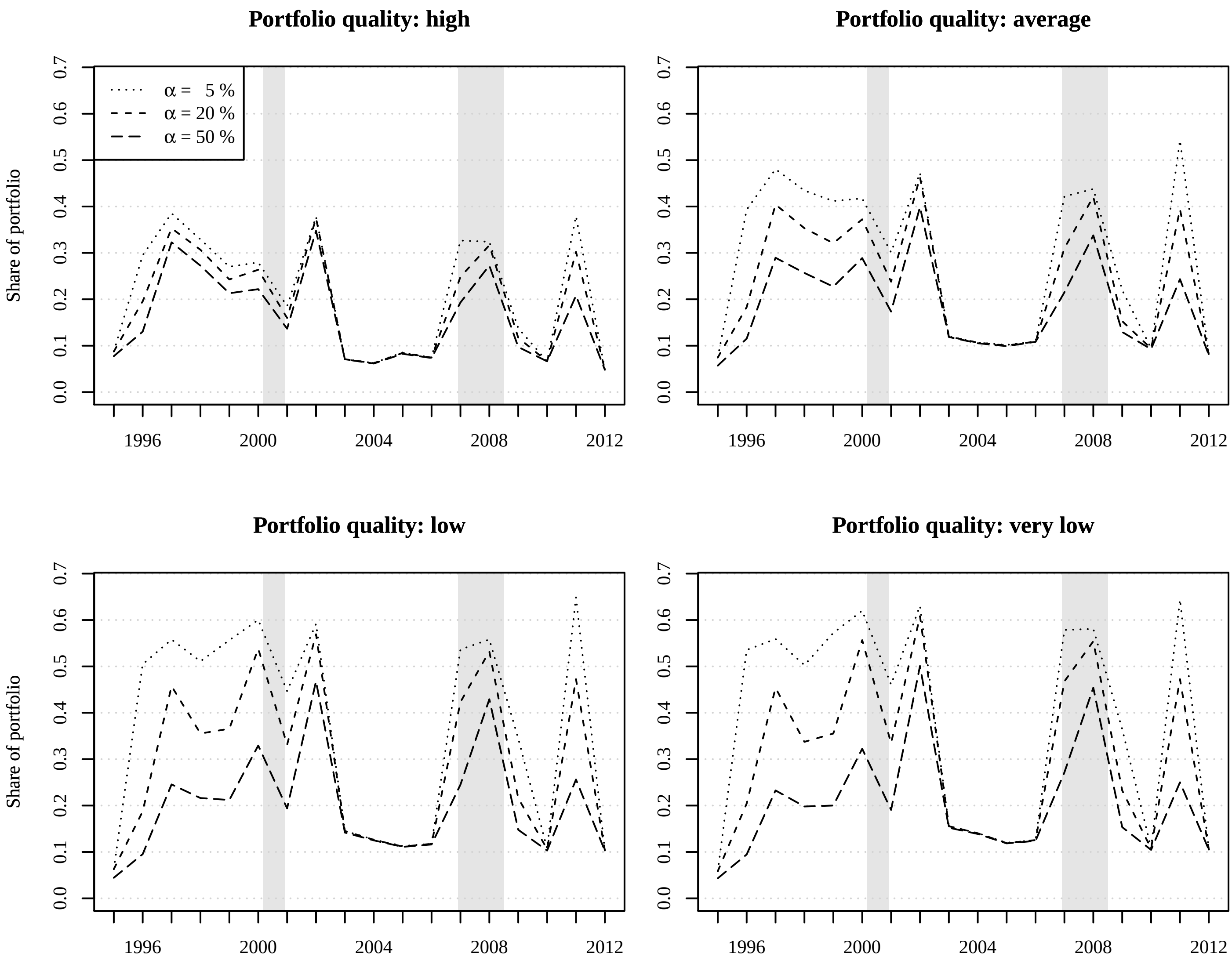
Notes: The LGD for each observation is predicted by the OLS model of Table 4. The figure shows for each year the resulting mean of predictions and the corresponding mean realized LGD. The shaded areas indicate recession dates of the National Bureau of Economic Research.

Figure 6: VIX and corresponding ACF and PACF plot



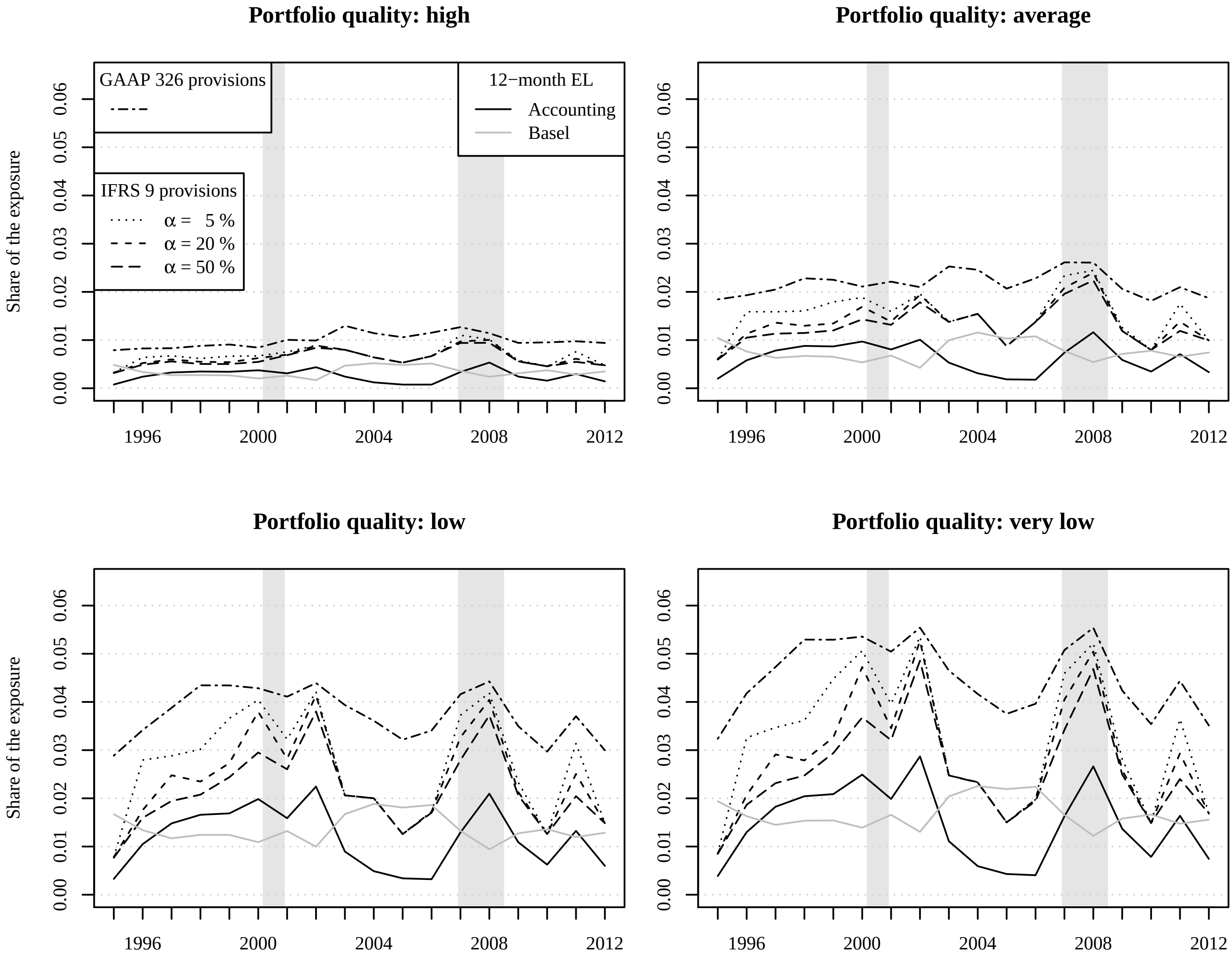
Notes: The figure shows the time-series of the VIX between 1990 and 2012 (upper panel). The autocorrelation function (ACF) and the partial autocorrelation function (PACF) suggest a time lag of one year for the autoregressive model.

Figure 7: Portfolio share of Stage 2 instruments in IFRS 9



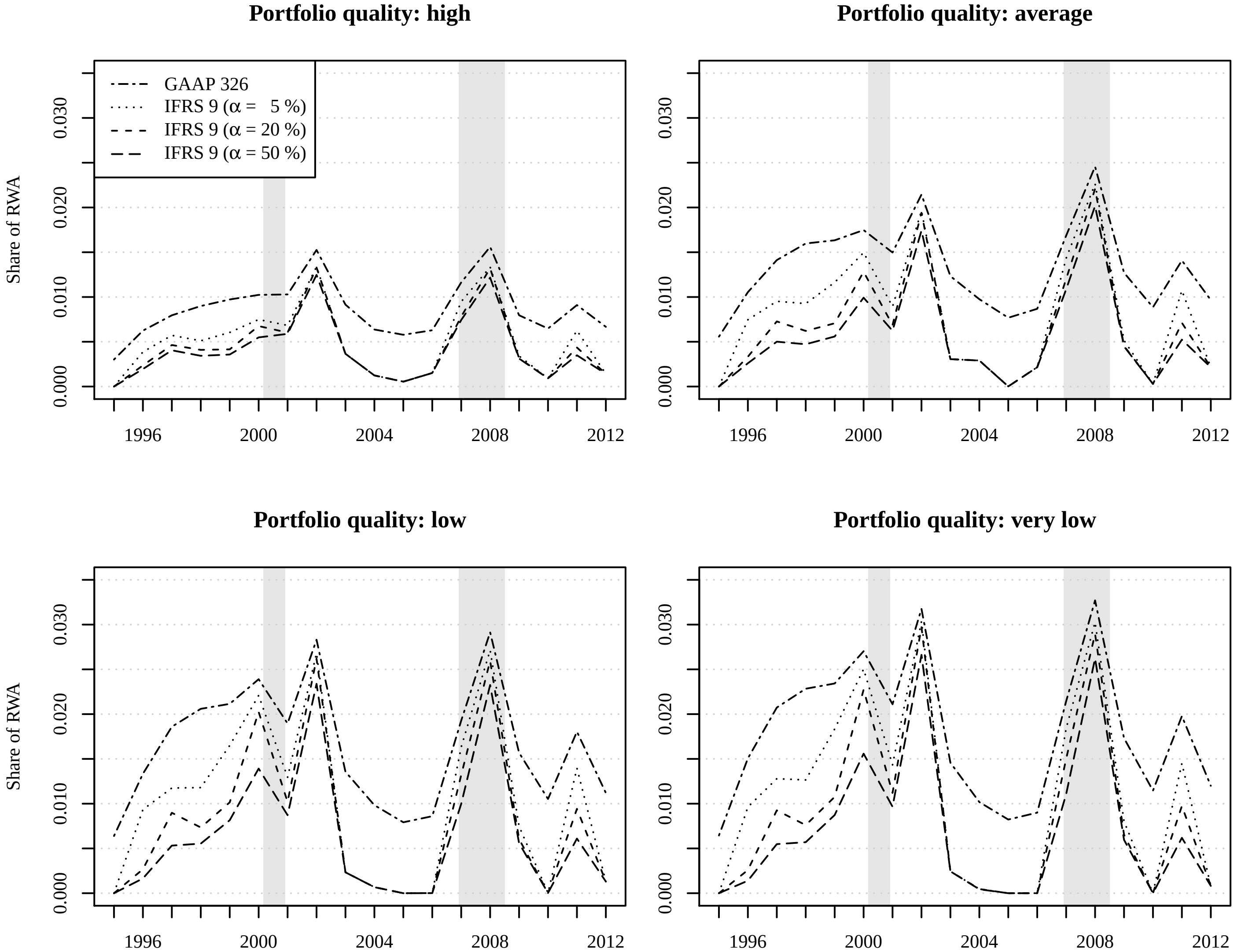
Notes: The figure shows the share of bonds in Stage 2 for different portfolio qualities using the semi-cyclical reinvestment strategy. The dashed and dotted lines represent three different SICR thresholds α in IFRS 9: 5 %, 20 % resp. 50 %. Each year (e.g., 2007) represents the financial year ending on the 31th December of the corresponding year (e.g., 31.12.2007). Each line corresponds to the average share over 100 sampled portfolios that represent 100 independent banks. The shaded areas indicate recession dates of the National Bureau of Economic Research.

Figure 8: Provisions and expected losses



Notes: The figure shows the Basel expected loss and the IFRS 9 as well as GAAP 326 provisions as share of the exposure for different portfolio qualities using the semi-cyclical reinvestment strategy. Each year (e.g., 2007) represents the financial year ending on the 31th December of the corresponding year (e.g., 31.12.2007). Each line corresponds to the average deduction over 100 sampled portfolios that represent 100 independent banks. The shaded areas indicate recession dates of the National Bureau of Economic Research.

Figure 9: Deduction of the Common Equity Tier 1 due to provisioning



Notes: The figure shows the difference of provisions and the Basel expected losses given as share of the risk-weighted assets for different portfolio qualities using the semi-cyclical reinvestment strategy. A positive difference (excess) leads to a deduction of the CET 1 and addition to Tier 2 capital. A deficit must be deducted of the CET 1 to calculate the eligible regulatory capital. Each year (e.g., 2007) represents the financial year ending on the 31th December of the corresponding year (e.g., 31.12.2007). Each line corresponds to the average deduction over 100 sampled portfolios that represent 100 independent banks. The shaded areas indicate recession dates of the National Bureau of Economic Research.