Ratings based capital adequacy for securitizations

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Abstract

This paper develops a framework to measure the exposure to systematic risk for pools of asset securitizations and measures empirically whether current ratings-based rules for regulatory capital of securitizations under Basel II and Basel III reflect this exposure. The analysis is based on a comprehensive US dataset on asset securitizations for the time period between 2000 and 2008. We find that the shortfall of regulatory capital during the Global Financial Crisis is strongly related to ratings. In particular, we empirically show that insufficient capital is allocated to tranches with the highest rating. These tranches account for the greatest part of the total issuance volumes. Furthermore, this paper is the first to calibrate risk weights which account for systematic risk and provide sufficient capital buffers to cover the exposure during similar economic downturns. These policy-relevant findings suggest a re-calibration of RBA risk weights and may contribute to the current efforts by the Basel Committee on Banking Supervision and others to re-establish sustainable securitization markets and to improve the stability of the financial system.

Key words: Asset-Backed Security, Basel II and III, Collateralized Debt Obligation, Economic Downturn, Mortgage-Backed Securities, Home Equity Loan Securities, Ratings-Based Approach, Regulation, Regulatory Capital, Risk Weights, Securitization

JEL classification: G20, G28, C51
1 Introduction

1.1 Motivation and Contributions

Asset securitizations are attractive to the financial industry as a source of funding, risk intermediation and asset and liability management. The merits of securitization, despite the controversial public discussion, are recognized by regulators. As a consequence of the Global Financial Crisis (GFC) 2007-2009 where many financial institutions worldwide suffered from tremendous losses due to investments in these products, the Basel Committee on Banking Supervision (2011) noticed a sharp decline of issuance volumes (e.g., in the US, from about US$ 2 trillion in 2007 to around US$ 400 billion in 2008). Therefore, regulators are working on re-establishing sustainable securitization markets. This paper contributes to these efforts by analyzing the rules for the ratings-based calculation of regulatory capital in relation to the financial risks of asset securitizations.

Asset securitizations include asset backed securities (ABSs), collateralized debt obligations (CDOs), commercial and residential mortgage-backed securities (CMBSs and RMBSs) and home equity loan securitizations (HELs). These instruments have been a major source of financial losses to investors and institution failures during the GFC. In hindsight, the ratings-based regulatory capital requirements for securitizations were often insufficient to cover losses during the GFC. The high default rates of structured financial instruments during the GFC indicate that securitization exposures are particularly sensitive to systematic risks.

Credit rating agencies (CRAs) consider probabilities of default (PDs) or expected losses (i.e., PDs weighted by losses given default) as key rating criteria. The structure of the credit rating models for securitizations used by the major rating agencies is quite similar. CDO evaluation models are VECTOR from Fitch rating agency (compare Fitch Ratings 2006), CDOROM from Moody’s Investors Service (compare Moody’s Investors Service 2006) and CDO Evaluator from Standard & Poor’s (compare Standard & Poor’s 2005). Rating agencies estimate expected losses or default probabilities of the different tranches as a result of these quantitative models. In these models, the default and loss rates for the individual tranches are derived from expected future cash flows generated by the underlying asset pool for different scenarios using Monte Carlo simulations. Copula or factor models are used to model the

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joint distribution of the default processes of the underlying individual assets. Cumulative portfolio loss rates are based on the combination of probabilities of default, recovery rates and asset correlations.

The current numbers of rating changes from rating agencies for structured products may indicate that ratings are very limited in terms of economic informativeness. From 2008 to 2011, the bulk of rating changes were downgrades. In 2010, Standard & Poor’s reports for European securitizations 617 upgrades and 2,663 downgrades and for US securitizations 662 upgrades and 18,461 downgrades. For January to September 2011, for European securitizations 410 upgrades and 2,177 downgrades and for the US securitizations 1,427 upgrades and 12,971 downgrades were reported. The other main rating agencies Moody’s Investors Service and Fitch Ratings report similar numbers (compare, e.g., Association of Financial Markets in Europe 2011). The large number of recent downgrades may be explained by a revision of rating agency expectations, poorer collateral performances and by changes in the rating methodologies, to address underestimated concentration- and correlation risks (compare European Central Bank 2011). The bunching of rating downgrades during economic downturns questions whether rating agencies thoroughly discriminate between systematic and non-systematic risk and whether the systematic risk of securitized products is sufficiently incorporated in the corresponding rating grades of all single tranches of a securitized exposure.

The current regulatory framework of risk-based capital provision for structured financial instruments strongly relies on the quality of a bank’s internal or external rating. Financial institutions have two ways to determine regulatory capital for securitized assets: the Ratings Based Approach (RBA) and the Supervisory Formula Approach (SFA). A bank is obliged to apply the RBA for securitization exposures if a credit rating is available.

The RBA for securitizations is attractive for its simplicity. It consists of two look-up tables displaying risk weights for long-term and short-term rated securitization tranches. The risk weights for the tranches increase with the external rating grades and vary according to the seniority of a specific tranche, the granularity of the underlying pool, and whether securitizations are included in the collateral pool (i.e., transaction is a re-securitization). The mapping tables have been crafted to match the default and loss performance of ratings prior to the GFC and their validity has not been scrutinized since this time.

The adequacy of regulatory capital requirements for securitizations under the RBA generally relies on the accuracy of external ratings. Earlier papers argue that (a) ratings-based capital
adequacy basically depends on the ability of rating agencies to measure and include systematic risk in their ratings, see Iannotta & Pennacchi (2011), and (b) securitized tranches are highly exposed to systematic risks, see Coval et al. (2009). If external ratings do not include the systematic risk accurately then capital requirements may be insufficient during periods of stress. Based on this hypothesis, the analyzed research questions and contributions of this paper are as follows.

Firstly, this paper develops a framework to empirically measure the exposure to systematic risk of the asset portfolio underlying a securitization. Existing approaches capture the systematic risk of securitized tranches, while the model underlying the calibration of risk weights for the RBA is based on the systematic risk of the asset portfolio. The accuracy of this framework is tested in Monte Carlo simulation studies.

Secondly, this paper calculates the conditional expected tranche loss (CEL) as a measure for capital based on the empirical exposure to systematic risk for securitization categories, granular and non-granular exposures, and re-securitization exposures. A comprehensive data set of asset securitizations, which includes five different transaction types with over 200,000 annual tranche observations is analyzed. We specify the impact of the effects from systematic risk of the asset portfolios on securitization exposures.

Thirdly, we compare the actual RBA capital and our calibrated ‘systematic risk implied’ CEL counterpart. As a result, the paper uncovers areas on the rating scale which provide insufficient capital coverage based on this comparison. We show that the capital shortfall from the underestimation of systematic risk predominantly relates to the tranches with higher ratings. This observation is exacerbated as the higher-rated tranches count for the larger part of issuance volumes. This is consistent with prior literature as Benmelech & Dlugosz (2010) argue that nearly 50% of the securitized tranches rated by Moody’s in 2008 were Aaa-rated. Erel et al. (2011) show that the largest write-downs and losses related to highly-rated tranches. Furthermore, the higher rated tranches are regarded as most sensitive to systematic shocks (compare, e.g., Coval et al. 2009).

Fourthly, this paper discusses ways to mitigate the gap between RBA and implied expected tranche loss. CRAs may consider changing their rating approach. Alternatively, capital regulation may have to account for the systematic risk of securitizations. This paper analyzes both alternatives and proposes that it should be capital regulation which needs to account for the higher systematic risk as it is practically challenging to influence the methodology of the rating agencies. Therefore, a re-calibration of the risk weights for securitizations in order
to avoid unexpected losses to financial institutions during economic downturns is suggested. The proposed risk weights exceed the current risk weights for the higher-rated tranches.

The remainder of the paper proceeds as follows. Section 1.2 gives a brief overview of the relevant literature. Section 2 provides an empirical analysis of ratings based capital adequacy for securitizations. Section 2.1 introduces and describes the data set of asset securitizations used in the empirical investigation and Section 2.2 develops the model framework to measure the exposure to systematic risk of pools of asset securitizations. Section 3 presents the main results and conclusions from our empirical analysis. Section 4 provides robustness tests. Finally, in Section 5 prudential regulatory policy implications are discussed.

1.2 Related Literature

This paper relates to three streams in the literature. The first stream focuses on the theoretical framework of the regulatory approaches for securitizations. The RBA is based on an analytical model for calculating capital charges based on conditional expected losses (CEL) for tranches of securitized large portfolios (so called ‘pools’) by Pykhtin & Dev (2002, 2003). The model is related to a single-factor model for individual asset returns by Merton (1974), and is also known as the ‘Gaussian factor copula model’. In order to develop a simple industry standard Peretyatkin & Perraudin (2004) have employed the Pykhtin-Dev model to calibrate risk weights for tranches of structured financial instruments. Their simulation results were considered when determining the current risk weights in the Basel documents.\(^2\) The risk weights range from 7% which is the floor for Aaa-rated tranches up to 1,250% for tranches rated below Ba3. Note that a risk weight of 1,250% implies that the whole securitization tranche has to be funded by capital as the required capital to risk-weighted assets is 8% (1,250% \times 8\% = 100\%). The SFA which is applied if no credit rating is available has been developed by Gordy & Jones (2003) and Gordy (2004). In this approach regulatory capital requirements are calculated based on a supervisory formula and require a set of input parameters provided by the investing bank. These parameters are the capital requirements prior to securitization, the weighted average loss given default of the underlying pool, the number of assets in the pool, the tranche thickness and the attachment level and relies on internal credit risk information of the bank. Our paper extends this stream by empirically estimating the parameters of the Pykhtin-Dev model for a comprehensive securitization dataset and

\(^2\) The current modified risk weight tables can be found at the web site of the Basel Committee on Banking Supervision, e.g., Basel Committee on Banking Supervision (2009).
measuring the CELs for various asset pool types. In addition, Ervin & Wilde (2001), Estrella (2004), Kashyap & Stein (2004), Gordy & Howells (2006), Heid (2007), Pederzoli et al. (2009) have analyzed the cyclicality of regulatory capital for credit risk portfolios. Santos et al. (2012) suggest a novel approach for the determination of regulatory capital for market risk. Our paper adds to this important literature by providing a proposal for a revision of regulatory capital requirements for securitisations and by discussing its cyclicality.

The second stream analyzes the effects from systematic risk on financial products. Iannotta & Pennacchi (2011) find that ratings of external rating agencies do not reflect systematic risk adequately because they focus on default probabilities or expected losses respectively. The authors argue that the ‘through-the-cycle’ approach applied by the major rating agencies is not suitable to reflect the fact that two bonds with the same probability of default and loss given default (LGD) and thus sharing the same rating, may react differently during an economic downturn. They suggest that credit spreads for corporate bonds would embed systematic risk to a far better extend than credit ratings based on physical risk measures. Accordingly, the authors conclude that banks are choosing bonds within the same rating grade that have the highest credit spreads and therefore the highest systematic risk. The authors underline that this conclusion may also explain why banks may have an interest in retaining securities on their balance sheet which are highly-rated but imply a high systematic risk.

In our paper we extend the approach by Iannotta & Pennacchi (2011) by measuring the exposure of asset pools of securitizations to systematic risk. This is important as other authors (Coval et al. (2009), Claußen et al. (2010)) show that structured financial instruments are more sensitive to systematic risk than comparable straight bonds. Moreover, these authors find that the effects are even more pronounced for multiple structure securitizations. Fender et al. (2008) show that the tranching process of a portfolio of bonds may lead to a higher probability of rating downgrades for tranched products compared to the underlying assets. Furthermore the authors find that tranching has a strong impact on the probability of large losses. Krahnen & Wilde (2009) compare risk characteristics of asset backed securities and those of corporate bonds referring to expected loss, LGD and systematic risk sensitivity across all rating grades. We then transfer the rationale by Iannotta & Pennacchi (2011) to regulatory capital for securitizations. We find that RBA capital does not adequately reflect the systematic risk exposure. This may create an incentive for financial institutions to invest in highly-rated securitizations with high systematic risk.

The third stream focusses on the quality of securitization credit ratings from external rating
agencies. The conflict of interest between the issuers and the credit rating agencies has been regarded as one source of failure for the unprecedented downgrades and defaults of higher-rated structured financial products. Originators mandate and pay the rating agencies directly (‘Paid-by-Originator-Approach’) and therefore have an incentive to select the credit rating agency offering the most optimistic rating (‘rating-shopping’). He et al. (2011) analyze this conflict of interest of the three major rating agencies and find that rating misjudgments are highly correlated with the size of the issuers and market conditions. The authors state that ratings are more optimistic for large issuers and during economic upturn periods. Pagano & Volpin (2010) suggest that rating agencies should be paid by investors rather than by issuers and require more transparent information about the underlying asset pool.

Bar-Isaac & Shapiro (2010) find that credit ratings for securitizations are more likely to understate the credit risk in booms rather than in recessions. Various authors suggest that external credit ratings assigned to securitization exposures by credit rating agencies may underestimate the underlying risk. Rajan et al. (2008) find that credit ratings omit ‘soft’ information and mis-evaluate the average credit quality of an asset portfolio. Rösch & Scheule (2012) find that capital levels for securitizations based on the RBA are insufficient to cover implied losses during economic downturns such as the GFC and provide an incentive for banks to rate and allocate capital based on the RBA rather than the SFA.

Heitfield (2008) underlines that the risk evaluation of structured securities is more difficult and exposed to more uncertainty than comparable evaluations of unstructured securities. Small estimation errors with regard to the parameters of the underlying pool may have a significant impact on the accuracy of the risk measures of the structured securities. Credit ratings do not sufficiently distinguish the performance of structured exposures under different systematic risk conditions and fail in assessing the particular risk associated with tail loss events. Benmelech & Dlugosz (2009) illustrate that there is a large gap between the credit ratings of collateralized loan obligations (CLOs) and the quality of the underlying collateral. Coval et al. (2009) argue that the extreme fragility of ratings for structured products to modest imprecision in the assessment of the risk of the underlying pool is a major reason for the failure of credit ratings. Stolper (2009) propagates a model to be introduced by the regulator which rewards credit rating agencies which do not assign inflated ratings. Griffin & Tang (2012) analyze positive adjustments to credit ratings of CDOs by a leading rating agency and find that these adjustments were not reasonably explained and are often succeeded by large downgrade numbers.

3 Compare Fons (2008), Skreta & Veldkamp (2009) and Bolton et al. (2012).
Our paper amends this stream of literature by analyzing the impact of rating deficiencies on regulatory capital. As capital is directly derived from external ratings in the RBA, their shortcomings may be transferred into capital in a straightforward way. We focus on their lack of reflecting systematic risk and provide some simple adjustments for capital risk weights rather than for the ratings themselves because the latter are much more difficult to re-design.

2 Empirical Analysis

2.1 Securitization Data

Moody’s credit rating agency has provided data on credit ratings, default and loss histories as well as descriptions of securitizations and securitization tranches. The data comprises 223,886 annual tranche observations and has been analyzed and described in prior literature (compare e.g., Rösch & Scheule 2012). We consider the data history for the period from 2000 to 2008. The data set contains five different categories of transaction observations according to the following classes: ABS (asset backed securities), CDO (collateralized debt obligations), CMBS (commercial mortgage-backed securities), HEL (home equity loans) and RMBS (residential mortgage-backed securities). In the context of the models used in the following analysis, the data set provides the ratings and characteristics of the tranches, such as attachment level and thickness, as well as impairment events. The detailed information of the rating and categorization of the tranches (e.g., seniority and granularity) enables us to determine the risk weights accurately and to calculate the capital requirements under the RBA.

In our data set retail asset portfolios comprise a large number of exposures with small amounts. They are exposed to systematic risk and can be generally considered to be granular. In particular ABSs, HELs and RMBSs relate to retail assets (e.g., auto, credit cards and mortgage loans). Corporate/wholesale asset portfolios can be considered to be non-granular because they comprise a small number of exposures with large amounts. They are exposed to idiosyncratic and systematic risk. In particular CDOs and CMBSs comprise corporate/wholesale loan portfolios and a part of ABSs exposures relates to corporate/wholesale asset portfolios (e.g., equipment loans and leases) as well. A tranche is considered to be senior according to the Basel II and III rules if it is the most senior tranche with a first claim on the assets or the cash flows in the portfolio.
We have hand-collected from the Bloomberg database securitization ratings at origination from Fitch, Moody’s and Standard & Poor’s to analyze whether the results can be generalized from Moody’s to other major rating agencies. 54,628 securitization ratings at origination which are rated by Moody’s and Standard & Poor’s, 29,323 securitization ratings at origination which are rated by Moody’s and Fitch and 18,325 securitization ratings at origination which are rated by Standard & Poor’s and Fitch. The Spearman correlation coefficient is 0.9762 for Moody’s and Standard & Poor’s, 0.9719 for Moody’s and Fitch and 0.9924 for Standard & Poor’s and Fitch. These results suggest that the information content provided by the three major rating agencies is very similar. Therefore, the results of this paper, which are based on Moody’s ratings, can be generalized to other CRAs. 4

2.2 Model Framework

2.2.1 The Model

The analytical model behind the RBA and thus the basis for the derivation of the risk weights, is the Model by Pykhtin & Dev (2002, 2003) which is an extension and generalization of the single-factor approach where a common factor is driving the default risk of a portfolio of loans. 5 It models the asset return $R_{k,t}$ of borrower $k$ at time $t$ ($k = 1, ..., K; t = 1, ..., T$) as

$$R_{k,t} = X_{i,t} \sqrt{\rho_{i,t}} + S_{k,t} \sqrt{1 - \rho_{i,t}}$$  

where $X_{i,t}$ is a sector or asset pool specific (for the pool to which the borrower belongs to) and $S_{k,t}$ an idiosyncratic risk component. $X_{i,t}$ and $S_{k,t}$ are independent and standard normal random variables. The parameter $\rho_{i,t}$ denotes the asset correlation within the pool and may vary across time and pools. The asset pool specific risk factor $X_{i,t}$ of sector $i$ ($i = 1, ..., I$) can be decomposed into two further factors:

4 Note that the extension of the analysis to other CRAs is not possible as we have their ratings at origination. Origination volumes drop during economic downturns and few observations are available during such periods.

\[ X_{i,t} = X_t^* \sqrt{\beta_i} + U_{i,t} \sqrt{1 - \beta_i} \quad (2) \]

where \( X_t^* \) denotes a macroeconomic or systematic risk factor and \( U_{i,t} \) denotes the pool specific component (see Gordy & Howells (2006)). Both factors \( X_t^* \) and \( U_{i,t} \) are standard normally distributed and serially independent. Bank portfolios can be different in their regional or industrial structure which may cause different effects from asset pool specific risk. In practice, systematic shocks do not necessarily activate changes across all pools to the same extent. In order to capture this feature, market segmentation has been introduced to the model. The parameter \( \beta_i \) denotes the factor loading of the systematic risk factor in pool \( i \) \((\beta_i \in [0, 1])\).

To derive the risk measures for securitized tranches in the single-factor model simplifying assumptions are employed. The underlying credit portfolio is assumed to be homogeneous and infinitely granular. The process of pooling and tranching assets has the effect that the idiosyncratic risk is fully diversified. The default rate of the portfolio or pool follows the ‘Vasicek-distribution’ under these assumptions. Tranches experience an impairment when the default rate of the underlying pool exceeds the relative attachment level of the particular tranche. Depending on the cumulative default distribution the default probability \( PD_{i,j,t}^{Tr} \) of a tranche \( j \) of pool \( i \) in time \( t \) with attachment level \( AL_{i,j,t} \) is given by

\[
PD_{i,j,t}^{Tr} = \Phi \left( \frac{\Phi^{-1}(\pi_{i,t}) - \sqrt{1 - \rho_{i,t}} \cdot \Phi^{-1} \left( \frac{AL_{i,j,t}}{LGD} \right)}{\sqrt{\rho_{i,t}}} \right) \quad (3)
\]

where \( \pi_{i,t} \) denotes the portfolio or pool probability of default. \( \Phi \) represents the cumulative standard normal distribution function and \( \Phi^{-1} \) its inverse. LGD denotes the loss given default of the pool. The conditional default probability of the tranche \( CPD_{i,j,t}^{Tr} \) given the realization \( x_t^* \) of the systematic risk factor \( X_t^* \) is

\[
CPD_{i,j,t}^{Tr} = \Phi \left( \frac{\Phi^{-1}(\pi_{i,t}) - \sqrt{1 - \rho_{i,t}} \cdot \Phi^{-1} \left( \frac{AL_{i,j,t}}{LGD} \right) - \sqrt{\rho_{i,t}} \sqrt{\beta_i} \cdot x_t^*}{\sqrt{\rho_{i,t}} \cdot \sqrt{1 - \beta_i}} \right) \quad (4)
\]

Depending on the cumulative loss distribution of the underlying pool the expression for the
unconditional expected loss of a tranche \( (EL_{i,j,t}^{Tr}) \) is

\[
EL_{i,j,t}^{Tr} = \frac{LGD}{AL_2 - AL_1} \left[H(AL_2) - H(AL_1)\right]
\]

with

\[
H(AL) = \begin{cases} 
\Phi_2\left(\Phi^{-1}\left(\frac{AL}{LGD}\right), \Phi^{-1}(\pi_{i,t}), \sqrt{1-\rho_{i,t}}\right), & \text{if } AL < LGD \\
\pi_{i,t}, & \text{otherwise}
\end{cases}
\]

where \( AL_1 \) is the lower attachment level and \( AL_2 \) is the upper attachment level of the particular tranche. \( \Phi_2(\cdot,\cdot,\cdot) \) denotes the cumulative bivariate normal distribution function.

Pykhtin & Dev (2002) investigate appropriate capital charges for securitized tranches based on the assumption that the tranches are held as a marginal fraction of a wider bank portfolio. They assume that the bank’s portfolio is diversified and driven by a single risk factor. Thus, aggregate losses may be modeled as a function of the single risk factor. The conditional expected loss then equals the marginal Value-at-Risk for the tranche (compare Peretyatkin & Perraudin 2004, Perraudin 2006).

The relative expected loss of the tranche conditional on the realization \( x_{i,t}^* \) of the systematic risk factor \( X_{i,t}^* \) is given by

\[
CEL_{i,j,t}^{Tr} = \frac{LGD}{AL_2 - AL_1} \left[H(AL_2) - H(AL_1)\right]
\]

with

\[
H(AL) = \begin{cases} 
\Phi_2\left(\Phi^{-1}\left(\frac{AL}{LGD}\right), \Phi^{-1}(\pi_{i,t}) + \sqrt{\rho_{i,t} \beta_i} x_{i,t}^*, \sqrt{\frac{1-\rho_{i,t}}{1-\rho_{i,t} \beta_i}}\right), & \text{if } AL < LGD \\
\Phi\left(\Phi^{-1}(\pi_{i,t}) + \sqrt{\rho_{i,t} \beta_i} x_{i,t}^* \right), & \text{otherwise}
\end{cases}
\]

Pykhtin & Dev (2002) show that this expression can be used to determine the tranche capital. The capital allocation model for securitized tranches results if \( x_{i,t}^* \) in Equation (8) is replaced by the quantile of the confidence level \( \Phi^{-1}(q) \). In Basel II/III, \( q \) is set to 99.9\%, and thus
\[ H(AL) = \begin{cases} \Phi_2 \left( \Phi^{-1} \left( \frac{AL}{LGD} \right), \frac{\Phi^{-1}(\pi_{i,t}) + \sqrt{\rho_{i,t} \beta_i} \Phi^{-1}(q)}{\sqrt{1 - \rho_{i,t} \beta_i}}, \frac{\sqrt{1 - \rho_{i,t} \beta_i}}{\sqrt{1 - \rho_{i,t} \beta_i}} \right), & \text{if } AL < LGD \\
\Phi \left( \frac{\Phi^{-1}(\pi_{i,t}) + \sqrt{\rho_{i,t} \beta_i} \Phi^{-1}(q)}{\sqrt{1 - \rho_{i,t} \beta_i}} \right), & \text{otherwise} \end{cases} \] (9)

The formula can be interpreted as the marginal Value-at-Risk for a given confidence level. \( \beta_i \) denotes the strength of the dependence between pools and can be interpreted as measure of systematic risk.

Figure 1 below shows the effect of an increasing value of \( \beta_i \) on the tranche capital (left graphic) and the Value-at-Risk (99.9th percentile) of the tranche (right graphic) respectively. For our example, we assume an LGD of 100%, a default probability of the pool of 1% and an asset return correlation of 20%. All these parameters are held constant in order to illustrate the impact of \( \beta_i \) for different tranches.

The tranche capital requirements are calculated by Equation (7) and Equation (9) for different values of \( \beta_i \) and weighted by the thickness of the tranches (left graphic). In our example, the thickness of all tranches is equal and amounts to 3%. For \( \beta_i = 1 \) all tranches require 3% regulatory capital and are therefore fully covered by capital (\( VaR = 100\% \)).

Figure 1 shows that the Value-at-Risk of all tranches is increasing with an increasing value of \( \beta_i \). However the slopes of the curves are different for the individual tranches. The VaR of the most senior tranche (Tranche 9% - 12%) is increasing on a progressive scale whereas the VaR of the First Loss Piece (FLP) (Tranche 0% - 3%) is increasing on a diminishing scale. This means that the capital requirements for the most senior tranches are growing faster for increasing values of systematic risk. In contrast, the capital requirements for the FLP, which start on a relatively high level, are increasing slower for rising values of systematic risk. The slopes of the two mezzanine tranches (Tranche: 3%-6% and Tranche: 6%-9%) increase almost proportionally.

2.2.2 Model Estimation

We estimate \( \beta_i \) for our portfolio of securitizations in order to calculate the capital requirements based on the formula given above in Equation (7) and Equation (9) and to compare the
results with the capital requirements under the RBA. We conclude that the ratings do not sufficiently consider the systematic risk for securitized tranches if the capital requirements based on our estimation for $\beta_i$ are higher compared to RBA requirements.

In order to calculate the capital requirements referring to Equation (7) and Equation (9) we additionally need to determine the parameters $\rho_{i,t}$ and $\pi_{i,t}$ next to $\beta_i$. Therefore, we apply a 2-step estimation approach. In a first step the parameters $\rho_{i,t}$ and $\pi_{i,t}$ are estimated per pool (or deal) and per year using the historic tranche default rates per rating class as proxies for the tranche-PD ($PD_{i,j,t}^{Tr}$) following Rösch & Scheule (2012). Note that the estimation of two parameters requires the funding of deals by two or more tranches. Solving Equation (3) for the attachment level as a function of the unconditional default probability of the tranche and accounting for an error term (where we assume that an attachment level is calculated according to a ‘target’ PD or rating, plus some measurement error) results in the following non-linear regression model

$$
\varepsilon_{i,j,t} = AL_{i,j,t} - LGD \cdot \Phi \left( \frac{-\sqrt{\rho_{i,t}} \cdot \Phi^{-1}(PD_{i,j,t}^{Tr}) + \Phi^{-1}(\pi_{i,t})}{\sqrt{1 - \rho_{i,t}}} \right)
$$ (10)

In a second step, we extend the estimation methodology of Rösch & Scheule (2012) to the conditional tranche-PD and use the results of the first estimation step in order to estimate the parameter $\beta_i$ for the overall observation period by Maximum Likelihood. As it is not possible to estimate $\beta_i$ for each pool or deal due to the low number of observations per pool, we have to make some simplifying homogeneity assumptions. To acknowledge however, that different classes of pools (e.g., ABS vs. HEL) may have different exposures to systematic risk, we estimate $\beta$ separately for the individual asset classes and other asset categories, which are described later on in this paper, and therefore skip the subscript $i$ in the following. Solving Equation (4) for the attachment level as a function of the conditional default probability of the tranche results in

$$
AL_{i,j,t} = LGD \cdot \Phi \left( \frac{\Phi^{-1}(\pi_{i,t}) - \sqrt{\rho_{i,t}} \cdot \sqrt{1 - \beta} \cdot \Phi^{-1}(CPD_{i,j,t}^{Tr})}{\sqrt{1 - \rho_{i,t}}} \right)
$$ (11)

We obtain the following expression if we account for an error
\[ \varepsilon_{i,j,t} = AL_{i,j,t} - \text{LGD} \cdot \Phi \left( \frac{\Phi^{-1}(\pi_{i,t}) - \sqrt{\rho_{i,t}} \cdot \sqrt{1 - \beta} \cdot \Phi^{-1}(CPD_{i,j,t}^{Tr}) - \sqrt{\rho_{i,t}} \cdot \sqrt{\beta} \cdot x_{i}^{*}}{\sqrt{1 - \rho_{i,t}}} \right) \]  

(12)

We assume the LGD of the asset portfolio to be equal to unity. Note that according to Equation (7) and Equation (9) of this model, tranches with both attachment levels above the LGD of the pool would require a capital coverage of 0%. As we are particularly interested in higher-rated tranches with typically high attachment levels, we need to assume a pool LGD of 100% in order to be able to determine the capital charges for all tranches based on the CEL-Formula and to compare them with RBA capital charges. However, we will show in Section 4 that our estimation results for \( \beta \) are robust with respect to the pool LGD assumption.

We use the actual default rates of the tranches per rating grade for each year and each asset class as a proxy for the term \( CPD_{i,j,t}^{Tr} \). We estimate \( \beta \) using the Maximum Likelihood method and the results of the first estimation (\( \pi_{i,t} \) and \( \rho_{i,t} \)) introducing three different classifications: Panel A shows the estimates for five different asset classes (i) ABS, (ii) CDO, (iii) CMBS, (iv) HEL and (v) RMBS. Panel B shows the estimates for granular and non-granular portfolios in-line with the main classification criterion in Basel II and III. Panel C shows the estimates for primary securitizations and re-securitizations.

The model is generally known as a non-linear mixed model, in which the error terms are modeled explicitly in terms of unobserved random effects \( X_{i}^{*} \). The distribution of \( \varepsilon_{i,j,t} \) conditional on a realization of the time-specific random effect \( X_{i}^{*} \) is denoted by \( p_{t}(\varepsilon_{i,j,t}|\beta, x_{i}^{*}) \). Let \( \phi(x_{i}^{*}) \) be the standard normal density function. Then the joint probability density function is \( p_{t}(\varepsilon_{i,j,t}|\beta, x_{i}^{*}) \cdot \phi(x_{i}^{*}) \) and the marginal likelihood is

\[
m(\beta) = \prod_{t=1}^{T} \int \prod_{j=1}^{J} \prod_{i=1}^{I} p_{t}(\varepsilon_{i,j,t}|\beta, x_{i}^{*}) \cdot \phi(x_{i}^{*}) dx_{i}^{*} \]  

(13)

The log of this expression is maximized to obtain the estimate of \( \beta \). We assume that \( \varepsilon_{i,j,t} \) has a normal density: \( \varepsilon_{i,j,t} \sim N(0, \sigma^{2}) \). This results in
\[
p_t(\varepsilon_{i,j,t}|\beta, x_t^*) = \frac{1}{\sigma \sqrt{2\pi}} \cdot \exp \left( -\frac{1}{2\sigma^2} \cdot \left( AL_{i,j,t} - LGD \cdot \Phi \left( \frac{\Phi^{-1}(\pi_{i,t}) - \sqrt{p_{i,t}} \cdot \sqrt{1 - \beta} \cdot \Phi^{-1}(CPD_{i,j,t}) - \sqrt{p_{i,t}} \cdot \sqrt{\beta} \cdot x_t^*}{\sqrt{1 - p_{i,t}}} \right) \right)^2 \right) \quad (14)
\]

and \( \phi(x_t^*) = \frac{1}{\sqrt{2\pi}} \cdot \exp \left( -\frac{1}{2}(x_t^*) \right) \). The log-likelihood is optimized numerically following Patefield (2002).

3 Results

The results for our estimation for \( \beta \) are presented in Table 1 (Column 1). The table additionally displays standard errors of the estimates (SE; Column 2), significance of estimation (p Values; Column 3) and number of tranche observations (N; Column 4).

[Insert Table 1 here]

Panel A shows that the pools of asset securitizations are to a large degree subject to systematic fluctuations for all asset classes. The estimates for \( \beta \) vary between 0.6048 and 0.8360. ABSs and CDOs asset portfolios are most sensitive to systematic shocks. The \( \beta \) estimates according to Panel B illustrate that non-granular pools are more sensitive to systematic risk than granular pools. The estimates for re-securitization exposures in Panel C also indicate a high systematic sensitivity of portfolios comprising securitizations.

Based on these estimates we calculate ‘implied’ CEL capital requirements. The mean CEL capital ratios per year are calculated by applying Equation (7) and Equation (9) using the parameter estimates of Panel A. Figure 2 plots these implied capital charges, as well as charges from the current RBA. The RBA capital ratios are determined by multiplying the RBA risk weight (RW) given a rating with 0.08: \( RBA_{\text{Ratio}} = RW \times 0.08 \).

[Insert Figure 2 here]

The red dashed line represents the CEL capital ratios based on the \( \beta \) estimation and the blue marked line the RBA capital ratios. The CEL capital ratios are significantly higher than the

[\footnote{Note that all subsequent analysis is based on the estimates of Panel A.}]

16
respective RBA ratios for each transaction class and for every year of the considered time period. This supports the conclusion that ratings do not capture systematic risk sufficiently.

One major property of the proposed approach is the fact that our implied systematic risk charges are calibrated to external ratings. Ratings provided by external credit rating agencies such as Fitch, Moody’s and Standard & Poor’s rate through the business cycle (i.e., do not take the business cycle into account). Several contributions in literature (e.g., Löffler (2004) and Heitfield (2005)) show that through the cycle (TTC) ratings exhibit higher default/loss rate volatility than PIT ratings. Rösch (2005) demonstrates that this can be explained by a higher exposure to systematic risk. Higher volatility due to systematic risk leads to higher VaR or conditional expected loss and, hence, higher capital.  

Our proposal measures the implied systematic risk exposure of external credit ratings and translates these into regulatory capital via the conditional expected loss.

When considering systematic risk, a further matter of discussion concerns the correlation of capital requirements with the business cycle. In our model (as in the Basel II loan IRB model), \( \pi_{i,t} \) and \( \rho_{i,t} \) are consistent with the TTC nature of external credit ratings. The cyclicality of CEL capital which can be seen in Figure 2 stems from the calibration of the TTC approach to long-run average default rates which are updated annually and reflect a modest link to the business cycle. Eventually, the correlation between CEL capital and the business cycle primarily depends on the changes of the probability of default \( \pi_{i,t} \). Given the current regime of external credit ratings, our final proposal illustrated below (Table 4 and Table 5) increases the level of regulatory capital by imposing a time-invariant ‘add-on’ for systematic risk but does not increase the cyclicality of capital.

Figure 3 presents the results of the rating-specific analysis. Implied CEL charges are plotted against RBA charges.

[Insert Figure 3 here]

For the GFC year 2008, we compute RBA and CEL capital requirements as mean capital charges per rating grade for each asset class. The x-axis denotes RBA capital and the y-axis denotes the CEL capital. A data point is on the diagonal line if RBA and CEL are the same for a given rating class. CEL and RBA capital requirements are weighted by the thickness

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7 This corresponds to loan portfolios under Basel II, where the systematic risk exposure is measured by the asset correlation.

of the tranches. Each rating grade is represented by a colored bubble. The size of the bubble illustrates the number of tranches of an individual rating grade. For all asset classes, the capital charges for tranches with ratings between B1 and Caa3 in RBA are quite similar to CEL. For CDO, HEL and RMBS the capital requirements are even lower for the CEL than for the RBA. In contrast, the CEL capital requirements for high volume tranches with ratings between AAA and Ba3 are significantly higher compared to the RBA. The capital increase is triggered by the higher-rated tranches. This provides evidence that systematic risk of higher-rated tranches is not appropriately reflected in the RBA. These findings support a re-calibration of RBA risk weights for higher-rated tranches. The following Table 2 summarizes the mean capital charges per rating grade for the RBA and the CEL formula respectively for the complete observation period.\(^9\)

\[\text{Table 2 here}\]

As an example, the mean ABS CEL (1.75%) exceeds the RBA capital requirements (0.24%) by a factor of 7.29. The corresponding factors for the remaining asset classes are as follows: HEL: 8.41, RMBS: 7.73, CDO: 2.80 and CMBS: 2.82. For the tranches rated B1 and below the corresponding factor is below one which means that RBA capital requirements exceed CEL capital requirements throughout at lower factors.

Next, we apply a more formal test as to whether CEL and RBA capital requirements are significantly different from each other. We estimate regression models of the following form

\[CEL = \alpha_0 + \alpha_1 \cdot RBA + \varepsilon\]  \hspace{1cm} (15)

where we regress CEL capital on RBA capital. The following two hypotheses are tested:

\[H_0 : \alpha_0 = 0 \hspace{1cm} H_0 : \alpha_1 = 1\]  \hspace{1cm} (16)

\(^9\) Note that we have also analyzed in extensions capital charges per rating grade per year for all asset classes. The results are consistent with the consideration of mean values for the overall time period. In some years, the RBA capital charges exceed the CEL capital charges for lower rating grades. However, the CEL formula requires more capital for the higher-rated tranches in all these instances.
If the hypotheses are rejected then CEL capital requirements differ significantly from the RBA capital requirements in terms of a constant surcharge \((\alpha_0)\) or in terms of a multiple \((\alpha_1)\). If \(\alpha_0 = 0\) and \(\alpha_1 = 1\) the capital requirements would match and be notified on the diagonal line. Table 3 presents the results of the regression analysis.

\[\text{[Insert Table 3 here]}\]

The regression analysis is performed for the crisis year 2008 and for the time period between 2000 and 2008. In both cases we distinguish between all asset classes. The figures in Table 3 show that the hypotheses are rejected and therefore underline the difference between CEL and RBA capital. For all instances the value of \(\alpha_0\) is significantly above zero which illustrates that a capital surcharge for higher-rated tranches is required. The values for \(\alpha_1\) are significantly below one (for CMBS even negative), which shows that the capital curve is flattening. Consequently, less capital is required for the lower-rated tranches.

Figure 4 illustrates the capital ratios for all rating grades according to the RBA and the CEL formula respectively.\(^\text{10}\) The results are presented for all asset classes as mean capital ratios for the entire observation period. The RBA requires a 100% coverage for the lower-rated tranches, while the mean CEL ratios fluctuate between 30% and 100%. In contrast, the higher-rated tranches generate mean CEL capital ratios of up to 60% while the RBA ratios hardly exceed 10% of tranche exposure.

\[\text{[Insert Figure 4 here]}\]

Figure 2 has shown that the capital ratios are significantly higher for the CEL formula than under the RBA. We now compare both capital ratios with the default ratios (purple solid curve) for all asset classes which are also plotted in Figure 2. The graphs show that RBA capital ratios for the transaction types CDO, HEL and RMBS are lower than the default ratios for the year 2007 and in particular for the year 2008. The capital ratios increase marginally while the default rates rise rapidly from 2007 to 2008. Unlike RBA capital ratios the CEL ratios are even in the years 2007 and 2008, well above the default ratios and provide a sufficient cover during severe economic downturns.

In a next step, we calculate the risks weights which are needed to cover the exposure to systematic risk and to meet the CEL capital requirements respectively for each rating grade (RG). Capital requirements under the RBA are calculated by: \(RBA_{\text{Capital}} = RW \times 0.08 \times \text{thickness}\). We replace RBA capital by CEL capital, as we are interested in the risk weights

\(^{10}\)Contrary to Figure 3, the capital ratios are not weighted by tranche thickness.
that match the CEL capital requirements and solve the equation for the risk weight which delivers our implied new risk weight \((RW_{\text{implied}} = \frac{CEL}{(0.08 \times \text{thickness})})\).

Table 4 shows the results of this calibration approach. We compare the average risk weights from the RBA approach for each rating grade with the implied new risk weights (Column 3). Note that the mean RBA risk weights account for the seniority and granularity of the securitized tranches. This explains why RBA risk weights may be non-monotone in rare instances (e.g., mean risk weight for Aa2 is 0.20 and mean risk weights for Aa3 is 0.19). Note that the implied new risk weights may not be monotone either. The reason for this observation is the distribution of risk characteristics of the tranches per rating class (in particular the thickness of the tranches). For regulation purposes risk weights may be smoothed and adjusted accordingly.

The new risk weights correspond to implied new rating grades according to Column 4. The new rating grades were assigned as the original rating grade with a risk weight that is equal or higher to the new risk weight. It is striking that an Aaa-rated tranche requires - based on the empirical data and the exposure to systematic risk - an implied new rating grade of Baa3. All tranches with a rating grade of Ba3 or better require risk weights which are higher than under the current RBA. The analysis suggests that the remaining tranches B1-C, which require under the current RBA a 100% coverage with equity (risk weight of 1,250%) may potentially obtain lower risk weights as a result of our calibration approach. This outcome is based on the estimated parameters and the given attachment levels in our data set applying Equation (7) and Equation (9). For a given estimated value of \(\beta\) the attachment levels of the individual tranches are decisive for reaching a 100% equity coverage or less (see Figure 1). However a conservative regulator may continue to require a 100% equity coverage. Given that the majority of tranches is rated Ba3 and above, we consider the calibration of B1-C tranches to be of a second priority.

[Insert Table 4 here]

Table 5 represents the implied new risk weights for the individual asset classes.

[Insert Table 5 here]

The results correspond to our previous findings. In addition, ABS tranches do have the highest implied new risk weights due to the high sensitivity of their underlying portfolios to systematic risks. The other asset classes follow according to the estimation of their individual \(\beta\).
In hindsight, with the implied new risk weights which correspond to the implied new rating grades, capital charges would have been sufficient to cover unexpected losses during the recent financial crisis.

Moreover, our proposal is based on risk charges for external through-the-cycle ratings. Gordy & Howells (2006) show that TTC ratings can be considered as a means for smoothing capital through the business cycle. Due to the TTC nature of external ratings and the fixed ‘add-on’, our proposal does not increase capital cyclicality. Note that the empirical data confirms that CRAs have a low likelihood to revise ratings (in particular to changes of the economy) prior to the realization of an economic downturn (compare e.g., Altman & Rijken (2004), Amato & Furfine (2004) and Löffler (2005)).

4 Robustness Checks

In order to check the accuracy of our estimation procedure, we perform a simulation study to analyze the impact of violations of the assumptions underlying the presented model. The model used to estimate $\beta$ is based on the following three key assumptions:

a) the empirical default rates per year and rating grade are reliable proxies for the conditional default probabilities of the tranches $CPD_{i,j,t}$;

b) the LGD is equal to unity;

c) $X_t$ in Equation (2) is i.i.d. and stationary.

We follow the same 2-step estimation approach used in our empirical model with the benefit that parameters of the data generating process are known in a simulation study. We generate a set of large credit portfolios by Monte Carlo simulation. These simulated portfolios are homogenous with regard to the probability of default. Correlated default events are generated based on the Gaussian one factor copula model. In line with Equation (1) and Equation (2), a common risk factor is driving the conditional default probabilities. The simulation runs over 10 years and for 50 asset portfolios simultaneously. Every portfolio is affected by the same systematic shocks. We now assume, following the results of our empirical study, that portfolios are highly dependent on realizations of systematic shocks and therefore determine $\beta$ to be $0.9$.\[\text{11}\]

\[\text{11}\] We also perform the same study for other values of beta. The test results confirm the robustness of the approach.
The portfolios are securitized into 8 tranches: AAA to an unrated First Loss Piece (FLP). The attachment levels are given as follows: AAA: 22%, AA: 18%, A: 13%, BBB: 10%, BB: 8%, B: 6%, CCC: 3%, FLP: 0.00% and are the same for each portfolio and every year. Under the assumption of infinitely granular credit portfolios, a tranche experiences an impairment if the default rate $P_{i,t}$ of the portfolio exceeds the relative attachment level of the particular tranche. The default rate is simulated via

$$P_{i,t} = LGD \cdot \Phi \left( \frac{\Phi^{-1}(\pi_{i,t}) - \sqrt{\rho_{i,t} \cdot X_{i,t}}}{\sqrt{1 - \rho_{i,t}}} \right)$$

where $X_{i,t}$ is simulated as in Equation (2). Thus, a tranche is impaired if

$$D_{i,j,t}^{Tr} = 1 \iff P_{i,t} > AL_{i,j,t}^{Tr}$$

where $D_{i,j,t}^{Tr}$ is an impairment indicator variable.

Following our empirical study we use the information of securitized tranches to estimate parameters of the pool using the Maximum Likelihood method. In a first step the parameters $\rho_{i,t}$ and $\pi_{i,t}$ are estimated per bank and per year using the historical average of tranche default rates as proxies for the tranche-PD ($PD_{i,j,t}^{Tr}$) according to Equation (10). In a second step, the results of the first estimation are used in order to estimate the parameter $\beta$ for the overall simulation period by applying again the Maximum Likelihood method (compare Equation 12). The simulation is repeated multiple times to ensure convergence of means. The results are shown in Table 6.

[Insert Table 6 here]

Our proxy for the conditional default probability of the tranches generates an average value for $\beta$ which is fairly close to the assumed value of $\beta = 0.9$. Furthermore the results show
that the variation of $LGD = 100\%$ instead of $LGD = 45\%$ has a very limited impact on the estimate for $\beta$ (assumption b)).

In a supplementary robustness test we assume according to assumption c) that systematic shocks follow an autoregressive process (AR-1):

$$X^*_t | x^*_{t-1} = x^*_{t-1} + \epsilon_t$$

with $E(\epsilon_t) = 0$, $Var(\epsilon_t) = 1$ and $E(X^*_t | x^*_{t-1}) = x^*_{t-1}$. Table 6 shows that the results are robust under these default rate dynamics.\footnote{All simulations are performed for different time series lengths. The robustness assumption is confirmed through all simulation results.}

5 Summary and Policy Implications

This paper develops a framework to measure the exposure to systematic risk of asset securitization portfolios. We measure empirically whether current ratings-based rules for regulatory capital of securitization reflect this exposure. The measure for systematic risk exposure of asset portfolios is a key parameter in the models underlying the RBA approach. The analysis is based on a US data set of asset securitizations for the time period between 2000 and 2008.

The paper finds that the shortfall of regulatory capital during the Global Financial Crisis is strongly related to ratings. In particular, the most senior tranches of securitized exposures which count for high issuance volumes are highly sensitive to the state of the economy and this exposure is not reflected in either (i) the ratings or (ii) the regulatory look-up tables, which map ratings to risk weights.

Furthermore, this paper is the first in-kind to calibrate risk weights which provide sufficient capital charges to cover the exposure during economic downturns. As a consequence, the results from our investigation suggest that prudential regulators may consider a re-calibration of the risk weights given by the current RBA approach. Due to their high volumes, the re-calibration should primarily focus on higher-rated tranches. Such a re-calibration may provide lower incentives to invest in higher-rated securities with a higher systematic exposure and may contribute to the current efforts to re-establish sustainable securitization markets.
Due to the through-the-cycle nature of external ratings our risk charges reflect higher VaR because of higher exposure to systematic risk. As they still relate to external ratings, the revised risk weights do not lead to an increase of capital cyclicality.

The re-calibration would have to be coordinated with rating agencies as they may be in the process of changing their rating methodology and continuing to do so in the future. Therefore, it may be reasonable for regulators to provide rules with regard to the standards, which are consistent with the revised RBA capital requirements.

In addition, the impact on financial markets, institutions and instruments of such a re-calibration would have to be quantified and transitionary regulations implemented to avoid larger market distortions which may be caused by the proposed changes.
References


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Löffler, G. (2005), ‘Avoiding the rating bounce: Why rating agencies are slow to react to new information’, Journal of Economic Behavior and Organization 56, 365–381.
Moody’s Investors Service (2006), ‘CDOROM v2.3 user guide’.
Fig. 1. Tranche capital, Value-at-Risk and systematic risk exposure

Notes: This figure shows the effect of $\beta_i$ on the tranche capital (left graphic) and the tranche Value-at-Risk (99.9th percentile) of the tranche (right figure) respectively. We assume an LGD of 100%, a default probability of the pool of 1% and an asset return correlation of 20%. Tranche capital requirements are calculated by Equation (7) and Equation (9) for different values of $\beta_i$ and weighted by the thickness of the tranches (left figure). The thickness of all tranches is equal and amounts to 3%. For $\beta_i = 1$, all tranches require 3% regulatory capital and are therefore fully covered by capital ($VaR = 100\%$). The Value-at-Risk of all tranches is increasing with an increasing value of $\beta_i$. However, the slopes of the curves are different for the individual tranches. The VaR of the most senior tranche (Tranche 9% − 12%) is increasing on a progressive scale whereas the VaR of the First Loss Piece (FLP) (Tranche 0% − 3%) is increasing on a diminishing scale. This means that the capital requirements for the most senior tranches are growing faster for increasing values of systematic risk. In contrast, the capital requirements for the FLP, which start on a relatively high level, are increasing slower for rising values of systematic risk.
Fig. 2. Empirical RBA and CEL capital and default ratios, per year

Notes: This figure shows the empirical RBA capital ratios (blue marked line), the CEL capital ratios based on our $\beta$-estimation (red dashed line) and the default rates (purple solid line) per transaction type for the time period 2000 - 2008. CEL capital ratios are significantly higher than the respective RBA capital ratios for each transaction type. Furthermore, the default ratios exceed RBA capital ratios in the years 2007 and especially 2008 for the transaction types CDO, HEL and RMBS. In contrast, CEL capital ratios are above the default rates in all years including the economic downturn in 2007 and 2008.
Fig. 3. Empirical RBA and CEL capital requirements per rating-category, weighted by tranche thickness

Notes: This figure plots the relation between mean RBA capital requirements (x-axis) and mean CEL capital requirements (y-axis) per rating grade based on the empirical data in 2008 for each asset class. CEL and RBA capital requirements have been weighted by the thickness of the tranches. Each bubble represents an individual rating grade and the size of the bubble indicates the number of tranches in every rating category. Evidently, CEL capital requirements for the higher-rated, high volume rating categories, are much higher than RBA capital requirements. RBA capital requirements for the lower-rated, low volume tranches are similar or even higher compared to CEL capital requirements.
Notes: This figure shows the relation between mean RBA capital ratios (x-axis) and mean CEL capital ratios (y-axis) per rating grade and securitization class and for the time period 2000 – 2008. The RBA requires a 100% coverage for the lower-rated tranches while mean CEL ratios fluctuate between 30% and 100%. The higher-rated tranches generate mean CEL capital ratios up to 60% while RBA ratios hardly cover 10% of tranche exposure. Mean RBA capital ratios increase for rating grade Aaa to Ba3 with deteriorating rating grades up to 52% tranche coverage. RBA capital ratios of tranches rated below Ba3 are by regulation 100%. In contrast, the mean CEL capital ratios increase more continuously up to a maximum coverage of 98%.
Tables

Table 1
Empirical $\beta$ estimation

This table shows the results of our $\beta$ estimation approach based on the empirical data for each asset class (Panel A), for the classification regarding granularity (Panel B) and for re-securitization exposures (Panel C). Retail asset portfolios comprise a large number of exposures with small amounts. These may be considered to be granular. In particular ABSs, HELs and RMBSs generally relate to retail assets (e.g., auto, credit cards and retail loans). Corporate/wholesale asset portfolios can generally be considered to be non-granular because they comprise a small number of exposures with large amounts. They are exposed to idiosyncratic and systematic risk. In particular CDOs and CMBSs comprise corporate/wholesale loan portfolios and a part of ABSs exposures relates to corporate/wholesale asset portfolios (e.g., equipment loans and leases) as well. The table additionally displays standard errors of estimation (SE), significance of estimation (p Value) and number of tranche observations (N). Note that the values for $\beta$ appear to be comparatively high. This indicates that pools of asset securitizations are highly sensitive to systematic risk. ABSs, CDOs and non-granular asset portfolios are more sensitive to systematic risk than others.

<table>
<thead>
<tr>
<th></th>
<th>$\beta$</th>
<th>SE</th>
<th>p Value</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel A: by securitization category</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ABS</td>
<td>0.8360</td>
<td>0.0064</td>
<td>&lt;0.0001</td>
<td>16,313</td>
</tr>
<tr>
<td>CDO</td>
<td>0.7176</td>
<td>0.0100</td>
<td>&lt;0.0001</td>
<td>26,593</td>
</tr>
<tr>
<td>CMBS</td>
<td>0.6994</td>
<td>0.0107</td>
<td>&lt;0.0001</td>
<td>30,874</td>
</tr>
<tr>
<td>HEL</td>
<td>0.6821</td>
<td>0.0071</td>
<td>&lt;0.0001</td>
<td>64,681</td>
</tr>
<tr>
<td>RMBS</td>
<td>0.6048</td>
<td>0.0245</td>
<td>&lt;0.0001</td>
<td>75,103</td>
</tr>
<tr>
<td>Panel B: by granularity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Granular</td>
<td>0.8618</td>
<td>0.0021</td>
<td>&lt;0.0001</td>
<td>151,789</td>
</tr>
<tr>
<td>Non-granular</td>
<td>0.9462</td>
<td>0.0014</td>
<td>&lt;0.0001</td>
<td>61,775</td>
</tr>
<tr>
<td>Panel C: for re-securitization exposures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Re-sec.</td>
<td>0.8227</td>
<td>0.0051</td>
<td>&lt;0.0001</td>
<td>1,499</td>
</tr>
<tr>
<td>Sec.</td>
<td>0.9028</td>
<td>0.0013</td>
<td>&lt;0.0001</td>
<td>213,564</td>
</tr>
</tbody>
</table>
This table presents the mean capital requirements per rating category for the RBA and CEL approach for the overall time period and for each securitization class. Evidently, CEL capital requirements for the higher-rated tranches are higher than RBA capital requirements. In contrast, RBA capital requirements for the lower-rated tranches are similar or higher compared to CEL capital requirements. These results are consistent with Figure 3 which relates to the GFC year (2008).

<table>
<thead>
<tr>
<th>Panel A: ABS</th>
<th>Aaa</th>
<th>Aa1</th>
<th>Aa2</th>
<th>Aa3</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>Baa1</th>
<th>Baa2</th>
<th>Baa3</th>
<th>Ba1</th>
<th>Ba2</th>
<th>Ba3</th>
<th>B1</th>
<th>B2</th>
<th>B3</th>
<th>Caa1</th>
<th>Caa2</th>
<th>Caa3</th>
</tr>
</thead>
<tbody>
<tr>
<td>RBA</td>
<td>0.0024</td>
<td>0.0014</td>
<td>0.0015</td>
<td>0.0010</td>
<td>0.0014</td>
<td>0.0021</td>
<td>0.0027</td>
<td>0.0036</td>
<td>0.0057</td>
<td>0.0177</td>
<td>0.01740</td>
<td>0.0412</td>
<td>0.0871</td>
<td>0.0625</td>
<td>0.0641</td>
<td>0.0564</td>
<td>0.0654</td>
<td>0.0839</td>
<td></td>
</tr>
<tr>
<td>CEL</td>
<td>0.0175</td>
<td>0.0201</td>
<td>0.0198</td>
<td>0.0170</td>
<td>0.0247</td>
<td>0.0230</td>
<td>0.0283</td>
<td>0.0356</td>
<td>0.0367</td>
<td>0.0437</td>
<td>0.0604</td>
<td>0.0383</td>
<td>0.0634</td>
<td>0.0711</td>
<td>0.0501</td>
<td>0.0588</td>
<td>0.0431</td>
<td>0.0607</td>
<td>0.0825</td>
</tr>
<tr>
<td>Panel B: CDO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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Table 3
Regression analysis

The table shows the results of our regression analysis testing whether CEL and RBA capital requirements are significantly different. Our linear regression model is given by the following expression and the two hypotheses are tested:

\[ CEL = \alpha_0 + \alpha_1 \cdot RBA + \varepsilon \]

\[ H_0: \alpha_0 = 0 \quad H_0: \alpha_1 = 1 \]

The regression analysis is performed for the year 2008 and for the time period between 2000 and 2008. In both cases we distinguish between all asset classes. The figures show that both hypotheses are rejected and therefore underline the difference between CEL and RBA capital. For all cases the value of \( \alpha_0 \) is significantly positive which illustrates that a capital surcharge for higher-rated tranches is required. The values for \( \alpha_1 \) are significantly below one (for CMBS even negative) which shows that the capital curve is flattening. A lower amount of capital is required for the lower-rated tranches according to the CEL relative to the RBA. The significance is indicated as follows: \( ** \): significant at 1%, \( ** \): significant at 5%.

<table>
<thead>
<tr>
<th></th>
<th>( \alpha_0 )</th>
<th>SE</th>
<th>( \alpha_1 )</th>
<th>SE</th>
<th>( R^2 )</th>
</tr>
</thead>
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<td>Year 2008</td>
<td></td>
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<td>0.0056</td>
<td>0.7533***</td>
<td>0.1160</td>
<td>0.7127</td>
</tr>
<tr>
<td>CDO</td>
<td>0.0187***</td>
<td>0.0020</td>
<td>0.4031***</td>
<td>0.0717</td>
<td>0.6503</td>
</tr>
<tr>
<td>CMBS</td>
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<td>0.0008</td>
<td>-0.1370***</td>
<td>0.1889</td>
<td>0.0300</td>
</tr>
<tr>
<td>HEL</td>
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<td>0.0008</td>
<td>0.2747***</td>
<td>0.0805</td>
<td>0.4066</td>
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<tr>
<td>RMBS</td>
<td>0.0026***</td>
<td>0.0004</td>
<td>0.2935***</td>
<td>0.0987</td>
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<td>Years 2000-2008</td>
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<tr>
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<td>0.0006</td>
<td>0.5982***</td>
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<td>0.7414</td>
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</table>
Table 4
Implied new mean risk weights of all asset classes

This table denotes the mean RBA risk weights in comparison to implied new risk weights based on our estimation of $\beta$. The mean RBA risk weights account for the seniority and granularity of our securitized tranches (Column 2), which explains that RBA risk weights may be non-monotone in rare instances (mean risk weight for Aa2 is 0.20 and mean risk weights for Aa3 is 0.19). The difference between mean RBA risk weights and implied new risk weights is substantial and indicates the gap of capital based on the estimated systematic risk factor $\beta$. Finally, in the last column we show the rating grade that would match the new risk weights.

<table>
<thead>
<tr>
<th>Rating grade</th>
<th>mean RW</th>
<th>implied new RW</th>
<th>implied new RG</th>
</tr>
</thead>
<tbody>
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<td>0.88</td>
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</tr>
<tr>
<td>Aa1</td>
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<td>Ba2</td>
</tr>
<tr>
<td>Aa2</td>
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<td>Ba2</td>
</tr>
<tr>
<td>Aa3</td>
<td>0.19</td>
<td>3.18</td>
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<td>0.26</td>
<td>4.01</td>
<td>Ba2</td>
</tr>
<tr>
<td>A2</td>
<td>0.27</td>
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<td>Ba2</td>
</tr>
<tr>
<td>A3</td>
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<td>Ba3</td>
</tr>
<tr>
<td>Baa1</td>
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<td>Ba3</td>
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<td>Baa2</td>
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<td>Ba3</td>
</tr>
<tr>
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<td>B1 and worse</td>
</tr>
<tr>
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<td>7.86</td>
<td>B1 and worse</td>
</tr>
<tr>
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<td>7.79</td>
<td>B1 and worse</td>
</tr>
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<td>Ba3</td>
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<td>Caa3</td>
<td>12.50</td>
<td>10.34</td>
<td>B1 and worse</td>
</tr>
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</table>
Table 5
Implied new mean risk weights per individual asset class

This table gives an overview of the mean RBA risk weights in comparison to the implied new risk weights based on our estimation of $\beta$ for each individual asset class. The implied new risk weights are the highest for ABS and CDO (highest estimated $\beta$) and the lowest for RMBS (lowest estimated $\beta$).

<table>
<thead>
<tr>
<th>Rating</th>
<th>ABS</th>
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<th>RMBS</th>
<th>CDO</th>
<th>CMBS</th>
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<td>ø RW</td>
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<td>ø RW</td>
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36
Robustness test

This table shows the results of the simulation study to analyze the robustness of the estimation for $\beta$, which is robust with respect to the assumption for the CPD proxy and the assumption of a LGD of 100%. The table also presents the results for the assumption that systematic shocks follow an autoregressive process (AR-1). The robustness supposition is confirmed for this assumption as well. SE denotes the empirical standard deviation.

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<td>b) $CPD^T$</td>
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<tr>
<td>c) with AR(1) process</td>
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