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Bank Regulation:

One Size Does Not Fit All

Dissertation

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One Size Does Not Fit All

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To my wonderful wife and my adorable sons.

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List of Abbreviations

APRA	Australian Prudential Regulation Authority
AT1	Additional Tier 1
BaFin	Bundesanstalt für Finanzdienstleistungsaufsicht
BBVA	Banco Bilbao Vizcaya Argentaria
BCBS	Basel Committee on Banking Supervision
BS	Balance Sheet
CAPM	Capital Asset Pricing Model
CBRC	China Banking Regulatory Commission
CET1	Common Equity Tier 1
CRD	Capital Requirements Directive
CRR	Capital Requirements Regulation
D-SIB	Domestic Systemically Important Bank
EBA	European Banking Authority
ECB	European Central Bank
EP	European Parliament
ES	Expected Shortfall
FE	Fixed Effects
GDP	Gross Domestic Product
GFMA	Global Financial Market Association
G-SIB	Global Systemically Important Bank
ICAAP	Internal Capital Adequacy Assessment Process
ICMA	International Capital Market Association
IIF	Institute of International Finance
ILAAP	Internal Liquidity Adequacy Assessment Process
IMF	International Monetary Fund
LAR	Liquid Asset Ratio
LCR	Liquidity Coverage Ratio
LLRR	Loan Loss Reserve Ratio
LSI	Less Significant Institution
mES	Modified Expected Shortfall
MFI	Monetary Financial Institution

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M/M	Modigliani and Miller
mVaR	Modified Value-at-Risk
NSFR	Net Stable Funding Ratio
Obs.	Observations
OLS	Ordinary Least Squares
O-SII	Other Systemically Important Institution
P1R-BM	Pillar 1 Requirements for Business Models
P2R	Pillar 2 Requirements
R	Retail Bank
RE	Random Effects
ROA	Return on Assets
RORWA	Return on Risk-Weighted Assets
RWA	Risk-Weighted Assets
SD	Standard Deviation
SI	Significant Institution
SIFI	Systemically Important Financial Institution
SREP	Supervisory Review and Evaluation Process
T	Trading Bank
T2	Tier 2
VaR	Value-at-Risk
VLaR	Value-Liquidity-at-Risk
VLES	Value Liquidity Expected Shortfall
W	Wholesale Bank
WACC	Weighted Average Cost of Capital
WAC(R)C	Weighted Average Cost of Regulatory Capital
W+T	Wholesale and Trading Banks

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Summary

The intensity and the scope of which banks are regulated and supervised have accelerated since the outbreak of the **financial crisis** in 2007. The crisis revealed the weak points in the previous regulation of banks with high levels of on- and off-balance sheet leverage, low quality of equity, inadequate liquidity buffers, or unstable funding structures. The trading and credit losses, which banks were not able to absorb resulted "*in a massive contraction of liquidity and credit availability*" (BCBS, 2011, p. 1), forcing central banks and governments across the world to support the financial system with liquidity, capital, and guarantees (BCBS, 2011). At the same time, banks with lower-risk business models, i.e., lower off-balance sheet leverage or stable funding sources, were less affected. However, unequal business models are still regulated the same.

As a consequence of the financial turmoil, the Basel Committee on Banking Supervision (BCBS) revised the three Pillars of the **regulatory framework**[1] to strengthen the global financial system and to reduce future spillovers to the real economy (BCBS, 2011). Among other things in Pillar 1, the reformed Basel III framework raised the quality and quantity of regulatory capital, introduced the new non-risk-sensitive leverage ratio to limit the off-balance sheet exposure, and presented two new liquidity standards. One of the two is the net stable funding ratio (NSFR), which promotes banks to fund long-term assets with stable long-term liabilities (BCBS, 2011). Basel III and its implementation in Europe via the Capital Requirements Regulation (CRR) and the Capital Requirements Directive (CRD) is mandatory for all banks with additional requirements for systemically relevant banks. Building on it, the European Banking Authority (EBA) designed Pillar 2 guidelines for a supervisory review and evaluation process (SREP). The European SREP consists of four parts: one, the assessment of risk to capital, two, the liquidity and funding, three, the internal governance and institutional wide controls, and four, the assessment of the business model. The latter is supposed to cover individual bank risks that are not fully considered in Pillar 1. Based on the results of the SREP, the ECB can ask individual banks for additional capital and liquidity requirements (EBA, 2014b).

[1] The regulatory framework covers minimum capital and liquidity requirements in Pillar 1, the supervisory review process in Pillar 2, and risk disclosures for market discipline in Pillar 3. The focus of the Ph.D. thesis is on the first and second Pillar. The third Pillar will not be considered in more detail.

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However, the **academic problems** with the regulatory framework are the equal treatment of unequal banks and the neglect of the differences between business models in Pillar 1. All banks are asked to comply with the same requirements "*no matter whether a bank pursues a low-risk or a high-risk business strategy*" (Grossmann, 2017, p. 2). Even if the SREP in Pillar 2 started to examine the business model of an individual bank, it disregards a systematic and consistent consideration of business models. Moreover, the SREP concept of the EBA is primarily used for significant institutions (SI, see ECB, 2018) in Europe. A harmonized Pillar 2 framework across regulatory jurisdictions, which also includes less significant institutions (LSI), does not exist. An exemplary overview of different regulatory concepts is provided in Appendix I of the summary. The given obstacles motivate a comprehensive integration of business models in Pillar 1. Otherwise, the mentioned problems could lead to an over-regulation of low-risk business models or, even worse, an under-regulation of high-risk business models regardless of the size or the systemically relevance of an individual bank. If the treatment of business models is internationally not harmonized, "*competitive disadvantages between European and global banks, due to different capital requirements, or […] regulatory arbitrage*" (Grossmann and Scholz, 2017, p. 2), could emerge.

Against this backdrop, the **aim** of the cumulative Ph.D. thesis is to show that a **one size** regulatory approach in Pillar 1 **does not fit all** banks. Therefore, the differences between retail, wholesale, and trading banks are taken into account to investigate whether diverse, but internationally harmonized capital and liquidity requirements for business models in Pillar 1 of the Basel framework are desirable and how they can be derived. Aiming at this, scientific risk management methodologies are applied to evaluate:

- Part I: How retail, wholesale, and trading bank business models react to higher capital requirements and shifts in funding structure.
- Part II: How the leverage ratio can be adjusted to consider the riskiness of different banks and to examine the resulting consequences for retail, wholesale, and trading bank business models.
- Part III: The risk of higher refinancing costs to assess whether retail, wholesale, and trading bank business models are subject to diverse funding liquidity risks and need to be regulated differently.

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The investigation of the research questions focuses on the heterogeneous European banking sector with banks of different sizes, strategies, and business objectives. Within this financial sector, certain banks show structural similarities regarding the risk characteristics (e.g., Altunbas et al., 2011, Ayadi et al., 2016), the risk of default (e.g., Koehler, 2015), profitability, business activities, or balance sheet structure (e.g., Roengpitya et al., 2014) and can, therefore, be clustered into strategic groups[2] (Porter, 1979) of competitive **bank business models**. The choice of a strategic business model is based on the long-term general orientation and the risk appetite of a bank's management (Mergaerts and Vander Vennet, 2016) as well as of the institute's statute. Depending on the scope of research, varying numbers of strategic groups are identified and analyzed. A list with the literary background regarding the research on bank business models, which primarily concentrates on identifying strategic groups or analyzing specific attributes, is shown in Appendix II. Most commonly known, Ayadi et al. (2016) cluster five groups of business models and Roengpitya et al. (2014) define three different business models, namely retail, wholesale, and trading banks. For example, retail banks concentrate on loan activities, which are mainly refinanced with customer deposits. Wholesale banks also focus on loan activities, but rely more on short-term banking and non-current liabilities for the funding. On the other hand, trading banks use diverse capital market-oriented funding strategies for the refinancing of trading and investment activities (Roengpitya et al., 2014, Hull, 2015). During the financial crisis, wholesale and trading banks were particularly hit harder compared to retail banks due to higher shares of unstable funding, lower equity ratios, and higher on- and off-balance sheet leverage. Consequently, the similarities within one business model group can be used "*as an additional indicator of emerging risks*" (Grossmann and Scholz, 2017, p. 1) for the regulation of banks to counteract the described problems of the regulatory framework.

For the analyses, an unbalanced **sample** of up to 120 European banks[3] with observations for the years 2000 to 2013 is used. The data are collected from the database bankscope and extensively supplemented with publicly available information from several statistics of the Deutsche Bundesbank, disclosure reports of banks, and time series for funding

[2] As an alternative, the banking sector could be separated by the ownership structure of banks. However, due to two- and three-pillar banking systems, the comparability among international banking sectors or different regulatory jurisdictions is restricted.
[3] A list of banks incorporated in the analyses is shown in Appendix V of the second paper (Part II).

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spreads. Due to the scope and the utilized variables, the number of observations varies for the three parts. The bankscope data, which was available for the thesis, consists of small, medium, and large European banks. The latter belong to the biggest bank holding companies in Europe based on the balance sheet total at the end of 2013 or the last known date within the observed timeframe. The high share of small- and medium-sized German banks is exemplarily chosen because the banking sector in Germany is one of the largest in Europe and data regarding regulatory Tier 1 capital are disclosed by small- and medium-sized German banks since 2008.

The bank sample is **split** into retail, wholesale, and trading bank business models. For the allocation, a procedure based on Roengpitya et al. (2014) is defined, which focuses on the balance sheet structure of assets, the funding structure of liabilities, and the trading activities of each bank in every year. The business models presented by Roengpitya et al. (2014) are chosen because of the same underlying database and the possibility to calculate the applied key ratios. Since the majority of observations belong to retail banks, a combined sample of wholesale and trading banks is observed as well. It should be kept in mind that the applied procedure for the allocation of the sample is limited to three types of business model. A more granular separation of the banking sector, however, requires supplementary information and internal data regarding the strategic objectives and target ratios for future balance sheet structures. Given the constraints, "*the applied procedure […] offers an objective approach based on financial statements with realized business activities and funding structures*" (Grossmann, 2017, p. 9).

The Ph.D. thesis is built on three **cumulative papers,** which are based on one another thematically, but are independent of each other. The papers contribute to the field of research about retail, wholesale, and trading bank business models and the prudential regulation of banks by closing open research gaps about the impact of additional capital requirements, the development of adjusted leverage ratios, and the assessment of liquidity-induced equity risks. As a side-effect, it is shown that regulatory ratios can be derived from scientific methodologies. The focus of the first and second paper is on capital requirements for business models, whereas the third paper focuses on the liquidity regulation of business models. Table 1 summarizes the research approach, the different methodical concepts, and key findings for the three parts of the thesis, which have been published or accepted for publication in peer-reviewed European scientific journals.

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Table 1

Cumulative Research Design

	Part I	Part II	Part III
Title	Bank Regulation: One Size Does Not Fit All	Leverage Ratios for Different Bank Business Models	The Golden Rule of Banking: Funding Cost Risks of Bank Business Models
Aim	Assessment of higher capital requirements and shifts in funding structure	Consideration of diverse risks of business models for capital requirements	Assessment of higher refinancing costs and its effect on funding cost risks
Focus	Equity Ratio - Net Return on Tier 1 Capital and Leverage	Leverage Ratio - Net Return on Non-Risk-Weighted Assets	Funding Liquidity Risk - Funding Gaps and VLaR relative to Equity
Scientific Value	Reveal differences of business models for capital requirements	Development of adjusted leverage ratios for business models	Reveal differences of business models for liquidity requirements
Timeframe	2000 - 2013	2000 - 2013	2000 - 2013
Sample	85 German Banks 30 European Banks	89 German Banks 31 European Banks	87 German Banks 31 European Banks
Data	615 Observations	1,265 Observations	1,238 Observations
Database	Bankscope	Bankscope	Bankscope
Additional Data	▪ Disclosure Reports ▪ Banking Statistics ▪ Securities Statistics	▪ Financial Structure	▪ Banking Statistics ▪ Securities Statistics ▪ Funding Spreads
Method	▪ WAC(R)C ▪ Proxy-Model ▪ OLS, RE, FE	▪ VaR - Historical ▪ ES - Historical	▪ VLaR - Historical ▪ VLES - Historical
Subsample	▪ Retail Banks ▪ Wholesale Banks ▪ Trading Banks ▪ W+T Sample	▪ Retail Banks ▪ Wholesale Banks ▪ Trading Banks ▪ W+T Sample ▪ Pre/Post-Crisis ▪ EU and GER	▪ Retail Banks ▪ Wholesale Banks ▪ Trading Banks ▪ W+T Sample ▪ Pre/Post-Crisis ▪ EU and GER
Robustness Check	▪ Control Variables ▪ Government Support ▪ Actual Leverage ▪ Fixed Effect Intercept ▪ Interest Rate Debt ▪ Without Tax-Effect	▪ Gaussian Approach ▪ Modified Approach	▪ Gaussian Approach ▪ Modified Approach ▪ Change of Maturities ▪ Input Parameters ▪ Rating Transition ▪ Shift Scenarios
Publication	Journal of Applied Finance and Banking (Blind Peer-Review)	Credit and Capital Markets (Blind Peer-Review)	Journal of Banking Regulation (Blind Peer-Review)

Notes: Overview of the research design for the three parts of the cumulative Ph.D. thesis.

Part I - Bank Regulation: One Size Does Not Fit All

The first part of the thesis contributes by examining the impact of additional capital requirements and the corresponding shifts in funding structure on different bank business models (cf. Grossmann and Scholz, 2017). Based on the example of a non-risk-sensitive equity ratio and an adapted methodology proposed by Miles et al. (2012), the 'Weighted Average Cost of Regulatory Capital' (WAC(R)C) for retail, wholesale, and trading banks is calculated. Since most banks in the sample are unlisted, a statistical proxy-model built on coefficient estimates from pooled ordinary least squares (OLS), fixed effects (FE), and random effects (RE) regression models, with and without control variables, is applied to calculate the return on Tier 1 capital for the WAC(R)C. The regression estimates for the proxy-model display a positive link between the historical net return on Tier 1 capital and leverage and can reflect an investor's risk preference. For the calculation of the WAC(R)C, an equity ratio of 3% and a potential doubling to 6% are exemplarily used and the relative impact between business models is compared. In addition, robustness checks are calculated for different interest rates, tax-effects, or actual leverage ratios.

Overall, it can be found that business models are affected differently by higher capital requirements, regardless of the assumed regression model approach or underlying parameters for the WAC(R)C. If regulatory requirements for equity ratios are increased, the relative impact on the cost of capital is lower for wholesale and trading banks compared to retail banks. Depending on the calculated model, the relative impact for retail banks is up to twice as high, leading to potentially higher funding costs. A potential doubling of equity could raise the cost of funding between 8 to 42 basis points for the examined time horizon. However, it should be considered that the unbalanced data set has an uneven distribution of observations, which limits the investigation of shorter time intervals. The differences between the business models are driven by the regression coefficients, which, however, are predominantly influenced by the chosen business strategy and risk-profile with different underlying return and leverage structures. As a result, it is proposed that the shown dissimilarities of business models should be considered for the development of capital and liquidity requirements in Pillar 1 of the regulatory framework.

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Part II - Leverage Ratios for Different Bank Business Models

For the consideration of different risk-profiles of business models, the second part of the thesis contributes by developing non-risk-sensitive leverage ratios for retail, wholesale, and trading banks (cf. Grossmann, 2017). Based on normal and non-normal distributions, Value-at-Risk (VaR) and Expected Shortfall (ES) methodologies are used to comply with the characteristics for a coherent risk measure and to counter the existing problems with the BCBS leverage ratio. This approach is comparable to the calibration of risk-sensitive capital requirements by the BCBS (2010) and has the advantages that both methods are based on a theoretical foundation to measure the risk exposure of a potential loss, respectively, the expected average loss to calculate sufficient levels of capital. Therefore, a distribution of the net return on non-risk-sensitive assets is generated and the left-hand tail with the largest losses is analyzed. Two approaches that take the different risk-profiles of business models into account are applied to design adjusted leverage ratios. First, the minimum requirement of the BCBS is supplemented with the differences between low-risk to high-risk bank business models. Second, the highest negative returns are added to the highest VaR and ES results of each business model subsample.

The results illustrate that a one size regulatory approach does not fit all business models. Retail banks account for lower potential losses compared to wholesale and trading banks, which need higher levels of capital to withstand financial distress. When observing the periods before and after the financial crisis, the VaR and ES results for all banks, based on a historical approach with a confidence level of 99%, are doubled. The financial crisis had the highest impact on the results of trading banks, which might be caused due to high trading exposures. Surprisingly, wholesale banks report comparable pre- and post-crisis results, indicating that the riskiness has not changed during the examined timeframe. A possible explanation could be lower levels of trading exposure compared to other business models. Based on the VaR, the leverage ratio for retail banks should account for 2.83% to 3.00%. As for the combined wholesale and trading bank sample, the results suggest an adjusted ratio between 3.70% to 4.21%. If the ES is considered, the leverage ratio for retails banks should be set at 3.76% and for the combined sample at 4.47% to 4.98%. Overall, adjusted Pillar 1 requirements for business models can account for the different business strategies and risk-profiles and can help to resist future crises without bailouts.

Part III - The Golden Rule of Banking: Funding Cost Risks of Bank Business Models

Due to a missing funding cost risk regulation in Pillar 1 of the Basel framework, the contribution of the third part is the assessment of liquidity-induced equity risks and the potential change of solvency for retail, wholesale, and trading bank business models (cf. Grossmann and Scholz, 2018). Since data on maturities are rarely published by the banks in the sample, maturities for assets and liabilities are derived from banking statistics of the Deutsche Bundesbank to calculate funding gaps. For the calculation of banks' longer-term refinancing costs, funding spreads are derived by comparing the yields of iBoxx bond indices to yields of risk-free rates. Based on the unique data set, the impacts of varying funding cost risks, triggered by exemplary rating shifts, are examined by using Value-Liquidity-at-Risk (VLaR) and Value Liquidity Expected Shortfall (VLES) methodologies. Therefore, the left-hand tail of a distribution curve, which is generated by comparing normal funding scenarios with stressed funding scenarios in relation to a bank's equity, is analyzed.

Summing up, diverse impacts on the capital adequacy of business models are found. Retail banks bear lower funding cost risks relative to equity compared to wholesale and trading banks in the sample. The VLaR and VLES results for wholesale and trading banks, based on normal and stressed scenarios, are two to four times as high as for retail banks. The financial crisis had a minor impact on the funding cost risk of retail banks as the results are slightly higher after the crisis. However, the post-crisis results for wholesale and trading banks differ due to adjusted funding strategies and business activities. While VLaR and VLES results are cut in half for wholesale banks, the results for trading banks almost triple. The reasons for the differences between the business models are diverse liquidity risk-profiles with different underlying balance sheet structures, the related diversification, respectively, concentration of refinancing sources, the longer-term mismatch of assets and liabilities, and the rating grades. Consequently, it is proposed that the liquidity risk-profiles of different business models should be included into a prudential Pillar 1 framework to cover diverse funding liquidity risks. Business model adjusted regulatory standards could require limitations for funding gaps or restrictions for potential losses in relation to banks' solvency.

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The results of the three research papers illustrate the potential to build upon the thesis and indicate that **future research** could concentrate further on the micro- and macroprudential regulation of bank business models. In this context, researchers could control for other Pillar 1 or 2 requirements regarding business models, the development of adjusted capital requirements for systemically relevant business models for on- and off-balance sheet assets, the assessment of different stress scenarios or combined stress scenarios for the funding cost risk, the development of business model adjusted liquidity requirements, interdependencies of business model requirements, as well as the impact of different business model requirements on the real economy. The required data set should include (more) detailed information about capital components of banks, on- and off-balance sheet exposures, maturities of balance sheet positions, the structure of investment portfolios of banks, and funding spreads for secured and unsecured refinancing instruments as well as for systemically important banks.

The **key findings** of the Ph.D. thesis show the necessity to consider capital and liquidity risk-profiles of different business models and pave the way for a more differentiated regulation of banks. Complementary, the EBA (2016, p. 7) writes in its work program for 2017 that "*the regulatory framework has become extremely complex, especially for banks with very simple business models*". A greater proportionality for small- and medium-sized banks is currently being discussed. The so-called 'small banking box' could reduce the intensity and complexity of requirements originally designed for international large banks regarding, e.g., disclosure, reporting, governance, or remuneration requirements (Dombret, 2017). However, the discussion about a 'small banking box' still neglects the different risk characteristics of business models. The results of the three papers display that a small bank with a high-risk business model needs different requirements than a medium bank with a low-risk business model. Therefore, the thesis proposes a combined approach of a bank's business model, relevance to the financial system, and size. Based on Grossmann (2016), Table 2 shows an extended and differentiated regulatory framework for Pillar 1.

A **differentiated framework** can set harmonized Pillar 1 requirements for, e.g., the leverage ratio or a possible future funding cost risk regulation. Standardized definitions of business models and a methodology to separate the banking sector, for example, based on Ayadi et al. (2016) or Roengpitya et al. (2014 or 2017), can be established by the committee on banking supervision in Basel. A harmonized methodology is unlikely able to take account of all different business models across international jurisdictions, but the differences within the banking sector can be considered more adequately than in the status quo. The classification of a bank's relevance to the financial system can be based on frameworks by the BCBS (2012 and 2013) for global systemically important banks (G-SIB) as well as domestic systemically important banks (D-SIB) and by the EBA (2014) for other systemically important institutions (O-SII). For European banks, an alternative differentiation can be made for SI, which are overseen by the European Central Bank, or LSI, which are supervised by competent national authorities.

Table 2

Differentiated Regulatory Pillar 1 Framework

Business Model	G-SIB	D-SIB	O-SII	SI	LSI
Retail Banks	-	-	-	-	-
Wholesale Banks	-	-	-	-	-
Trading Banks	-	-	-	-	-

Notes: A differentiated regulatory framework for Pillar 1 requirements based on Grossmann (2016) that considers the business model, the systemically relevance, and the size of a bank. The separation of business models is based on Roengpitya et al. (2014). The clustering for global systemically important banks (G-SIB), domestic systemically important banks (D-SIB), and other systemically important institutions (O-SII) are based on frameworks by the BCBS (2012 and 2013) and the EBA (2014). Alternative clusters for significant institutions (SI) and less significant institutions (LSI) refer to the European supervisory mechanism. The respective ratios are to be determined.

Regarding the respective **ratios** for the differentiated Pillar 1 framework, the thesis offers first results in Part II for business model adjusted leverages ratios. Furthermore, differentiated results for a possible regulation of the funding cost risk are provided in Part III, but should be complemented with additional data regarding maturities of balance sheet positions and funding spreads. In addition, the second and third paper of the thesis examine subsamples for small- and medium-sized **German banks**, which can be used for LSI, and large **European banks**, which can be applied for SI. In this respect, however, it has to be considered that the comparability might be limited because the business model subsamples as well as the pre- and post-crisis results differ in the number of available observations.

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A **systemic and consistent regulation of bank business models** via an international harmonized Pillar 1 framework can promote different level playing fields across regulatory jurisdictions for strategic groups that represent the diversification of the banking system. Complementary to a Pillar 2 approach, which can impose individual requirements for a bank, a standardized Pillar 1 approach can cover general risks that affect all banks with the same business model at the same time, e.g., if certain business models display hazardous financing structures or business activities just as before the financial crisis of 2007. The consideration of the key findings of the thesis and the implementation of the proposed differentiated Pillar 1 framework can help avoid possible disadvantages between European and non-European banks, reduce the impact on the real economy if future crises are triggered by certain business models, and relieve low-risk business models. At the same time, the requirements for riskier business models can be tightened to strengthen the comprehensive regulation of unequal banks.

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Appendix I.

Diverse Regulatory Concepts - Exemplary Overview

	Australia	**China**	**Europe**	**USA**
Authority	APRA	CBRC	ECB / EBA and national authorities	The Federal Reserve Board
Legal	Prudential Standards	Capital Rules	CRR / CRD IV	Dodd-Frank Wall Street Reform
Supervised Banks (i.a.)	Deposit-taking Institutions; Level 1 to 3: stand-alone entities, industry groups, and conglomerates	Banking Institutions; Large, city and rural commercial banks, rural cooperative banks	Significant Institutions; Less Significant Institutions are supervised by national authorities	State-Chartered Banks; Financial Market Utilities; SIFI's; Securities Holdings, Bank Holding Company
Pillar 1 - Adoption	Compliant: ▪ Risk-based capital standards	Compliant: ▪ Risk-based capital standards ▪ Liquidity (LCR) ▪ G-SIB / D-SIB requirements	Materially non-compliant ▪ Risk-based capital standards Largely compliant: ▪ LCR Compliant: ▪ G-SIB / D-SIB requirements	Assessment for large banks: Largely compliant: ▪ Risk-based capital standards Compliant: ▪ Liquidity (LCR) ▪ G-SIB / D-SIB requirements
Pillar 2 - Focus (i.a.)	▪ ICAAP ▪ Liquidity ▪ Governance ▪ Business Continuity Management	▪ ICAAP ▪ Remuneration ▪ Internal Controls ▪ Risk-profile	For SI: ▪ ICAAP ▪ ILAAP ▪ Internal Governance ▪ Business Model Analysis	Diverse regulatory and supervisory concepts for depository and financial institutions
Source	APRA (2017) BCBS (2017)	CBRC (2016) BCBS (2017)	EBA (2014) BCBS (2017)	EP (2015) BCBS (2017)

Notes: Exemplary overview of regulatory concepts for different jurisdictions. The adoption of the Pillar 1 framework is based on the regulatory consistency assessment programme of the BCBS (2017).

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Appendix II.

Literature Review on Bank Business Models

Title	Author	Focus
Bank profitability and macroeconomic conditions: are business models different?	Bonaccorsi di Patti and Palazzo (2018)	Analyzing the impact of macroeconomic conditions on the profitability of business models; GDP growth affects mainly business models with high and medium shares of loans.
Bank business models: popularity and performance	Roengpitya et al. (2017)	Division of business models based on balance sheet characteristics: retail-funded, wholesale-funded, trading-oriented, and universal bank business models; commercial banking models show lower cost-to-income ratios and higher stable returns than trading-oriented banks.
Bank and Credit Union Business Models in the United States	Ayadi et al. (2017)	Clustering methodology to identify retail (type 1 and 2), wholesale, and investment bank business models; portrayal of diverse regulatory approaches for individual business models in the United States.
Banking business models and the nature of financial crisis	Hryckiewicz and Kozlowski (2017)	Assessment of profitability and risk of specialized, investment, diversified, and trader banks; funding structures of certain business models are seen responsible for systemic impact during the financial crisis.
Bank business models at zero interest rates	Lucas et al. (2017)	Novel statistical model to cluster six business models: large universal banks, international diversified banks, fee-based banks, domestic diversified lenders, domestic retail lenders, and small international banks; banks grow larger once long-term interest rates decrease.
Business models of the banks in the euro area	Farné and Vouldis (2017)	Identifying four business models based on a clustering method; wholesale funded, traditional commercial, complex commercial, and securities holding.
Business models and bank performance: A long-term perspective	Mergaerts and Vander Vennet (2016)	Factor analysis to identify retail and diversified business model strategies; retail-oriented banks show better profitability and stability; integration in regulatory practice is suggested.
Bank business models in Europe: why does it matter for the future of regulation and resolution?	Ayadi (2016)	Policy paper about the relevance to consider business models, i.e., review of balance sheet and business model risk factors, before setting regulatory standards to increase stability.
Banking Business Models Monitor 2015 Europe	Ayadi et al. (2016)	Clustering methodology to identify business models, namely, focused retail bank, diversified retail bank (type 1 and 2), wholesale bank, investment-oriented bank.

Regulatory arbitrage in EU banking: do business models matter?	Ayadi et al. (2016b)	Working paper about different distances to default of business models; certain business models are engaged in regulatory arbitrage; business models matter for regulation.
Which banks are more risky? The impact of business models on bank stability	Koehler (2015)	Analysis of business model stability; savings, cooperative, commercial, and investment banks; income diversification increases stability and profitability; non-deposit funding decreases stability for retail-oriented banks, but increases stability for investment banks.
Bank business models	Roengpitya et al. (2014)	Design of a methodology to cluster the banking sector into retail, wholesale, and trading bank business models; lower costs and more stable profits for retail and wholesale banks compared to trading banks.
Systemic risk and bank business models	Van Oordt and Zhou (2014)	Relationship between bank characteristics, e.g., balance sheet positions, with bank tail risks and systemic linkage.
Regulation of European Banks and Business Models: Towards a New Paradigm?	Ayadi et al. (2012)	Policy-oriented analysis of different banks, risk indicators, and regulatory standards; it is proposed that the regulation of banks needs a better identification of business models and underlying ex-ante risks.
Business Models in European Banking: A Pre- And Post-Crisis Screening	Ayadi et al. (2011)	Analyzing European business models, the risk, performance, and governance before and after the financial crisis; identifying retail, investment, and wholesale banks.
Bank Risk During the Financial Crisis - Do Business Models Matter?	Altunbas et al. (2011)	Relationship of risk and business model is analyzed; banks with higher deposit funding and income diversification display lower risk.
Bank activity and funding strategies: The impact on risk and return	Demirgüc-Kunt and Huizinga (2010)	Assessment of bank activity and short-term funding strategies; non-deposit funding and non-interest income strategies are considered riskier.
Strategic groups and bank's performance	Halaj and Zochowski (2009)	Categorizing strategic banking groups in Poland based on cluster analysis; groups react differently to external shocks.
Hybrid Strategic Groups	DeSarbo and Grewal (2008)	Concept of hybrid strategic groups; rivalry depends on pure strategic group and on the overlap to other strategic groups; illustrating on public banks.
New Institutional Economics' Contribution to Strategic Groups Analysis	Tywoniak et al. (2007)	Four-level framework to analyze the Australian banking sector; institutional and regulatory settings are initial basis for different strategic banking groups.

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Resource and Market Based Determinants of Performance in the U.S. Banking Industry	Mehra (1996)	Assessment of competitive patterns in the U.S. banking industry based on resources, rivalry, and performance; identified two strategic groups.
Strategic Groups in Banking	Amel and Rhoades (1988)	Clustering six strategic groups in the banking industry with differences in profitability.
The Structure within Industries and Companies‘ Performance	Porter (1979)	Theoretical concept of determinants for strategic groups; similarities and stable differences in business strategies and profits.

Notes: Literature review of selected studies with a focus on business models in banking.

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Part I

BANK REGULATION:
ONE SIZE DOES NOT FIT ALL
*

Abstract

Bank business models show diverse risk characteristics, but these differences are not sufficiently considered in Pillar 1 of the regulatory framework. Even if the business model is analyzed within the European SREP, global Pillar 2 approaches differ and could lead to competitive disadvantages. Using the framework of Miles et al. (2012), we examine a data set of 115 European banks, which is split into retail, wholesale, and trading banks. We show that shifts in funding structure affect business models differently. Consequently, a 'one size' approach in Pillar 1 for the regulation of banks does not fit all.

JEL classification: G21, G28, G32

Keywords: Bank Business Models, Bank Capital Requirements, Cost of Capital, Leverage Ratio, Regulation, SREP

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1. Introduction

The Basel Committee on Banking Supervision (BCBS) establishes global standards for the regulation of all banks, but neglects the individual attributes of business models for Pillar 1 requirements. The chosen business model, however, reflects the risk appetite of a bank and can be viewed as an additional indicator of emerging risks. So far, the risks of business models are only incorporated in Pillar 2 of the regulatory framework. Since 2015, the European supervisory review and evaluation process (SREP) evaluates the business model to cover risks that are not fully considered by Pillar 1 (EBA, 2014). However, the Pillar 2 implementations vary internationally and the substantial analysis of business models is fairly new in Europe. Especially, since the results of the SREP may lead to additional capital requirements for different business models. In addition, the SREP of the EBA (2014) does not consider the future non-risk-sensitive leverage ratio and only affects European banks. The mentioned problems can lead to biases between business models because low-risk banks have to meet the same Pillar 1 requirements as high-risk banks, including the additional costs for the implementation. Furthermore, diverse international Pillar 2 interpretations can lead to competitive disadvantages between European and global banks, due to different capital requirements, or to regulatory arbitrage if headquarters are relocated to other regulatory jurisdictions. Based on this background, it seems to be necessary to consider business models in Pillar 1. Therefore, we analyze how bank business models react to higher capital requirements and shifts in funding structure.

The reasons to consider business models, in general, are diverse risk characteristics of banks (Ayadi et al., 2016, Mergaerts and Vander Vennet, 2016). Existing and emerging risks of business models can include the underlying risk-profile and risk appetite, strategic risks, poor financial performance, dependencies of the funding structure, or concentrations to certain customers and sectors (EBA, 2014). Previous studies about bank business models focus on the profitability and operating costs (Roengpitya et al., 2014), the probability of default (Ayadi et al., 2016), the impact of income and funding on the risk and return (Koehler, 2015), or the performance and risk (Mergaerts and Vander Vennet, 2016). Building on that, we expand this field of research by examining the impact of additional capital requirements on different business models using the example of a non-risk-sensitive capital ratio. We find that bank business models react differently to

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higher capital requirements, which illustrates once more the differences of the banking sector. If leverage decreases, the relative impact on the funding costs of retail banks is higher than for wholesale and trading banks. We conclude that bank business models should be considered in Pillar 1 of the regulatory framework to account for these differences. Furthermore, we suggest that capital requirements for non-risk-sensitive capital ratios should be adjusted to the business model as well.

Our analysis is divided into two steps. In a first step, we define a procedure based on a study by Roengpitya et al. (2014) to allocate 115 European banks into retail, wholesale, and trading bank business models. The distinction is based on funding structures and trading activities for each bank and for every year from 2000 to 2013. Since the European banking system is dominated by unlisted banks, a high share of unlisted banks is selected for the sample. In a second step, we examine exemplary shifts in the funding structure for each bank in the sample. The focus is on the 'one size fits all' leverage ratio requirement of Pillar 1 because it can be seen as an equity ratio that limits the maximum leverage. An equity ratio seems to be the appropriate starting point to test impacts of additional capital requirements. For that reason, a methodology proposed by Admati et al. (2013) and Miles et al. (2012) is chosen. Miles et al. (2012) use the method of the weighted average cost of capital (WACC) to test the impact of a potential doubling of Tier 1 capital on funding costs. We adapt the method into the 'Weighted Average Cost of Regulatory Capital' (WAC(R)C) in order to address regulatory book capital only. Since the bank sample consists of unlisted banks, the positive link between the historical net return on Tier 1 capital and leverage is used as a proxy-model for the expected return. The statistical proxy-model can reflect the risk preferences of investors and is built on coefficient estimates from pooled ordinary least squares, fixed effects, and random effects regression models. Measurable differences in the regression coefficients of retail, wholesale, and trading bank business models are found. The regression coefficients are used to calculate the WAC(R)C and to compare the impacts of changing equity ratios.

2. Brief Literature Review

We focus on a related field of research about the cost of higher capital requirements. After the financial crisis and the initial discussions about Basel III some argued that additional equity is expensive and would increase the funding costs for banks.[4] In contrast, Admati et al. (2013) argue that higher equity is not expensive because the risk premium in the return on equity decreases. They state that the benefits of better-capitalized banks reduce the likelihood of default. Admati et al. (2013) base their statements on the propositions of Modigliani and Miller (M/M) (1958). They also refer to Miller (1995) and Pfleiderer (2015) for the use the of the M/M propositions on banks. The empirical test of the statements by Admati et al. (2013) are provided by Miles et al. (2012). Miles et al. (2012) test if higher equity ratios increase the cost of funding for a UK bank sample. Other empirical studies, which we refer to, find their origin in the work of Miles et al. (2012): the European Central Bank (ECB) (2011), Junge and Kugler (2013), Toader (2015), Clark et al. (2015), and Cline (2015).

The comparative studies test to what extent shifts in funding structures affect the overall costs of banks. To determine the cost of equity for the WACC-method, the studies use the capital asset pricing model (CAPM) to estimate expected returns for listed banks. Miles et al. (2012) examine the six largest banks in the UK and find an M/M offset of 45%-90% between 1997 and 2010. The M/M offset describes to what extent the WACC is independent of its capital structure and if a bank's cost of capital increases once leverage changes. An M/M offset of 100% describes a total independence and approves the M/M propositions (Miles et al., 2012). The ECB (2011) tests 54 global systemically important banks (G-SIB) and finds an M/M offset of 41%-73%. Junge and Kugler (2013) find an M/M offset of 36%-55% for Swiss banks. For large European banks, between 1997 and 2012 a 42% M/M offset is found by Toader (2015). Clark et al. (2015) examine 200 banks from the USA and find an M/M offset of 41%-100%, which increases with the size of a bank. The hypothetical doubling of equity has a higher impact on the cost of capital for smaller banks than for the largest banks of their US sample. Last but not least, Cline (2015) tests US banks and finds an M/M offset of 60%.

The works of Admati et al. (2013) and Miles et al. (2012) offers an appropriate

[4] Admati et al. (2013) present several statements of bankers and researchers relating to this discussion.

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methodology for our research because it enables to examine the impacts of additional capital requirements on different bank business models. We expand the existing research about the cost of higher equity ratios with a focus on the European banking sector. In contrast to the use of the CAPM, we apply a proxy-model for the expected return because the sample is dominated by unlisted banks.

3. Data Set

The data set for the sample is collected from the bankscope database Bureau van Dijk Electronic Publishing (2015). Additionally, for about 30% of the observations, further data on regulatory capital is collected from published disclosure reports based on §26a of the German Banking Act. The initial selection of the data set is based on the balance sheet total by the end of 2013 for the biggest 90 banks in Germany and the 30 biggest banks in Europe. The majority of observations belong to German banks because of the availability of data regarding Tier 1 capital. The sample includes both listed and unlisted banks with a majority of bank/year observations for unlisted banks (63%). The data set is an unbalanced panel that includes data from 2000-2013. Due to size and disclosure requirements of the banks, only yearly data are available for the full sample since semi-annual and quarterly reports are not published for more than half of the sample. The panel sample does not include data for all banks for every year, but we retain the banks in the analysis because they represent the financial system in Europe. The data set is tested for banks with no observation for either the dependent or the independent variables, for data errors such as incorrect units, or for banks that are overtaken by competitors. Once an observed bank is under control of another European competitor for more than 50 percent of its shares the bank is dropped from the sample for the examined year. Due to the data set, which is collected before Basel III is established, single components of the leverage ratio's exposure measure, e.g., off-balance sheet exposure, derivate exposure, and securities financing transaction exposure, are not available. As a consequence, lower ratios of leverage could be estimated due to missing off-balance sheet exposure. Hence, our results are solely based on published on-balance sheet exposure. The data set also includes European G-SIB. Since all variables used for the models are measured in percentages, G-SIB's are not treated differently. The sample covers the timeframe after the Lehman Brothers bankruptcy. During the financial crisis, several banks received

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government support, e.g., guarantees or capital actions. The supportive actions of the European governments presumably saved the financial system. Nevertheless, government support can lead to a distortion of competition. Banks that received government support might have otherwise not survived and therefore, are not considered for the timeframe during which they received support to ensure comparability with banks not receiving governmental support. For robustness purposes, results for banks with government support are presented in Footnote 6. The handling of banks with government support does not foster a possible survivorship bias. Quite the contrary, it increases the comparability among the remaining banks in the sample. Banks that failed and did not receive government support are included in the sample. Due to the availability of sufficient observations, we are not able to create comparable subsets regarding timeframes, e.g., pre- and post-crisis, within the time series. Approximately one-sixth of the observations is collected before 2007 as shown in Appendix II. The final sample includes 85 German and 30 European banks with 615 bank/year observations for both the dependent and the independent variables.

4. Separation of the Banking Sector

Our first step is to separate the data set. The banking sector can be divided by several approaches such as the ownership structure, the liability system, the earning structure, or the bank business model (Deutsche Bundesbank, 2015c). In order to enable comparability with international banking sectors and to consider the riskiness of different business activities, we choose to differentiate the banks by the individual business model. Different methodologies to classify bank business models such as cluster analyses (Roengpitya et al., 2014, Ayadi et al., 2016), factor analyses (Mergaerts and Vander Vennet, 2016), or a combination of ownership structures and business attributes (Koehler, 2015) exist. Based on Roengpitya et al. (2014), we define a procedure to separate the banking sample. The study is chosen because of the availability of the same database, operating figures, and utilized variables. Roengpitya et al. (2014) distinguish bank business models solely by their business activities and funding structures[5] and develop three business models: retail

[5] It should be considered that information regarding the strategic plans, internal reporting, execution capabilities, or recovery and resolution plans as reviewed by the EBA (2014) is not publicly available. The internal data could complement the classification of business models.

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banks, wholesale banks, and trading banks. By definition, retail banks comprise collecting deposits from private and small corporate customers to deal in credits. Larger corporate customers, as well as financial institutions, are provided with banking services by wholesale banks. Retail and wholesale banks both have high shares of loans, but differ in the type of refinancing. Retail banks use mainly customer deposits, whereas wholesale banks choose a broader funding structure (Hull, 2015, Roengpitya et al., 2014). Koehler (2015) finds that banks with a high share of deposit funding are more stable than non-deposit funded business models. By contrast, trading banks, which are also known as investment banks, focus on trading and investment activities with a predominantly market-based funding structure. They assist customers in raising equity and debt, consult on corporate finance decisions, and provide brokerage services (Hull, 2015, Roengpitya et al., 2014). Overall, Ayadi et al. (2016) discover that European retail business models resisted the financial crisis better and are less likely to default compared to wholesale and investment business models.

Roengpitya et al. (2014) identify key and supportive ratios to differentiate between business models. These ratios include the share of loans (gross loans), the share of interbank liabilities (interbank borrowing), and the share of refinancing without customer and bank deposits (wholesale debt). Gross loans relate to the composition of the asset side, whereas interbank borrowing and wholesale debt relate to the funding structure of a bank. The procedure to allocate the banks in the sample is based on the key and supportive ratios. Furthermore, we add 'Derivative Exposure', and 'Trading Exposure' as additional ratios. In the first step, we look at banks with a high share of gross loans above 50 percent on the balance sheet as well as the corresponding funding structure. A retail bank is classified as a bank that depends largely on customer deposits (≥ 50%). In addition, a bank is classified as a retail bank if the share of gross loans is above 35%, with the share of investment activities below 20%, and if customer deposits exceed wholesale debt and interbank borrowing. Through this procedure, wholesale or trading banks characteristics are not dominating. If the refinancing through interbank borrowing (i.e., bank deposits) and wholesale debt (i.e., long-term liabilities, other deposits, and short-term bonds) exceed customer deposits, the bank is classified as a wholesale bank. In addition, a bank is classified as a wholesale bank if the share of gross loans is above 35%, with a share of investment activities below 20%, and if the interbank borrowing and wholesale debt exceed customer deposits. Through this procedure, retail or trading banks characteristics are not dominating. In the second step, we look at banks with a share of gross loans below 50 percent. Roengpitya et al. (2014) find that trading banks hold approximately 20% of the balance sheet total in interbank related assets and liabilities (e.g., tradable securities). Therefore, banks whose trading activities (i.e., trade liabilities and derivative exposure) are above 20% are assigned to trading banks. In addition, banks whose share of interbank lending and trading activities exceeds the share of gross loans are classified as trading banks. As an exception, public development banks with high subsidies awarded to other banks are not classified as trading banks since they do not pursue trading activities. They are classified as wholesale banks. Every bank is classified for each year to allow for changes over time. Two bank/year observations could not be separated due to incomplete data regarding the asset structure. Both banks are assigned to retail banks because the business model did not change in the course of the timeframe.

Table 1

The Diversity of Bank Business Models

Variables	Retail	Wholesale	Trading	All Banks
Gross Loans	63% (62%)	51% (65%)	29% (26%)	52% (58%)
Interbank Borrowing	14% (8%)	26% (14%)	23% (19%)	20% (11%)
Wholesale Debt	9% (11%)	37% (37%)	19% (18%)	20% (19%)
Interbank Lending	8% (9%)	21% (8%)	25% (22%)	16% (11%)
Deposits	65% (67%)	26% (36%)	28% (38%)	46% (54%)
Stable Funding	73% (74%)	60% (63%)	43% (49%)	63% (67%)
Derivative Exposure	0.2% (n/a)	5% (n/a)	18% (n/a)	6% (n/a)
Trading Exposure	0.1% (n/a)	2% (n/a)	15% (n/a)	4% (n/a)

Notes: Gross Loans: loans / total assets; Interbank Borrowing: deposits from banks / total assets; Wholesale Debt: other deposits plus short-term borrowing plus long-term funding / total assets; Interbank Lending: loans and advances to banks / total assets; Deposits: customer deposits / total assets; Stable Funding: total customer deposits plus long-term funding / total assets; Derivative Exposure: derivative / balance sheet; Trading Exposure: trading liabilities / total assets. Total assets are net of derivatives to avoid different balance sheet volumes through various accounting standards. Results of Roengpitya et al. (2014) in parentheses.

The allocation of the sample matches predominantly the percentages of the comparative sample of Roengpitya et al. (2014) as seen in parentheses in Table 1. The chosen procedure to allocate the sample seems to be appropriate. The European sample shows a

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much higher share of interbank borrowing and interbank lending. The retail banks in the sample have above-average shares of gross loans and deposits and almost match the comparative sample. Wholesale banks in the sample have a smaller share of gross loans and a higher share of interbank lending compared to retail banks as well as the comparative sample. At the same time, wholesale banks account for the highest share of wholesale debt in our sample. Trading banks in the sample have the highest share of interbank lending as well as derivative and trading exposure. For the comparison of the results, it should be considered that not all data are available for the formulas 'interbank lending' and 'interbank borrowing'. Hence, 'reverse repurchase agreements and cash collateral', which could be added to the counter of the formulas, are not considered. Altogether, the sample consists of 302 retail bank observations, 193 wholesale bank observations, and 120 trading bank observations.

5. Methodical Framework

To test our hypothesis that higher equity ratios will raise funding costs for bank business models differently, we base our analysis on a methodology used by Miles et al. (2012). They empirically test the statements by Admati et al. (2013) that are based on the capital structure theory of Franco Modigliani and Merton H. Miller. The M/M propositions state that the WACC of a company is independent of its capital structure because the return on equity will decrease once leverage is lowered. The cost for the higher share of equity will be offset due to a reduced financial risk spread on equity. Lower leverage makes equity less risky. At the same time, when the share of debt decreases, the required interest rate of debt will decrease as well because the probability of default will be reduced. Overall, the WACC remains unchanged (Modigliani and Miller, 1958). The M/M propositions assume perfect market conditions, such as no transaction costs and identical financing costs for private and corporate investors, but complicate the practical use. The M/M propositions will not be used to increase a bank's value, but to examine possible shifts in funding structure for different business models.

Our general methodology follows Miles et al. (2012) and the above-mentioned studies, which have tested the M/M offset on listed banks in the UK, Europe, and the US. For more details on the comparative studies see Appendix I. In contrast, our focus is on a sample of listed and unlisted banks in Europe. Since the primary focus is on regulatory capital, we adapt the model of the WACC into the WAC(R)C for banks and concentrate on Tier 1 capital and the return on Tier 1 capital. The adaption is based on a WACC bank model designed by Heidorn and Rupprecht (2009), which distinguishes between a bank's equity components. However, the WAC(R)C is a more simplified model due to the available granularity of data regarding regulatory equity. The regulatory equity for a bank can be divided into Tier 1 and Tier 2 capital. Tier 1 capital is referred to as going-concern capital whereas Tier 2 capital is referred to as gone-concern capital. We use Tier 1 capital as equity only since other components of a bank's equity such as hybrid capital or Tier 2 capital can be seen as debt regarding accounting standards and tax law. Tier 1 capital consists of common equity Tier 1 (CET1) and additional Tier 1 capital and is the sum of common shares, stock surplus, retained earnings, and accumulated other comprehensive income as well as other disclosed reserves (BCBS, 2011). Miles et al. (2012) refer to incomplete data regarding CET1 capital and use Tier 1 capital because they found a positive relationship between CET1 and Tier 1 capital. In addition, the leverage ratio formula of Basel III focuses on Tier 1 capital because non-Tier 1 capital components were seen less useful to absorb losses during the crisis (BCBS, 2010). The WAC(R)C is estimated as follows:

$$WAC(R)C = \frac{Tier1}{V} \cdot R_{Tier1} + \frac{D}{V} \cdot R_{Debt} \cdot (1 - t) \tag{1}$$

where $Tier1$ is the amount of banks' regulatory core capital, V is the exposure measure of a bank, D the amount of debt, $Tier1/V$ the equity ratio, D/V the debt ratio, and t the corporate tax rate. As for the capital cost rates, R_{Tier1} is used as the return on Tier 1 capital and R_{Debt} as the interest rate on debt capital.

The comparative studies, and we as well, use book values for $Tier1$ because Tier 1 capital is available as a balance sheet value only. For the calculation of the expected return, the comparative studies use the capital-market-oriented CAPM. As an alternative, Miles et al. (2012) suggest using realized earnings over the stock price as a proxy for the expected return. Since most European banks are not listed[6], we use a proxy-model based on realized

[6] Exemplary for Germany: at the end of 2013 a total of 1,846 banks reported to the Deutsche Bundesbank (2015b). Merely 19 of them were listed.

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historical returns for R_{Tier1}. The use of historical returns follows the approach of the BCBS (2010), which concentrates on historical earnings to develop risk-sensitive capital ratios. As the desired proxy, the historical net return on Tier 1 capital and leverage are used. A positive relationship between the two variables is assumed because of to the M/M propositions. Due to the use of book values, listed banks are treated as unlisted banks regarding the utilized variables. Our approach neglects the CAPM due to the underlying perfect market assumptions as well as the missing empirical prove of the model (Fama and French, 1992). Using realized returns on Tier 1 capital might differ from previously calculated expected returns on equity and limits the comparability towards the CAPM. However, the advantage of the proxy-model is that we do not rely on peer group betas or other benchmark betas that do not distinguish between bank business models. The statistical proxy-model does not calculate the risk premium, but the coefficients of the model can reflect the risk preferences of investors (Damodaran, 2013).

6. The Proxy-Model

For the return-proxy, we use a panel regression approach. We need to assume that the average realized return on equity is close to the actual cost of equity. The regression models are based on log regressions due to skewed distributions of the variables. The regression is estimated as follows:

$$ln(R_{Tier\,1_{i,t}} + 1) = a + b \cdot ln(Leverage_{i,t}) + c_{i,t} + z_t + \varepsilon_{i,t} \qquad (2)$$

where i = 1 to N is the individual bank and t = 1 to T is the time index. We use a as a constant, b as the coefficient of leverage, and c as a control variable for additional explanatory bank-specific effects. Further, z is used for time-specific effects (e.g., time dummies) and epsilon (ε) is used as the error term for the non-systematic part of the regression model (Wooldridge, 2002 and 2009).

The historical return on Tier 1 capital after taxes ($R_{Tier\,1}$) is used as the dependent variable. We choose the net return since dividends on shares are paid to investors after the company has paid corporate taxes. However, with the use of historical returns, years with financial losses are also included in the data set. This is a mathematical problem since negative numbers cannot be logarithmized. There are various possibilities to deal with negative returns: the data could be trimmed, winsorized, swapped, or a constant could be added. Trimming or winsorizing data can reduce extreme values, but could lead to a misinterpretation of the results. Cline (2015) suggests to swap negative returns for a minimum expected return of a five year treasury bond plus a risk spread. Another option is to swap the negative returns for the average return of the time series. Swapping generates a minimum expected return for investors, who might otherwise not invest if the bank is expected to generate a loss. However, this assumption might only work for a short investment-period because investments with negative expected returns can turn into positive expected returns in the long run. We decide to keep the negative returns and add a constant of 1 to all returns since equity is a risky asset, which generates positive and negative returns. The adding of a constant $ln(R_{Tier\ 1_{i,t}} + 1)$ enables us to logarithmize the variables.

Leverage as the independent variable is measured as total assets divided by Tier 1 capital. We decide to use on-balance sheet exposure only because off-balance sheet data are not available for every bank in our sample. Because of changes in the definition of Tier 1 capital during Basel I to III and the lack of adjusted Tier 1 capital figures during the observed timeframe, the ratios of leverage might not be entirely comparable to each other. This should be considered when the results are interpreted. It is challenging to control for the impact of bank-specific effects over time. The effects of changes in risks of assets can be assessed through control variables that reflect the overall situation of the individual bank such as the profitability, the liquidity situation, potential losses, or size (Miles et al., 2012). For the explanatory bank-specific control variables, we follow Miles et al. (2012) and use the return on assets (ROA), a liquid asset ratio (LAR), and a loan loss reserve ratio (LLRR). The ROA is measured as net income divided by total assets and reviews the profitability of the total assets of a bank. The LAR is computed as liquid assets divided by total liabilities minus Tier 1 equity and stands for the capability to sell assets without high losses. The LLRR is calculated as the total loan loss reserves divided by total assets and checks for the probability of potential future losses due to loan defaults. In addition, the size of a bank (logarithm of total assets) as suggested by the ECB (2011) is used. Further, to cover the impact on the average riskiness of assets from year to year, such as a general economic boom (ECB, 2011), additional time dummies are added to the

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regression model.

7. Statistics and Results

We aim to find a robust regression model to use the coefficients of the proxy-model to calculate the return on Tier 1 capital for the WAC(R)C. For that reason, four regression models are used: one baseline model and three extended panel regression models. The models are based on pooled ordinary least squares (OLS), fixed effects (FE), and random effects (RE) regression methods. The extended models consider additional control variables to test for bank-specific effects as well as annual time dummies. Subsequently, the individual models are statistically tested against each other. The procedure is based on the procedure of the comparative studies.

7.1 Descriptive Statistics

The descriptive statistics for the utilized dependent and independent variables are presented in Appendix III.[7] The variables show some extreme minimum and maximum values, e.g., outliers, that might have an influence on the regression models. Extreme values are not trimmed nor winsorized to reveal the actual banking sector. It should be noted, that the financial crisis, as well as the regulatory driven build-up of Tier 1 capital, are also covered in the data set. The majority of bank/year observations with about 49% belong to retail banks. The remaining observations are split with approximately 31% to wholesale and with approximately 20% to trading banks. The average leverage for the sample is 26.19 for the observed timeframe. Retail banks have an average leverage of 18.65, while wholesale (29.59) and trading (39.69) banks account for a higher leverage. With a lower leverage, retail banks seem to be less risky. Trading banks display a comparatively high standard deviation due to the retained outliers. Without five extreme outliers that display leverage above 100, the average leverage for trading banks would account for approximately 36.13. The average return on Tier 1 capital for the sample is 8.50%. Trading banks account for the highest realized net return on Tier 1 capital with an average of 9.40% compared to retail (9.01%) and wholesale banks (7.10%). The

[7] All variables are stationary as the null-hypotheses of an Augmented Dickey-Fuller test can be rejected.

descriptive statistics indicate that leverage might have an impact on the return on Tier 1 capital. The sample with the highest leverage claims the highest return.

7.2 Baseline Regression Model

Starting with a fixed effect baseline regression, as shown in Table 2, a positive link between the net return on Tier 1 capital and leverage can be found for all samples.

Table 2

Baseline Regression

FE - Baseline	**All Banks**	**Retail**	**Wholesale**	**Trading**	**W + T**
Coefficient Leverage	0.040'	0.041	0.005	0.081	0.027
Standard Error	0.022	0.026	0.041	0.052	0.033
Adjusted R^2	0.005	0.008	0.000	0.020	0.002
F-Test (p-value)	0.070	0.122	0.905	0.119	0.418
Observations	615	302	193	120	313

Notes: The dependent variable is the log of the return on Tier 1 capital after taxes since dividends are paid after corporate taxes. The independent variable is log leverage. The null-hypothesis of the Breusch-Pagan test is rejected for all models, which indicates heteroskedasticity. A Breusch-Godfrey/Wooldridge (2002) test indicates autocorrelation in residuals for all banks and retail banks. The wholesale and trading banks sample cannot reject the null-hypothesis.

*Level of significance: *** p<0.001, ** p<0.01, * p<0.05, ' p<0.10.*

Hence, a higher return on equity can be connected to higher levels of debt. The link is statistically significant (p-value 0.070) for the whole bank sample. If the confidence level is changed to 88%, a statistically significant relationship can also be found for retail banks (p-value 0.122) and trading banks (p-value 0.119). For retail banks, positive significant coefficients are also found for a baseline regression model based on ordinary least squares (0.031**) and random effects (0.044**). Wholesale banks display a positive relationship, but a statistically significant relationship cannot be found for the number of observations. A fourth sample consisting of the wholesale and trading bank samples (W+T) is added for a better comparability with the retail bank sample regarding the number of observations. A positive relationship for W+T is found, but the link does not seem to be statistically significant mostly due to the wholesale bank observations.

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7.3 Extended Regression Models

The following three models are calculated with control variables. As mentioned above, the selection of control variables is based on the comparative studies. It should be noted, that our approach differs from the comparative studies in the use of unlisted banks and the derivation for the rates of return. The majority of the comparative studies regress leverage and the control variables on the equity beta of a listed bank, which supposedly reflects the equity risk of the bank (Miles et al., 2012). In the CAPM, the equity beta has a strong, although indirect, influence on the expected return on equity. In contrast, we regress the independent variables directly on the return on Tier 1 capital. The explanatory bank-specific control variables show diverse impacts. The coefficients for ROA indicate a strong positive link to the net return on Tier 1 capital for all samples. Appendix IV shows that ROA has a strong impact on the adjusted R-squared when added to the regression models. It seems reasonable that the return on total assets has a positive influence. However, ROA cannot be attributed to regulatory equity as a whole. The positive correlation[8] of 0.732 between the net return on Tier 1 capital and ROA indicates that other components of a bank's equity or debt, regarding accounting standards and tax law, benefit from ROA. Hence, ROA could be split into components that belong to Tier 1 capital and into components that can be attributed to hybrid capital (e.g., loss-absorbing debt) or other accounting equity components that are not regulatory Tier 1 capital. Therefore, we decide to keep ROA as a control variable. The coefficients for LAR in the OLS regressions have a positive link for the all banks samples and are statistically significant for the FE and RE models. The liquidity situation seems to have a positive impact on the return on Tier 1 capital. However, for the retail, wholesale, and trading bank subsamples, the LAR indicates a positive link in most cases, but is not significant for the FE and RE models. The LLRR does not seem to have an influence on the dependent variable as no significant links can be found. The total assets variable does not produce robust results either. For more than half of the models tested, the influence is negative, albeit not statistically significant. The size of the bank only seems to have a minor influence on the return on regulatory capital of retail banks in the RE model, but

[8] A Kendall's tau test for variables that are not normally distributed is used to measure the correlation. As a comparison, the correlations between the net return on Tier 1 capital and: leverage is 0.460; LAR is 0.668; total assets is 0.146; and LLRR is -0.094.

not for the all banks, wholesale, and trading banks samples. The results surprise because the ECB (2011) finds a robust relationship. One possible explanation could be the selection of mostly unlisted banks. Overall, we decide to drop LLRR and total assets as control variables from all regressions because they do not show an impact on the regression models. The different impacts can be seen in Appendix IV with an overview of all variables for the fixed effects regression models. We also check for the Gauss-Markov assumptions for the regression models (Wooldridge, 2009). All variables cannot reject the null-hypotheses of the Jarque-Bera-test for normal distribution.

Model 2 - OLS

When using the remaining independent variables for the OLS regressions, as shown in Table 3, we find positive significant relationships for the all bank, retail bank, and wholesale bank samples. A negative, albeit not significant link for trading banks is found. In addition, the combined sample of wholesale and trading banks shows a positive, but not statistically significant link.

Table 3

Ordinary Least Squares Regression

OLS	**All Banks**	**Retail**	**Wholesale**	**Trading**	**W + T**
Coefficient Leverage	0.039***	0.076***	0.029*	-0.008	0.013
Standard Error	0.006	0.007	0.012	0.014	0.009
Constant	-0.098***	-0.225***	-0.053	-0.017	-0.023
ROA	20.382***	17.434***	24.004***	26.729***	24.387***
LAR	0.004	-0.000	0.011'	-0.024'	0.010'
Adjusted R^2	0.768	0.828	0.790	0.676	0.767
F-Test (p-value)	0.000	0.000	0.000	0.000	0.000
Observations	610	297	193	120	313
Year Effects	Yes	Yes	Yes	Yes	Yes

*Notes: The dependent variable is the log of the net return on Tier 1 capital. The independent variables are log leverage, log return on assets, log liquid asset ratio, as well as year dummies. Annual time dummies are not shown. The null-hypotheses of the Breusch-Pagan test can be rejected for all models except for trading banks. A Breusch-Godfrey/Wooldridge (2002) test indicates serial correlation in residuals for all models. Level of significance: *** p<0.001, ** p<0.01, * p<0.05, ' p<0.10.*

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Model 3 – FE

The FE model can account for bank-specific, unobserved effects and allows the unobserved effects to be correlated with the independent variables in each time period. For the within models in Table 4, statistically significant relationships for all banks, retail banks, trading banks, and the combined W+T sample are found. As for wholesale banks, we find a positive link, but the model does not seem to be statistically significant.[9] For the FE models, the null-hypotheses for the Breusch-Godfrey/Wooldridge (2002) test that there is no serial autocorrelation cannot be rejected. Further, the null-hypotheses of the Breusch-Pagan test can be rejected, which indicates heteroskedasticity for the FE models except for the trading bank sample. For that reason, robust covariance matrix estimators by Arellano (1987) for the FE and RE models for the unbalanced panel data set are chosen. The Arellano estimator permits heteroskedasticity and serial correlation.[10]

Table 4

Fixed Effects Regression

FE	**All Banks**	**Retail**	**Wholesale**	**Trading**	**W + T**
Coefficient Leverage	0.066***	0.076***	0.025	0.122**	0.047*
Standard Error	0.020	0.021	0.017	0.044	0.019
ROA	24.011***	18.401***	27.121***	38.349***	29.349***
LAR	0.014*	0.005	0.008	0.010	0.015
Adjusted R^2	0.642	0.626	0.631	0.531	0.637
F-Test (p-value)	0.000	0.000	0.000	0.000	0.000
Observations	610	297	193	120	313
Year Effects	Yes	Yes	Yes	Yes	Yes

Notes: The dependent variable is log return on Tier 1 capital after taxes. The independent variables are log leverage, log return on assets, log liquid asset ratio, and year dummies. Annual time dummies are not shown. The results for the FE within models are computed by one-way (individual) effects. Consistent standard errors are used to address for heteroskedasticity.

*Level of significance: *** p<0.001, ** p<0.01, * p<0.05, ' p<0.10.*

[9] As a robustness check, the FE regression models are calculated including banks that received government support during the financial crisis. The tendencies of the results are similar with positive leverage coefficients for all banks (0.038**), retail banks (0.078***), trading banks (0.064*), and the combined W+T sample (0.007).

[10] Robust standard errors by Driscoll and Kraay (1998) are not used because the timeframe is shorter than the recommended minimum timeframe of 20 to 25 years. Instead, the vcovHC function with the Arellano estimator in 'R' as offered by Croissant and Millo (2008) is used.

Model 4 – RE

The RE model can also account for bank-specific, unobserved effects, but assumes that the unobserved effects are uncorrelated with the independent variables in all time periods. The last of the panel regression models is the RE model. We test for the empirical relationship of leverage on the return on Tier 1 capital and assume that unobserved effects are uncorrelated with the independent variables. For the RE models in Table 5, statistically significant links for all banks, retail banks, wholesale banks, and the combined W+T sample are estimated. As for the trading banks, a significant link cannot be found. A serial correlation in residuals for the RE models is found as the null-hypotheses of the Breusch-Godfrey/Wooldridge (2002) test can be rejected for all samples. A Breusch-Pagan test indicates heteroskedasticity for all samples except for the trading banks.

Table 5

Random Effects Regression

RE	**All Banks**	**Retail**	**Wholesale**	**Trading**	**W + T**
Coefficient Leverage	0.041***	0.074***	0.028'	-0.003	0.019'
Standard Error	0.015	0.017	0.015	0.029	0.020
Constant	-0.128***	-0.197***	-0.071	-0.043	-0.074
ROA	22.114***	17.885***	25.531***	28.313***	26.232***
LAR	0.006*	0.002	0.010	-0.020	0.008
Adjusted R^2	0.779	0.821	0.796	0.677	0.781
F-Test (p-value)	0.000	0.000	0.000	0.000	0.000
Observations	610	297	193	120	313
Year Effects	Yes	Yes	Yes	Yes	Yes

*Notes: The dependent variable is the log of the return on Tier 1 capital after taxes. The independent variables are log leverage, log return on assets, log liquid asset ratio, and annual time dummies. Yearly time dummies are not shown. The results for the RE models are computed by one-way (individual) effects. Consistent standard errors based on Arellano (1987) are used to address for heteroskedasticity and serial correlation. Level of significance: *** p<0.001, ** p<0.01, * p<0.05, ' p<0.10.*

7.4 Selection of Regression Model

Overall, the results of the three panel regression models show positive relationships between the dependent and independent variables. After estimating the models with

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additional control variables, we use statistical tests to choose between the different regressions models as described by Wooldridge (2009). First, the OLS and the FE models are compared. We choose the FE models over the OLS models because the null-hypotheses for the F-test, which indicates no individual unobserved effects, can be rejected for all banks (p-value 0.000), retail banks (p-value 0.000), wholesale banks (p-value 0.000), trading banks (p-value 0.000), and the combined W+T sample (p-value 0.000). Secondly, the OLS and the RE regression models are compared. We use a Lagrange Multiplier Test for panel models computed by Breusch-Pagan. If the null-hypothesis can be rejected, the RE model is better. We find that the RE models seem to be more appropriate than the OLS for all samples. Thirdly, both the FE and RE models seem to be consistent. Compared to the within models, the RE models have higher explanatory values for the adjusted R-squared. To decide which model to use, we test for statistically significant differences in the coefficient of the time-varying independent variables for the FE and RE models by using a Hausman test (Wooldridge, 2009). The null-hypothesis means that the differences in the coefficients are not significant and that unobserved variables are not correlated with the independent variables. The Hausman test indicates that the FE model can be used for retail banks (p-value 0.000), trading banks (p-value 0.000), and the combined W+T sample (p-value 0.000). The RE model seems better for all banks (p-value 0.150) and wholesale banks (p-value 0.347). Overall, we choose the FE over the RE models because it allows a comparison between the retail banks and combined W+T sample with almost identical numbers of observations. An alternative method could be to use both the FE and RE models for the calculations, but the comparison of the results might be biased. By choosing the FE model the unobserved effects can be correlated with the independent variables. Overall, we choose the baseline regressions and the FE estimates for the proxy-model to calculate the return of Tier 1 capital for the WAC(R)C.

The results seem to be in line with the referred study of Miles et al. (2012), who find a positive coefficient for leverage for the six largest UK banks of 0.031 for an FE model. The ECB (2011) observes international G-SIB and finds a positive leverage coefficient for the FE model of 0.079. Clark et al. (2015) find a positive coefficient of 0.062 for an FE model for the largest US banks between 2007 and 2012. Furthermore, Toader (2015) estimates an FE coefficient of 0.026 for 85 European listed banks. In spite of the similarities, it is important to mention that the results are not directly comparable due to the underlying assumptions, e.g., the use of control variables, the use of the CAPM with expected return assumptions, and the proxy-model based on actual realized returns.

8. Calculating the WAC(R)C

The regression estimates for the proxy-model show that an increase of leverage can be connected to a higher net return on Tier 1 capital with measurable differences between bank business models for the European sample. We follow Miles et al. (2012) and use two exemplary illustrations for the calculation of the WAC(R)C. Two identical equity ratios for all bank business models of 3% and 6% (leverage of 33.33 and 16.67) are used. This assumption might not represent the reality because the leverage of the whole bank sample is lower and only the trading bank sample has a higher leverage. The BCBS leverage ratio of 3% is a minimum requirement that most banks in the sample exceed. However, the hypothetical assumption enables us to test if bank business models react differently to shifts in funding structure. For robustness purposes, the actual leverage for all samples is used as well. We use the coefficients of the regression models to calculate $R_{Tier\ 1}$ for the above-described formula *(1)* of the WAC(R)C. The return on Tier 1 capital can be calculated by inserting the coefficient of leverage into the proxy-model:

$$exp(a + b \cdot ln(Leverage)) = R_{Tier\ 1} \quad (3)$$

with a as the constant and b as the coefficient of leverage. For the calculation of formula *(3)* two aspects have to be considered. One, the fixed effects models do not report intercepts for the regression outcomes. Therefore, we assume zero as the intercept. This enables an equal basis for the regression lines. An alternative method could be the average of the fixed effects for the individual banks of the FE regressions. However, this would not be an intercept in a classical meaning because it would be the average of the unobserved variable across time (Wooldridge, 2002). Second, for the results of R_{Tier1} the previously added constant of 1 to handle negative returns is subtracted after the calculation of formula *(3)*. Overall, the net return on Tier 1 capital for the all bank sample in the baseline model with an equity ratio of 3% is 15.06%. The rate is comparable to the

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return on equity of 14.85% that Miles et al. (2012) calculate for their (baseline) model.[11]

For the debt part of the WAC(R)C formula, the comparative studies use a constant debt rate regardless of the debt structure, which is a simplification and overlooks the possible impact of leverage on the actual cost of debt. The assumption follows the idea that debt (e.g., savings deposits) can be seen as risk-free due to deposit insurance and implicit state guarantees. The probability of default for debt can still be measured, but the value of risk-free debt is not correlated with general market movements (Clark et al., 2015). If non-constant debt rates are assumed for the WAC(R)C, the probability of default could be measured by exploiting credit ratings for different bank business models. However, both the German Savings Banks and Giro Association with about 600 members as well as the German Cooperative Financial Network with about 1,000 members have group ratings for all members due to the ownership based liability system. Banks within one liability system might have different rating grades if the ratings were based on the individual bank business model. However, individual-based rating grades do not exist for the majority of banks in the sample. Additionally, G-SIB can have lower funding costs than non-systemically important banks due to an expected state support (Ueda and Weder di Mauro, 2013), which affects the comparability. Given the described obstacles, we follow the simplification of the comparative studies and assume a constant risk-free debt rate. This assumption reduces the M/M effect on debt for the bank sample. Miles et al. (2012) choose a debt rate of 5%, which is the approximately average bank rate between 1999 and 2009. In contrast, Junge and Kugler (2013) use a constant rate of debt of 1%. The 1% debt rate seems to be in line with market conditions since the end of 2011 when the yield of German treasury bonds with a maturity of five years fell below 1% or since 2009 (and again 2011) when the ECB set the interest rate for main refinancing operations at 1% (Deutsche Bundesbank, 2015). We use 5% for the debt rate, but also present calculations with 1%. As for the corporate tax rate a flat rate of 35% is used for the calculations.

For the baseline calculation as presented in Table 6, the WAC(R)C for the whole bank sample accounts for 3.60%[12]. The hypothetical doubling of equity for the illustrative

[11] If using the average of the fixed effects as the intercept, the return on Tier 1 capital would account for 9.03% for the all bank sample, 11.69% for retail banks, and 7.37% for the W+T sample. The relative impact on the WAC(R)C would be approximately 1.75% higher for retail banks compared to the W+T sample.
[12] Calculation: equity ratio (3%) · R_{Tier1} (15.06%) + debt ratio (97%) · R_{Debt} (5%) · (1- tax rate 35%).

calculations would reduce the return on Tier 1 capital to 11.91% and increase the WAC(R)C by 16.6 basis points to 3.77%.

Table 6

Cost of Capital - Baseline

Cost of Capital	**All Banks**	**Retail**	**W+T**
Coefficient Leverage	0.040	0.041	0.027
$R_{Tier\ 1}$ for 3% Equity Ratio	15.06%	15.46%	9.93%
WAC(R)C with 3% Equity Ratio	3.60%	3.62%	3.45%
$R_{Tier\ 1}$ for 6% Equity Ratio	11.91%	12.23%	7.89%
WAC(R)C with 6% Equity Ratio	3.77%	3.79%	3.53%
Δ Impact on Cost of Capital	0.166	0.173	0.079
Relative Impact	**4.61%**	**4.78%**	**2.29%**
M/M Offset	53%	53%	61%

Notes: The constants and coefficients are withdrawn from Table 2. The return on Tier 1 capital is based on the proxy-model. WAC(R)C is measured with an interest rate for debt of 5% (risk-free debt) and a corporate tax rate of 35%. The delta shows the impact of increased capital requirements on the overall funding costs in basis points. The M/M offset describes to what part the WAC(R)C is independent of the capital structure.

If we assume that the M/M propositions would not hold at all, investors would expect the same return on equity regardless of leverage. Therefore, the WAC(R)C would increase by 35.4 basis points to 3.96% (i.e., 6% · 15.06% + 94% · 5% · (1-35%)). If the M/M effect would not be present, the WAC(R)C would rise about 47% (16.6 bps./35.4 bps.). Conversely, the M/M offset is about 53% for all banks of the sample.[13] It is assumed that higher equity ratios will reduce the risk of banks. This assumption can be measured for the return on Tier 1 capital as it will drop for retail banks from 15.46% to 12.23% and for the combined W+T sample from 9.93% to 7.89%. When comparing the relative impacts of decreased leverage, we find that the WAC(R)C of retail banks rises by 4.78% compared to 2.29% for the combined sample. If taxes are neglected (Miles et al., 2012, Toader, 2015, Clark et al., 2015) the relative impact for retail banks would drop to 2.25% compared to 0.50% for wholesale and trading banks. If the interest rate for debt is changed to 1% and taxes are neglected (Junge and Kugler, 2013) the relative impact for retail

[13] An M/M offset of 100% describes a total independence of the cost of capital on capital structure.

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banks would account for 16.72% compared to 11.48% for wholesale and trading banks.[14]

In the extended models, the relative impact on the cost of capital for the combined wholesale and trading sample (5.77%) is lower than for retail banks (10.22%).[15] It can be seen that the M/M offset is higher for the W+T sample (52%) than for retail banks (49%). Both indicate a partly dependence of the funding costs on a bank's capital structure. If the M/M propositions completely hold, the WAC(R)C would not change if leverage decreases and the relative impact would tend toward zero. The smaller the relative impact, the higher the irrelevance of capital structure. At first sight, the returns on Tier 1 capital seem to be high, particularly when compared to the baseline model. Though, it seems realistic that a minimum equity ratio of 3%, which barely fulfills the regulatory requirements, will call for a higher return. However, it surprises that the calculated cost of Tier 1 capital in both models is higher for retail banks than for the combined W+T sample.

Table 7

Cost of Capital - Extended

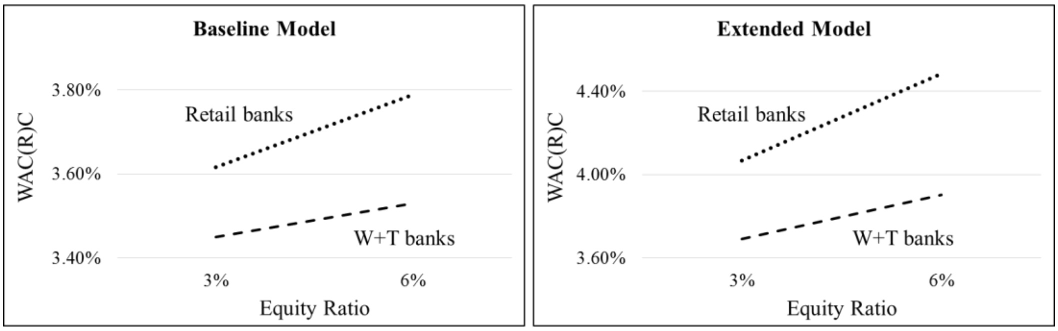
Cost of Capital	**All Banks**	**Retail**	**W+T**
Coefficient Leverage	0.066	0.076	0.047
$R_{Tier\ 1}$ for 3% Equity Ratio	26.04%	30.54%	17.92%
WAC(R)C with 3% Equity Ratio	3.93%	4.07%	3.69%
$R_{Tier\ 1}$ for 6% Equity Ratio	20.40%	23.84%	14.14%
WAC(R)C with 6% Equity Ratio	4.28%	4.49%	3.90%
Δ Impact on Cost of Capital	0.345	0.416	0.213
Relative Impact	**8.77%**	**10.22%**	**5.77%**
M/M Offset	49%	49%	52%

Notes: The constants and coefficients are withdrawn from Table 4. WAC(R)C is measured with an interest rate for debt of 5% (risk-free debt) and a corporate tax rate of 35%. The impact of higher capital ratios on the cost of regulatory capital are shown in basis points by the delta. The M/M offset describes to what part the WAC(R)C is independent of the capital structure when the amount of equity is doubled.

[14] Based on actual data, retail banks disclose an average leverage of 18.65 compared to wholesale and trading banks with a combined leverage of 29.74. If the calculation of the WAC(R)C is based on the actual levels of leverage the relative impact is 2.69% for retail banks and 2.01% for the combined W+T sample.

[15] If the tax-effect is neglected (Miles et al., 2012), the relative impact for retail banks (6.32%) is twice as high as for the wholesale and trading bank sample (2.98%).

An explanation could be the chosen timeframe and the existing data for the time series. First, after the financial crisis, 70% of the observations with negative returns (i.e., losses) belong to wholesale and trading banks. With less negative returns retail banks seem to be the less risky business model. Second, the unbalanced panel data set has an uneven distribution of observations regarding retail, wholesale, and trading banks before and after 2007 (see Appendix II). Further research could increase the number of observations. Nevertheless, the calculations are not meant to identify the actual cost of capital for banks, but to show the impacts of shifts in funding structure.



Notes: The figures show the WAC(R)Cs for an equity ratio of 3% and a potential doubling of equity to 6% for retail banks and the combined wholesale and trading (W+T) bank sample. The WAC(R)C increases relatively more for retail banks, which can be seen in the slope of the line or in Table 6 and 7. The relative impacts on the WAC(R)C are smaller for the W+T sample.

Figure 1

Unequal Impacts on the Cost of Regulatory Capital

Overall, we can support the comparative studies surrounding Miles et al. (2012) that the cost of capital is partly irrelevant regarding the capital structure of banks. A potential doubling of equity would raise the funding costs of European banks between 8 basis points in the baseline model to 42 basis points in the extended model, the tax-effect included. Higher capital requirements are not free, but the amount seems to be acceptable to strengthen the financial system. The results for retail banks and the combined wholesale and trading bank sample vary in both the baseline and the extended calculations. Regardless of the assumptions for the proxy-model with historical returns, the different regression models, or the calculated parameters for the WAC(R)C, bank business models react differently to shifts in funding structure. Consequently, the differences of business models should also be considered for a non-risk-sensitive equity ratio. A 'one size' approach in Pillar 1 does not fit all.

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9. Conclusion

The examination of a bank's business model through Pillar 2 is fairly new in the European supervisory practice. Therefore, we analyze the impact of shifts in funding structure on bank business models by using the framework of Miles et al. (2012) and the example of the non-risk-sensitive leverage ratio. We find that the observed bank business models react differently to shifts in funding structure. The outcome that differences between banks exist may not surprise much. However, this raises the question why bank business models have not been considered before in Pillar 1?

The reasons for the observed differences are the business activities and the underlying funding structures. Both are based on the chosen strategy, the risk appetite, and risk-return-profile of the business model. Deposits are the most important source of debt refinancing for retail banks. Wholesale and trading banks use a broader mix of debt capital. Hence, a retail bank with a high share of deposit funding needs different capital and liquidity requirements than a low-deposit funded wholesale or trading bank. The results support Ayadi et al. (2016) and Mergaerts and Vander Vennet (2016) that the differences between business models should be considered in regulatory and supervisory practice. The diverse risk characteristics can be used as an additional indicator of emerging risks and require differentiated capital and liquidity requirements. Further, we can support Ayadi et al. (2011) that a non-risk-sensitive leverage ratio requirement should be adjusted to the risk-profile of the individual bank business model. Future research could concentrate on developing different capital and liquidity requirements for bank business models.

The EBA has made the first step towards a differentiated regulation of banks. However, the implementation of the new European SREP differs to other global Pillar 2 approaches, which could lead to disadvantages or regulatory arbitrage. An internationally coordinated approach and a consistent implementation could prevent possible disadvantages. For this reason, the consideration of bank business models in Pillar 1 of the Basel framework is desirable.

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Appendix I.

Comparative Studies

	Miles et al. (2012)	**ECB (2011)**	**Junge and Kugler (2013)**	**Toader (2015)**	**Clark et al. (2015)**	**Cline (2015)**
Location	UK	G-SIB	Swiss	Europe	USA	USA
Sample	6 banks	54 banks	5 banks	85 banks	200 banks	51 banks
Timeframe	6/1997 – 6/2010	6/1995 – 6/2011	6/1999 – 6/2010	1997 – 2012	3/1996 – 12/2012	2001 – 2013
Data Origin	n/a	Bloomberg	Datastream, FINMA	Bankscope	Chicago FED, CRSP	Bloomberg, bank's websites
Observations	n/a	652 – 1,372	n/a	721	10,577	579
M/M Offset	45% – 90%	41% – 73%	36% – 55%	42%	41% – 100%	60%
R-squared	0.634 – 0.671	0.360 – 0.530	0.307 – 0.849	0.025 – 0.099	0.395 – 0.486	0.268
Regression	$\beta = X'b + (\alpha + \mu)$	$\beta = a + b \cdot CR + X + d + u$	$\log(\beta) = a + b \cdot log(lr) + \eta + \delta + \varepsilon$	$\beta = \alpha + X'CR + u$	$\beta = b + x + z + \mu$	$NI/E = a + z + d$
Variables	β – Equity beta X – Lagged leverage + year dummies b – Control var. α – Bank-specific effect μ – Error term	β – Equity beta a – Fixed effects CR – Lagged capital ratio X – Control var. d – Time fixed effects u – Error term	β – Equity beta a – Constant lr – Leverage η – Bank-specific effect δ – Time specific effect ε – Error term	β – Equity beta CR – Capital ratio- RWA X – Bank-specific control variable and time dummy u – Error term	β – Equity beta b – Lagged leverage x – Bank-specific variables z – Year dummy or macro. variable μ - Error term	NI/E – Net income to equity ratio a – Constant z – Ratio of debt to equity d – Dummy variable

Control Variables	- LLRR - LAR - ROA	- ROA - Size - RWA	n/a	- LLRR - LAR - ROA + Size	- LLRR - LAR - ROA	n/a
Coefficient	OLS: 0.025*** RE: 0.025*** FE: 0.031***	No control var.: -0.045*** With control var.: -0.079***	n/a	OLS: -0.022*** RE: -0.0257*** FE: -0.0259***	FE Basic: 0.064*** FE Extended: 0.062***	OLS: 0.636*** RE: n/a FE: 0.708
Coefficient Log-Model	OLS: 0.602*** RE: 0.602*** FE: 0.692***	n/a	OLS: n/a RE: 0.763** FE: 0.554**	OLS: -0.251*** RE: -0.418*** FE: -0.426***	OLS: n/a RE: n/a FE: 0.902***	n/a
Specific model characteristics	Control variables were dropped because of no significance	- Log-RWA - Log-Total assets (Size)	n/a	- Log-CR-RWA - Log-Total assets (Size) - 'Expected' ROE	- Pre/post-crisis - Size 200 bn. $ - Leverage ≤ 66.67	- Actual returns - Swap negative returns

*Notes: Variables: Leverage = total assets / Tier 1 capital; Capital ratio (CR) = Tier 1 capital / total assets; Capital ratio-RWA = Tier 1 capital / RWA. Control Variables: Loan loss reserve ratio (LLRR) = Total loan-loss reserves / Assets; Liquidity (asset) ratio (LAR) = (cash/ deposits of depository institution + available-for-sale securities) / (total liabilities – equity); Return on assets (ROA) = net income / total assets; Size = logarithm of total assets. Level of significance: : ***p<0.01, **p<0.05, *p<0.1.*

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Appendix II.

Yearly Observations

Appendix III.

Dependent Variable - Net Return on Tier 1 Capital

Sample	Obs.	Mean	Min.	Max.	Median	SD
All Banks	615	0.085	-0.447	0.460	0.074	0.114
Retail Banks	302	0.091	-0.356	0.460	0.071	0.094
Wholesale Banks	193	0.071	-0.447	0.411	0.062	0.130
Trading Banks	120	0.094	-0.378	0.362	0.097	0.131

Notes: Calculated as net income divided by Tier 1 capital.

Independent Variable - Leverage

Sample	Obs.	Mean	Min.	Max.	Median	SD
All Banks	615	26.19	7.49	149.78	22.58	14.87
Retail Banks	302	18.65	7.49	69.90	17.63	7.43
Wholesale Banks	193	29.59	8.38	76.29	28.02	10.46
Trading Banks	120	39.69	10.18	149.78	36.75	21.86

Notes: Calculated as balance sheet total divided by Tier 1 capital.

Independent Variable - Return on Assets

Sample	Obs.	Mean	Min.	Max.	Median	SD
All Banks	611	0.004	-0.018	0.025	0.004	0.005
Retail Banks	298	0.005	-0.018	0.025	0.004	0.005
Wholesale Banks	193	0.003	-0.015	0.017	0.002	0.005
Trading Banks	120	0.003	-0.009	0.014	0.003	0.004

Notes: Calculated as net income divided by balance sheet total.

Independent Variable - Liquid Asset Ratio

Sample	Obs.	Mean	Min.	Max.	Median	SD
All Banks	610	0.254	0.002	7.467	0.185	0.347
Retail Banks	297	0.166	0.002	7.467	0.136	0.434
Wholesale Banks	193	0.279	0.020	0.833	0.241	0.176
Trading Banks	120	0.432	0.133	1.031	0.387	0.209

Notes: Calculated as liquid assets divided by balance sheet total minus equity.

Appendix IV.

Fixed Effects Regression Models Including Control Variables

All Banks

FE	(1)	(2)	(3)	(4)	(5)	(6)
Leverage	0.040' (0.022)	0.003 (0.025)	0.064*** (0.013)	0.066*** (0.013)	0.067*** (0.013)	0.064*** (0.022)
ROA			23.951*** (0.656)	24.011*** (0.654)	24.000*** (0.656)	25.296*** (0.806)
LAR				0.014* (0.006)	0.013** (0.006)	0.003 (0.012)
Total Assets					-0.003 (0.015)	-0.002 (0.019)
LLRR						-0.007 (0.005)
Year Effects	No	Yes	Yes	Yes	Yes	Yes
Observations	615	615	611	610	610	421
R^2	0.007	0.311	0.818	0.820	0.820	0.863
Adjusted R^2	0.005	0.245	0.643	0.642	0.641	0.615
F Statistic	3.289* (df = 1; 497) 15.592*** (df = 14; 484) 143.714*** (df = 15; 480) 135.984*** (df = 16; 478) 127.734*** (df = 17; 477) 104.863*** (df = 18; 300)					

*Notes: The dependent variable is the log of the net return on Tier 1 capital. The independent variables are logarithmized. ROA is the return on assets. LAR is the liquid asset ratio. Total Assets is the balance sheet total. LLRR is the loan loss reserve ratio. Calculations without standard robust errors. Standard errors in parentheses. Level of significance: *** p<0.001, ** p<0.01, * p<0.05, ' p<0.10.*

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Retail Banks

FE	(1)	(2)	(3)	(4)	(5)	(6)
Leverage	0.041 (0.026)	-0.015 (0.030)	0.075*** (0.014)	0.076*** (0.014)	0.073*** (0.014)	0.036 (0.028)
ROA			18.290*** (0.639)	18.401*** (0.645)	18.458*** (0.643)	20.321*** (1.181)
LAR				0.005 (0.004)	0.007 (0.004)	0.007 (0.016)
Total Assets					0.026* (0.014)	0.039 (0.025)
LLRR						0.017 (0.019)
Year Effects	No	Yes	Yes	Yes	Yes	Yes
Observations	302	302	298	297	297	160
R^2	0.010	0.279	0.848	0.849	0.851	0.884
Adjusted R^2	0.008	0.208	0.629	0.626	0.625	0.492
F Statistic	2.407 (df = 1; 234) 8.694*** (df = 10; 225) 112.023*** (df = 11; 221) 102.703*** (df = 12; 219) 96.030*** (df = 13; 218) 48.680*** (df = 14; 89)					

Combined Wholesale and Trading Bank Sample

FE	(1)	(2)	(3)	(4)	(5)	(6)
Leverage	0.027 (0.033)	0.039 (0.039)	0.045** (0.019)	0.047* (0.019)	0.054*** (0.020)	0.062** (0.028)
ROA			29.400*** (1.043)	29.349*** (1.045)	29.372*** (1.042)	28.518*** (1.086)
LAR				0.015 (0.015)	0.013 (0.015)	0.015 (0.016)
Total Assets					-0.036 (0.025)	-0.045 (0.029)
LLRR						-0.006 (0.005)
Year Effects	No	Yes	Yes	Yes	Yes	Yes
Observations	313	313	313	313	313	261
R^2	0.003	0.337	0.848	0.849	0.850	0.880
Adjusted R^2	0.002	0.255	0.640	0.637	0.636	0.634
F Statistic	0.658 (df = 1; 250) 8.621*** (df = 14; 237) 87.908*** (df = 15; 236) 82.491*** (df = 16; 235) 78.088*** (df = 17; 234) 76.364*** (df = 18; 188)					

Notes: The dependent variable is the log of the return on Tier 1 capital after taxes. The independent variables are logarithmized. ROA is the return on assets. LAR is the liquid asset ratio. Total Assets are the balance sheet total. LLRR is the loan loss reserve ratio. Calculations without standard robust errors. Standard errors in parentheses.

*Level of significance: *** p<0.001, ** p<0.01, * p<0.05, ' p<0.10.*

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Part II

LEVERAGE RATIOS FOR DIFFERENT BANK BUSINESS MODELS

*

Abstract

The development of the Basel III leverage ratio does not consider the different risk characteristics of bank business models. All banks have to achieve the same requirements even if a high-risk business model is chosen. For that reason, leverage ratios which are adjusted to the risk-profile of retail, wholesale, and trading banks are developed. Based on Value-at-Risk and Expected Shortfall calculations, the left-hand tail of a net return on non-risk-weighted assets distribution of 120 European banks is analyzed. Retail banks are less risky and can withstand financial distress with a smaller amount of capital.

JEL classification: G21, G28, G32

Keywords: Bank Business Models, Bank Capital Requirements, Expected Shortfall, Leverage Ratio, Regulation, Value-At-Risk

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1. Introduction

Banks choose their business model to meet their strategic objectives and thus display different risk characteristics. However, the different risks of business models, such as the risk-return-profile or dependencies of the capital structure, are not considered for the development of the leverage ratio requirement in Pillar 1 of the Basel framework. All banks have to achieve the same leverage ratio no matter whether a bank pursues a low-risk or a high-risk business strategy. A ratio, which accounts for numerous problems and was designed without a reasonable method for the measures of financial risks. Given these problems, Ayadi et al. (2011) and Grossmann and Scholz (2017) state that bank business models require diverse capital requirements and suggest to adjust the leverage ratio to account for the different risk-profiles of business models. The consideration of bank business models can complete the existing regulatory framework to cover business model risks in Pillar 1. Against this backdrop, the main questions are: how can the leverage ratio requirement be adjusted to consider the riskiness of different bank business models? And, what are the consequences for retail, wholesale, and trading bank business models?

Previous research on business models concentrates on the classification of banks, the profitability and performance, the return and costs, the risk and default, or the impact of higher capital requirements (cf. Roengpitya et al., 2014, Ayadi et al., 2016, Koehler, 2015, Mergaerts and Vander Vennet, 2016, Grossmann and Scholz, 2017). We expand the field of research on bank business models with the development of different leverage ratio requirements. For this reason, established methods to measure financial risks are chosen to overcome problems of the current development of the leverage ratio. Since the existing method of the Basel Committee on Banking Supervision (BCBS, 2010) does not coincide with the characteristics of a coherent risk measure, Value-at-Risk (VaR) and Expected Shortfall (ES)[1] calculations are used to match the requirements of Artzner et al. (1999). VaR and ES seem to be appropriate risk measurement methods because they promote sufficient levels of capital for banks to withstand financial distress, are approved by regulators, and are commonly used by banks. First, we find that retail banks account for the lowest risk of the examined business models in the sample. Wholesale and trading banks account for higher potential losses and need higher leverage ratios to withstand

[1] The ES can also be called Conditional Value-at-Risk, Expected Tail Loss, or Tail Conditional Expectation.

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financial distress. Based on VaR calculations, the adjusted leverage ratio for retail banks should be between 2.83% and 3.00%, and for wholesale banks between 3.28% and 4.21% relative to total assets. Trading banks should have an adjusted leverage ratio of 3.76% to 4.41% relative to total assets. Second, to capture 'tail risks' the ES calculations indicate a leverage ratio including an additional buffer between 3.00% and 3.76% for retail, 3.81% and 4.16% for wholesale, and 4.78% and 5.13% for trading banks. We also report ratios for a combined wholesale and trading bank sample. The main findings, at least for medium and small banks in the sample, illustrate the potential to account for the different risk characteristics of business models. Third, the results support Grossmann and Scholz (2017) that a 'one size' approach for the regulation of banks does not fit all. Adjusted leverage ratios can help to keep the existing differences between bank business models and must not lead to a more similar banking system. The impact on a bank's balance sheets seems to be acceptable to strengthen both, the individual bank and the financial stability.

The approach to investigate the research questions is based upon two steps. In a first step, 120 banks are separated into retail, wholesale, and trading bank business models. The separation is based on a study by Roengpitya et al. (2014) and a procedure defined by Grossmann and Scholz (2017) for each bank from 2000 to 2013. In a second step, leverage ratios for three bank business models are developed. In contrast to the BCBS (2010), VaR and ES are applied to adjust the current leverage ratio requirement. Since the leverage ratio focuses on a bank's total exposure, a return distribution of the net return on non-risk-weighted assets is created and the left-hand tail is analyzed. The idea is comparable to the calibration of capital requirements for risk-weighted assets (RWA), but with a focus on non-risk-sensitive assets. The use of VaR can be a good estimate of sufficient capital because *"high percentiles of this distribution might be reasonable proxy value for the degree of shock"* that a bank is able to withstand (BCBS, 2010, p. 2). As for the method of the ES, we refer to the revised standards for minimum capital requirements for market risk by the BCBS (2016), which introduces a shift from VaR to ES to capture 'tail risks' for adequate levels of equity under significant periods of financial stress. Two approaches to adjust the current BCBS leverage ratio are presented. Firstly, the current requirement of 3% is used as a minimum basis. Supplementary, the differences between low-risk and high-risk bank business models are added as extra capital requirements. Secondly, the highest VaR and ES calculations are added to the highest negative returns for each bank business model over the examined timeframe. In both approaches, the different risk characteristics of business models are considered and sufficient levels of capital are promoted for banks to withstand financial distress without government support.

2. The BCBS Leverage Ratio

Before the focus shifts to the adjustments, the development of the original BCBS leverage ratio, the accompanying problems, and a brief literature review on the leverage ratio are discussed. After the financial crisis, the BCBS proposed new capital requirements, commonly known as Basel III, to strengthen the financial system. One part of Basel III is the leverage ratio, which is the ratio of a bank's Tier 1 equity to its on- and off-balance sheet exposure and is a non-risk-weighted capital requirement (BCBS, 2011 and 2014). The leverage ratio requirement is invented to reduce the creation of leverage within the financial system, which the RWA approach was not intended for. Hence, the leverage ratio serves as a backstop supplementary to the RWA approach. Moreover, it serves as a safety net and prevents a possible over-reduction of capital requirements due to the use of internal risk models (BCBS, 2013). The BCBS (2010) establishes a conceptual framework for a top-down approach to determine capital requirements for a bank's risk-sensitive as well as non-risk-sensitive exposure. The top-down approach is used as one of the inputs for the Basel III framework.[2] For the development of the RWA requirements, the BCBS (2010) examines the left-hand tail of the historical net return on risk-weighted assets (RORWA) distribution, which is conceptually comparable to the VaR to measure potential losses. In contrast to the RWA approach, the BCBS (2010) uses historical losses to calibrate the current leverage ratio requirement. The survey focuses on Tier 1 capital to on-balance sheet assets and identifies a critical value at 3%-5% between severely stressed and non-severely stressed banks. Severely stressed banks are defined as banks that failed, are acquired under stress, or receive government assistance (BCBS, 2010).

The problems with the development of the BCBS leverage ratio are manifold. First, when the BCBS calibrates the leverage ratio, it is simply based on historical leverage ratios and

[2] The other inputs for Basel III are the long-term economic impact group and the 'bottom up' quantitative impact study. For more details see BCBS (2010).

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a critical value between severely and non-severely stressed banks. The BCBS admits that it is not a direct approach to set capital requirements, but it is "*at least a rough indication*" (BCBS, 2010, p. 18). By contrast, Jarrow (2013, p. 973) calls the proposed leverage ratio of Basel III a "*standard with no economic reasoning provided*". In addition, the BCBS approach does not consider the characteristics of a coherent risk measure. Second, the BCBS is inconsistent regarding the methodology to develop capital requirements. Third, the data set: the calibration of the leverage ratio is based on severely stressed banks, but only 12.5% of the first sample and only 17% of the broader second sample were stressed banks. For the first working group, a sample of 88 banks (11 of them were stressed) is observed over a period from the mid-1990s to 2006. Additionally, 117 large banks are observed for a broader second sample (BCBS, 2010). However, the data are calculated at the end of 2006, one year before the financial crisis started. Significantly stressed banks during the crisis are not considered. Fourth, the current leverage ratio of 3% seems to be too low. Miles et al. (2012) find an optimal ratio between 7-10% and Admati et al. (2013) suggest an equity ratio of even 20-30% of a bank's total unweighted assets. Fifth, the new supervisory review and evaluation process (SREP) of the EBA in Pillar 2 does not consider the leverage ratio for additional capital requirements (Pillar 2 Requirements, P2R) for risky banks (cf. EBA, 2014). Sixth, the diversification of the banking sector is not sufficiently considered (Ayadi et al., 2011 and 2016, Grossmann and Scholz, 2017).

Most scientific research in this field of activity relates to the disadvantages and advantages of a leverage ratio requirement. To name a few: the leverage ratio is criticized for that it could reduce the amount of lending (Frenkel and Rudolf, 2010), will have a negative impact on the business policy of banks due to higher funding costs (Hartmann-Wendels, 2016), seduce banks to shift towards riskier assets (IMF, 2014), and lead to a more similar banking sector that may undermine the financial stability (Kiema and Jokivuolle, 2013). In contrast, the leverage ratio is praised to induce truthful risk reporting, to increase the ability to sanction banks (Blum, 2008), and to reduce the probability of bank runs because it puts a floor on the risk-weighted capital requirements (Dermine, 2015). Overall, the necessity of a leverage ratio is not discussed because it can serve as a sound and robust safety net (cf. EBA, 2016). The primary goal is to consider the riskiness of different bank business models for the adjustment of the leverage ratio. Besides the above-described method of the BCBS (2010), other approaches to design a leverage ratio exist. On the one hand, Fender and Lewrick (2015) calibrate a leverage ratio based on the link between the historical leverage ratio and the historical Tier 1 risk-weighted capital requirement. The calibration considers the ratio of RWA to on- and off-balance sheet exposure and assumes that the leverage ratio requirement is cyclical to the RWA approach. On the other hand, Jarrow (2013) designs a maximum leverage ratio (calculated as debt over equity) based on the probability of insolvency over a given timeframe. The maximum leverage ratio ensures that banks' equity exceeds banks' debts. Otherwise, a bank needs to be restructured, e.g., through haircuts.

In contrast, we focus on existing risk measurement methods that are detached from an interaction with the RWA and neglect a possible dependence between different regulatory concepts. Thereby, the leverage ratio can serve as an independent backstop supplementary to the RWA requirements and other non-risk-weighted assets. Furthermore, we do not focus on haircuts or on severely stressed banks. The definition of stressed banks (cf. BCBS, 2010) intervenes too late, e.g., banks that failed. The consideration of negative earnings seems to be a more appropriate method for an earlier detection of expected bank failure because non-stressed banks can turn into stressed banks after negative earnings adjoin or exceed a bank's capital, e.g., losses over several quarters or years. The development of the BCBS leverage ratio does not consider the larger losses of wholesale and trading banks during the financial crisis. Therefore, our approach considers the experienced losses to set higher levels of capital requirements for riskier business models. Overall, both the maximum leverage ratio and VaR control for the same insolvency risks and can be seen as equivalent instruments (Jarrow, 2013). In addition, a combination of VaR and ES can be a good risk-adjusted performance measurement tool (Frey and McNeil, 2002).

3. Data Set

The final sample consists of 89 banks with a banking license in Germany and additional 31 banks with a banking license in Europe. The bank sample is based on Grossmann and Scholz (2017) who analyze the return on Tier 1 capital for a European bank sample. The composition of the sample consists of large, medium, and small European banks. The large banks belong to the biggest banks in Europe, based on their balance sheet volume

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at the end of 2013 or the last known. The majority of medium and small banks are selected from Germany for two reasons. One, the German banking sector is chosen as an example because it is one of the largest in Europe based on the number of credit institutions and the ratio of assets to GDP (ECB, 2015). Two, information about regulatory Tier 1 capital, especially for medium and small banks, which is based on disclosure reports according to §26a of the German Banking Act, is available for the investigated timeframe. We like to mention that the largest banks in Germany could also be categorized to the group of large European banks. Appendix V shows the list of banks. Nevertheless, it should be considered that the results of the analysis are influenced by the majority of German banks. Banks operating in Germany that are a subsidiary of an European bank holding company in the sample are not considered to avoid duplications. The data are collected for the timeframe of 2000 to 2013 from the bankscope database Bureau van Dijk Electronic Publishing (2015). The data set does not contain data for all banks for every year from 2000 to 2013, but the available observations are kept because the banks represent the financial system. The predominant share of data exists for the years 2006-2013 with more than one hundred yearly observations as Appendix I shows. The observed timeframe allows us to split the sample into two subsamples: 'pre-crisis' for the years 2000 to 2006 and 'post-crisis' for the years 2007 to 2013. The data sample is checked for banks with no observations for the examined data, i.e., yearly earnings and total assets. Furthermore, data errors such as incorrect units and banks that are overtaken by competitors are deleted from the final sample. If a competitor in the sample overtakes 50 percent of the shares of another bank in the sample, the examined bank is dropped for the observed year. The observations before the merger are taken into account in order to avoid a selection bias. The observations of the overtaken bank for the years following the merger are deleted because they would otherwise be considered twice. Each bank and possible merger are examined for every year. Hence, the sample considers banks that might be acquired after the investigated timeframe. Due to disclosure requirements of medium and small banks, only yearly data are available for every bank in the sample. About half the banks in the sample do not disclose semi-annual and quarterly reports. We decide not to mix annual, semi-annual, and quarterly data to avoid a possible distortion of observations towards banks with higher publishing requirements. The unbalanced panel data set includes a total of 1,265 observations.

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The data set is used to analyze losses of the past to calibrate capital requirements for future distress. However, it should be considered that the use of historical data might not be a good predictor of future distress. More sophisticated simulation methods could be used instead, but would rely on several assumptions and require internal bank data, e.g., the interest margin, new business volume, or the future cost structure. As far as we know, the development of most regulatory ratios is based on historical data.

4. Bank Business Models

In the current regulatory framework, the business model of a bank is considered in Pillar 2 as one out of four parts in the European SREP. The goal is to cover individual risks that are not considered by Pillar 1 (EBA, 2014). However, several problems with the current supervisory review process exist, which motivate the consideration of bank business models in Pillar 1. One, the SREP of the EBA is primarily for significant European institutes (SI). Less significant institutes (LSI) are supervised by national authorities that may use adapted Pillar 2 concepts. Two, in practice, the composition of additional P2R for SI is nontransparent and not comparable with P2R for LSI.[3] Three, the business model analysis is primary for European banks. Other regulatory jurisdictions can have different Pillar 2 concepts that do not analyze the business model. The described disadvantages could lead to competitive national and international disadvantages for banks (cf. Grossmann and Scholz, 2017). A possible solution could be standardized Pillar 1 requirements for business models (P1R-BM), which would be applied by all SI and LSI within and outside Europe to ensure a certain level of capital. P1R-BM are irrespective of risk estimates, which focus on single risk-weighted assets, and could cover general risks that affect all banks within one business model, e.g., dependencies of the capital structure or certain business activities. Changes in the P1R-BM, due to a revised risk assessment by the supervisory board, would affect all banks of one business category at the same time, in contrast to a delayed individual consideration within the next SREP. Irrespective of this, additional P2R could still be applied if individual bank risks are found under the SREP.

[3] See for example the EBA SREP Guideline versus the LSI SREP of the BaFin and Deutsche Bundesbank.

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The allocation of the banking sample into business models follows Roengpitya et al. (2014). The allocation is based on the business activities, the compositions of the asset side, and the funding structures of the individual banks. Grossmann and Scholz (2017) define a procedure based on three key ratios and five supportive ratios identified by Roengpitya et al. (2014) as well as two additional supportive ratios to split the banking sample into retail, wholesale, and trading banks. In step one, the allocation procedure focuses on the funding structure. In step two, the focus is on a bank's business activities. The allocation of banks to business models is made for each bank and for every year from 2000 to 2013. Changes of business models over time are possible and are taken into account for the calculations. The results of the allocation for the banking sample are presented in Table 1.

Banks choose balance sheet structures that suit their strategic goals best. The aim of a retail bank is to collect deposits from private and small corporate customers to deal in credits. Hence, a retail bank has a high share of gross loans, which is refinanced via customer deposits and has low shares of wholesale debt or interbank borrowing. A bank is therefore classified as a retail bank if the gross loans are above 50% with customer deposits above 50%, or if gross loans are above 35% with customer deposits exceeding wholesale debt and interbank borrowing, and investment activities (i.e., derivative exposure and trade liabilities) below 20% of the balance sheet total net of derivatives. The aim of a wholesale bank is to provide banking services to financial institutions and larger corporate customers. Thus, a wholesale bank also has a high share of gross loans, but differs in the funding mix. Wholesale banks depend less on customer deposits and use more banking and non-current liabilities. A bank is therefore classified as a wholesale bank if the gross loans are above 50% with interbank borrowing and wholesale debt exceeding customer deposits, or if gross loans are above 35% with wholesale debt and interbank borrowing exceeding customer deposits, and investment activities below 20%. By contrast, the aim of trading banks is to consult on corporate finance decisions, provide brokerage services, and to assist customers in raising equity and debt. Trading banks have a smaller share of gross loans and a higher share of loans to banks. Moreover, they have a high share of investment activities such as derivative or trading exposure and use a market-based funding strategy (see also Hull, 2015 and Roengpitya et al., 2014). Roengpitya et al. (2014) discover that the share of interbank related assets and investment activities is about 20% of the balance sheet total for trading banks. A bank is therefore classified as a trading bank if investment activities are above 20%, or if interbank lending (e.g., loans and advances to banks) and investment activities exceeds gross loans. In total, the sample provides 685 retail bank observations, 350 wholesale bank observations, and 230 trading bank observations.

Table 1

The Allocation of Banks

Variables	All Banks	Retail	Wholesale	Trading
Gross Loans	53% (58%)	**62%** (62%)	**52%** (65%)	29% (26%)
Interbank Borrowing	22% (11%)	18% (8%)	29% (14%)	23% (19%)
Wholesale Debt	19% (19%)	8% (11%)	**38%** (37%)	24% (18%)
Interbank Lending	15% (11%)	9% (9%)	20% (8%)	**26%** (22%)
Deposits	47% (54%)	**64%** (67%)	24% (36%)	29% (38%)
Stable Funding	63% (67%)	71% (74%)	59% (63%)	46% (49%)
Derivative Exposure	5% (n/a)	0.9% (n/a)	3% (n/a)	**18%** (n/a)
Trading Exposure	3% (n/a)	0.5% (n/a)	1% (n/a)	**11%** (n/a)

Notes: Gross Loans show the share of loans relative to total assets. Interbank Borrowing describes the share of deposits from banks relative to total assets. The share of other deposits plus short-term borrowing plus long-term funding relative to total assets is shown by Wholesale Debt. Interbank Lending displays the share of loans and advances to banks in relation to total assets. Customer Deposits are calculated by the share of customer deposits relative to total assets. The Stable Funding is displayed by the share of total customer deposits plus long-term funding relative to total assets. The share of derivatives relative to total assets is presented by Derivative Exposure. Trading Exposure is the share of trading liabilities in relation to total assets. The total assets are net of derivatives. The results in parentheses are from Roengpitya et al. (2014).

The described procedure to split the banking sample into business models illustrates one possible approach. Other approaches that use different databases with other variables, such as Ayadi et al. (2016) who offer five business models, exist. A more granular classification of business models, which considers more differences between banks could increase the practicability of the analysis, but would require additional internal and external data. In practice, the yearly allocation of a bank to a business model could be made by the supervisory authority. In the case of borderline-decisions or differences between business models across countries, competent supervisory authorities could use additional data regarding, e.g., strategic plans, internal reporting, recovery and resolution plans, business development and specialized mortgage loans, or domestic characteristics

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of banks to allocate banks. Nevertheless, we believe that the chosen business models offer a first approach to consider the different risk characteristics of banks more appropriate than a single leverage ratio for all banks. In a next step, a more detailed allocation of banks could build upon our analysis. In addition, we find that ownership structure, as another possibility to separate a banking sample, does not allow to distinguish between international banks because of the differences between two- and three-pillar banking systems. Moreover, ownership structures are not a robust measure to distinguish between the riskiness of different banks. For example, both cooperative and savings banks claim to collect deposits at a local level to deal in credits to their customers or owners. However, based on the balance sheet structure, which can reflect the chosen business strategy, some cooperative and savings banks in the sample feature characteristics of wholesale or trading banking. Hence, it is important to analyze each bank in every year and to consider possible changes over time.

Overall, the applied procedure to separate the banking sector offers an objective approach based on financial statements with realized business activities and funding structures. The focus on business models allows differentiating capital requirements for the regulation of unequal banks.

5. Characteristics for a Coherent Risk Measure

We aim to find rules of capital regulation that are based on an 'economic reasoning' method, can be seen as a coherent measurement of risk, and consider the differences of business models. In particular, the focus is on financial risks for the European bank sample. Financial risks can include various categories of risk, e.g., market, credit, and operational risk. The focus on financial risks as a whole provides a unified risk perspective that considers possible correlations among various risk categories. In this respect, the definition of characteristics for a coherent risk measure by Artzner et al. (1999) is chosen. A coherent risk measure considers the aspects monotonicity, translation invariance, positive homogeneity, and subadditivity. The characteristics are chosen because they enable to deliver a judgment about sufficient capital to cover financial risks and are indirectly considered by the BCBS (2016) for minimum requirements to capture 'tail risk' in periods of significant financial market stress.

Following Artzner et al. (1999, p. 203), "*these measures of risk can be used as (extra) capital requirements to regulate the risk […]*". This means for our approach: certain bank business models that are riskier than other business models should have higher capital buffers (monotonicity). The additional equity, e.g., cash out of retained earnings, will make riskier bank business models less risky (translation invariance). If the relative trading activities and funding structure of a bank and the related classification to a bank business model are unchanged, even if the size of the bank increases, the relative capital requirement should stay the same. If a bank changes its business strategy and the related trading activities and funding structure, the capital requirement should be adjusted (positive homogeneity). We look at the sample as a portfolio of positions of a diversified banking sector. If two banks of the same bank business model merge, the risk measure should not increase (subadditivity). If two banks of different bank business models merge, the future risk measure should consider the new bank business model. The new business model should again be classified based on the funding structure and trading activities. However, our approach does not consider size dependencies and the related systemic importance of banks, but additional capital buffers for global systemically import banks (G-SIB) could be added.

6. Methodical Approach

The practical implementation of the characteristics for a coherent risk measure can be accomplished by using two existing risk measurement methods: VaR and ES. The VaR approach satisfies the first three proposition of Artzner et al. (1999) and is used to adjust the leverage ratio requirement. Though, VaR is not a coherent risk measure because it lacks the subadditivity proposition. However, VaR is used because it requires a smaller sample size than ES for the same level of accuracy (Yamai and Yoshiba, 2002). The ES is considered because it complies with all four propositions of Artzner et al. (1999) and is used to calculate additional leverage ratio buffers for periods of significant financial stress. Overall, VaR and ES have the advantage of an underlying economic methodology, can capture financial risks, have been approved by regulatory and supervisory authorities, are used in practice by banks, and can be used to differentiate between business models.

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The VaR is a method to measure the risk exposure of a potential change in value of a single asset or a portfolio for a predefined timeframe with a given probability (J.P. Morgan and Reuters, 1996). Depending on the aim of the research and the number of observations, different values for α can be used to calculate the VaR, with the most common $\alpha = 0.95$ and $\alpha = 0.99$. Theoretically, a 99.9% confidence level can be used as well, but requires sufficient data (Embrechts et al., 2003). The VaR can be used for investment, hedging, or general portfolio management decisions (Dowd, 1999). In contrast to traditional methods that are based on risk-return analysis or the capital asset pricing model, the VaR approach concentrates on the downside of return distributions to measure financial risk (Lu et al., 2008). Moreover, the VaR can create an incentive for banks to adjust their leverage. Adrian and Shin (2014) find in a contracting model of leverage and balance sheet size that the VaR at a given confidence level determines a bank's leverage. The financial risks involved will be managed to the extent that the VaR will not exceed a bank's equity capital. The methods to calculate the VaR can be divided into the local valuation method, which presumes a normal distribution of returns, and the full valuation method, which presumes non-linear and non-normal distributions of returns (cf. Jorion, 2007). Three different VaR calculations are used to analyze the bank sample. One, the Gaussian VaR that assumes a normal distribution of returns. Two, the historical VaR that is based on historical returns. According to Jorion (2007) the historical method does not have underlying assumptions for the return distribution. Though, historical data cannot predict future results, trends in the data, the occurrence of new risks, or unpredictable market movements (Damodaran, 2007). Third, the modified VaR (mVaR) calculates the potential loss in value based on the Cornish-Fisher expansion to correct the percentiles of the return distribution for skewness and kurtosis (cf. Zangari, 1996, Boudt et al., 2008). However, the mVaR approach does not work under market stress because it underestimates the likelihood of extreme values and 'tail risks' of the return distribution (Yamai and Yoshiba, 2002b). Furthermore, mVaR might disregard the diversification of a portfolio and does not declare the potential size of a loss (cf. Embrechts et al., 2003).

The ES is the average expected loss at a given confidence beyond the calculated VaR level and is a coherent risk measure (Yamai and Yoshiba, 2002). For example, if the $ES_{\alpha\,0.99}$ is 5%, the average loss in the worst 1% of returns will be 5% within the predefined timeframe. The ES can be applied to different categories of risk (Acerbi and

Tasche, 2001) and can supplement the VaR because it provides information about the size of a loss (cf. Embrechts et al., 2003). In both methods, 'tail risks' are more significant under periods of market stress than under normal market conditions (Yamai and Yoshiba, 2002b). However, Yamai and Yoshiba (2002) find that ES, other than VaR, can easily be optimized, but requires a larger sample size. In order to compare the results of the ES with the VaR estimates, three different ES calculations are used. First, the Gaussian ES that assumes a normal distribution of returns, but disregards that empirical time series are often skewed and can have fat tails. Second, the historical ES that is based on historical returns with no distributional assumptions, but with larger observations of outliers. Third, the modified ES (mES), which is based on the Cornish-Fisher and Edgeworth approximations to address skewness and kurtosis of the return distribution. Compared to the Gaussian method, Boudt et al. (2008) state that the modified method seems to be the better estimator for VaR and ES. The mES is consistent with the mVaR. In contrast, Martin and Arora (2015) find that mVaR and mES are inefficient risk estimators because the standard errors are larger than for comparable VaR and ES estimations. However, we do not try to compare or model different methods of risk estimators, but use all three calculation methods to test the differences in the riskiness of bank business models for the adjustment of capital requirements.

7. Statistics and Results

The adjustment of the leverage ratio to consider different bank business models is based on the examination of return distributions using VaR and ES. The focus is on the left-hand, negative net income tail of the distribution because it contains the largest losses (cf. Hull, 2015). The return distributions for all three bank business models are based on yearly earnings and losses, i.e., negative earnings. More precisely, the positive or negative net return (numerator) relative to total non-risk-weighted assets (denominator). The denominator considers total asset rather than the exposure measure of the leverage ratio formula due to incomplete data of the sample regarding off-balance sheet exposure, derivate exposure, and securities financing transaction exposure. The use of total assets is in line with the BCBS (2010), who focus on on-balance sheet assets for the development of the BCBS leverage ratio. Future research could examine the net return

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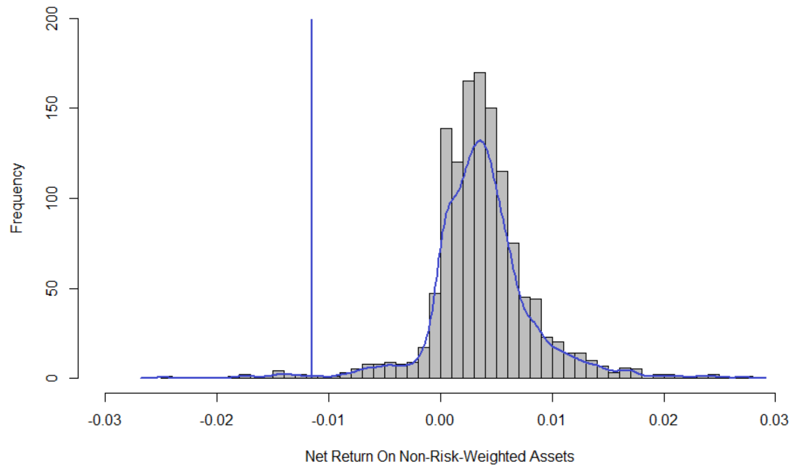
relative to on- and off-balance sheet assets if sufficient data are available. The return distribution for all banks in the sample can be seen in Figure 1 with a mark for the 99th percentile.



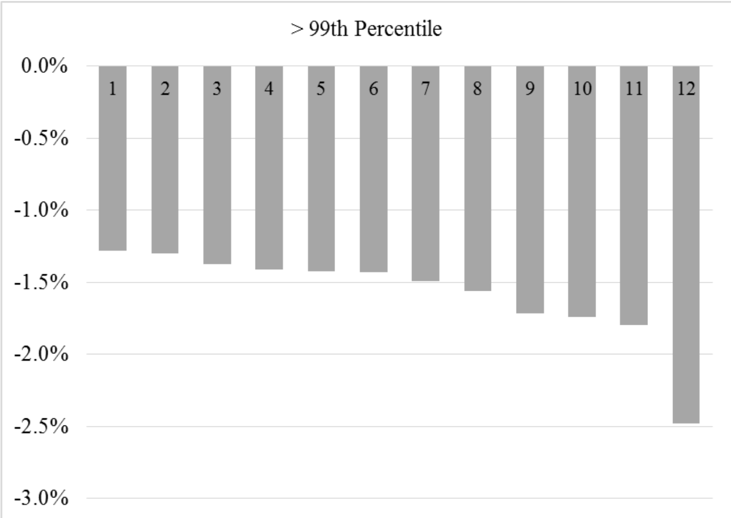
Notes: The figure shows the distribution of the net return on non-risk-weighted assets for all banks. The assets are based on on-balance sheet exposure. The vertical line marks the 99th percentile of the distribution.

Figure 1

Distribution of the Net Return on Non-Risk-Weighted Assets for All Banks

7.1 Descriptive Statistics

The descriptive statistics, as presented in Appendix II, show that retail banks (0.47%) on average have the highest net return on non-risk-weighted assets for the observed timeframe compared to wholesale banks (0.26%) and trading banks (0.25%). One reason is that from the ten percent of the highest returns, the majority of observations with approximately 60% belong to retail banks. Another reason is that retail banks in the sample report the fewest observations with yearly losses. About 97% of all retail bank observations are positive compared to 83% of wholesale bank observations and 77% of positive trading bank returns. At the same time, trading banks (-2.48%) account for the highest loss compared to retail banks (-1.80%) and wholesale banks (-1.74%). For clarification, if a bank generates a loss of -2.48% of the total assets it nearly breaches the potential leverage ratio requirement of 3%. As a result, the mentioned trading bank had to be rescued by its liability system. Overall, a total of 118 bank observations generated negative returns between the years 2000 and 2013 with a high share of about 62% during the financial crisis between the years 2007 and 2011. Figure 2 shows the results for the 99th percentile of the return distribution for all banks in the sample. The 99th percentile results range from -1.28% to -2.48% with a mean of -1.58%.



Notes: The figure shows the results for the 99th percentile of the net return on non-risk-weighted assets distribution for twelve banks.

Figure 2

Net Return on Non-Risk-Weighted Assets – 99th Percentile Results

As mentioned above, three different VaR and ES methods, as well as two subsamples, are considered. The chosen timeframe for the calculations can have an influence on the estimation of VaR and ES. In order to estimate comparable results with the BCBS (2010) and to address the circumstance that only annual data are available for the sample, a timeframe of one year is chosen as well. We choose confidence levels of 99% for the VaR and 97.5% for the ES. Both are in line with the BCBS (2016) guidelines for the calculation of market risk. Confidence levels of 99.9% (i.e., one in a thousand) are not considered because the number of sample observations are too low for each business model sample. The return distributions of the samples are tested for normal distribution to see if the Gaussian methods can be used. For this, a Jarque-Bera-test that is based on skewness and kurtosis of the distribution is used. The test shows that all samples are non-normal distributions as the null-hypothesis, which indicates a normal distribution, can be rejected (p-value 0.000). As seen in Appendix II, the skewness of retail banks and wholesale banks are right skewed (> 0) and the trading bank sample is left-skewed (< 0). The kurtosis is

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above 0 for all samples. As a result, the Gaussian methods are not used for the remainder of this paper.[4]

7.2 Historical Approach

The historical VaR and ES methods can be used to address non-normal return distributions. Therefore, a time series of returns is created by using actual historical data of positive and negative earnings (cf. Damodaran, 2007).

Table 2

Value-at-Risk and Expected Shortfall for Non-Normal Distribution

Historical	**Method**	**All Banks**	**Retail**	**Wholesale**	**Trading**	**W+T**
Total	VaR 99%	-1.15%	-0.26%	-1.46%	-1.06%	-1.42%
	ES 97.5%	-1.09%	-0.40%	-1.47%	-1.25%	-1.40%
	Obs.	1,265	685	350	230	580
Pre-Crisis < 2007	VaR 99%	-0.52%	n/a	-1.49%	-0.18%	-1.20%
	ES 97.5%	-0.62%	n/a	-1.35%	-0.52%	-1.09%
	Obs.	524	292	152	80	232
Post-Crisis ≥ 2007	VaR 99%	-1.29%	-0.49%	-1.42%	-1.25%	-1.42%
	ES 97.5%	-1.23%	-0.65%	-1.47%	-1.47%	-1.50%
	Obs.	741	393	198	150	348

Notes: Historical Value-at-Risk (VaR) and Expected Shortfall (ES) calculations for retail, wholesale, and trading bank business models. A combined subsample of wholesale and trading banks (W+T) is added. The methods are used for the distribution of historical data of the net return on non-risk-weighted assets. The timeframe for the examination of the returns is one year. The confidence levels are based on BCBS (2016) guidelines of 99% for the VaR and 97.5% for the ES. The subsamples account for different periods of time. The VaR and ES calculations for retail banks for the pre-crisis subsample produce unreliable results because negative returns do not occur between 2000 and 2006.

Table 2 shows the results of the historical methods for the three bank business models and subsamples. Since retail banks have the highest number of observations, a combined wholesale and trading bank sample (W+T) is added to increase the comparability. Overall, the calculations with the chosen confidence levels for VaR and ES seem to produce comparable results. The results support the indented shift from VaR to ES of the

[4] An overview of the results for the Gaussian models is displayed in Appendix III.

BCBS (2016). The VaR result of the full sample illustrates that the potential loss of a bank over a period of one year with a given probability of 99% is not more than -1.15%. In other words, one out of one hundred banks could lose 1.15% or more of its total assets within one year. The ES result for all banks shows the average expected loss at a given confidence level of 97.5%, which is -1.09%. In other words, the average loss in the worst 2.5% of returns would be 1.09% within the predefined timeframe. The combined W+T sample displays the highest VaR and ES results. Retail banks, with the lowest estimates, seem to be less risky. The subsamples before and after 2007 show extensive variations as the results for VaR and ES for the all banks sample double. Obviously, the financial crisis had a huge impact on the return distribution of the investigated banks. As for trading banks, the financial crisis increased the potential losses up to six times and almost tripled the average expected losses. Though, it should be considered that the trading bank sample has the fewest observations. Surprisingly, wholesale banks produce consistent VaR and ES outcomes throughout the different subsamples. The riskiness does not seem to have changed. A possible explanation could be the business activities and balance sheet structure with less trading exposure, e.g., asset-backed securities than comparable trading banks.

7.3 Modified Approach

The last methods to calculate VaR and ES are the modified methods that consider skewness and kurtosis of the Gaussian return distributions. The modified methods correct the Gaussian distributions for non-normal returns. The results can be seen in Table 3. Overall, the mVaR and mES results are not as comparable as for the historical VaR and ES. The spreads between the mVaR and mES vary from 0.095 to 0.950. Whereas the spreads for the historical methods vary merely from 0.012 to 0.165. Compared to the historical methods, the mVaR and mES account for higher results for the all banks sample. For the subsample ‘post-crisis’, the mES are highest in each bank sample for both methodological approaches. The differences in the ES calculations between the historical and modified approach vary from 0.181 to 1.309, which means that the average expected loss at a given confidence level of 97.5% can exceed the historical results up to 1.31% of the total assets of a bank.

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Table 3

Modified Value-at-Risk and Modified Expected Shortfall Calculations

Modified	**Method**	**All Banks**	**Retail**	**Wholesale**	**Trading**	**W+T**
Total	VaR 99%	-1.30%	-0.67%	-1.44%	-1.69%	-1.52%
	ES 97.5%	-2.06%	-0.73%	-1.89%	-2.52%	-2.20%
	Obs.	1,265	685	350	230	580
Pre-Crisis < 2007	VaR 99%	-0.79%	n/a	-1.31%	-0.09%	-1.09%
	ES 97.5%	-0.88%	n/a	-1.71%	-1.04%	-1.27%
	Obs.	524	292	152	80	232
Post-Crisis ≥ 2007	VaR 99%	-1.52%	-1.04%	-1.54%	-1.93%	-1.73%
	ES 97.5%	-2.34%	-1.96%	-2.07%	-2.65%	-2.50%
	Obs.	741	393	198	150	348

Notes: Modified Value-at-Risk (mVaR) and Expected Shortfall (mES) calculations for retail, wholesale, and trading bank business models as well as a combined wholesale and trading bank sample. The methods are based on Cornish-Fisher expansions to correct the percentiles of the distribution of the net return on non-risk-weighted assets for skewness and kurtosis. The time period for the examination of the returns is one year. The confidence levels are 99% for the mVaR and 97.5% for the mES. The subsamples account for different observed timeframes. The mVaR calculation for retail banks for the pre-crisis subsample produces unreliable results due to missing negative returns.

Again, retail banks display the lowest estimates of the three business models. Trading banks, with the fewest observations, display the highest results for the total timeframe and for the years after the crisis. Both, the results of the historical and modified methods, provide estimates that display the differences in the riskiness of bank business models for the underlying sample.

The underlying banking sample is dominated by German banks. Therefore, separate results for German banks and for all other European banks in the sample are offered. The results for historical calculations are shown in Appendix IV. The tendencies of the results for the German subsample, due to a large number of observations, are comparable to the whole banking sample. The European subsample shows different results and seems to have been affected differently by the financial crisis. Like the total banking sample, the majority of losses occurred after 2006. However, the overall VaR and ES calculations for the investigated timeframe are lower for the total sample, wholesale bank sample, and the trading banks. In contrast, European retail banks in the sample have significantly higher results due to higher losses during and after the financial crisis. The VaR and ES calculations for European retail banks are almost as high as for comparable European wholesale banks and are even higher than for European trading banks in the sample. However, it should be considered that the European subsample has significantly fewer observations and therefore does not allow a comparison. Nevertheless, the results of the subsamples indicate that separate calculations for large, international banks are necessary in order to account for the different risk characteristics of business models in relation to the size of a bank. A combination of bank business models and the relevance of banks to the financial system as suggested by Grossmann (2016) gives room for future research and might help to increase the financial stability. Overall, the analyses for the German and European bank subsamples show that the findings for the whole banking sample may be limited to medium and small banks, but illustrate the potential to build upon the findings.

8. Adjusting the Leverage Ratio

The results of the VaR and ES calculations indicate that the BCBS leverage ratio of 3% seems to be adequate for a minimal capital level. If a bank's equity at least equals or is greater than the VaR and ES exposure then capital is sufficient and a bank's assets need not be restructured (cf. Jarrow, 2013). If banks would have had an equity ratio of at least 3% relative to total assets before the crisis, they might have surpassed financial distress during the crisis with less support from liability systems or governmental assistance. However, the highest losses would have been covered, but the continuation of the operational business would not have been ensured. Furthermore, a uniform leverage ratio does not account for the riskiness of different bank business models. The results show that the potential losses of wholesale and trading banks for the historical and modified methods at a confidence level of 99% is twice as high as for retail banks for the examined timeframe from 2000 to 2013.

The absolute differences between retail banks compared to wholesale banks, trading banks, and the combined wholesale and trading bank samples are shown in Table 4. For each subsample and method, retail banks have lower values for VaR and ES than

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comparable wholesale or trading banks.[5] The absolute differences in the VaR for both methods range from -0.502 to -1.205. The range for the historical ES is -0.818 to -1.074 and for the modified ES -0.108 to -1.784. Noteworthy, the historical ES of wholesale and trading banks during the crisis is up to five times as high as for retail banks. Retail banks would have needed the smallest amount of capital to withstand financial distress. Consequently, wholesale and trading bank business models need higher equity ratios than retail banks. Following Grossmann and Scholz (2017), different leverage ratios can account for the diversification of the banking sector.

Table 4

The Lower Riskiness of Retail Banks

		Δ Value-at-Risk			**Δ Expected Shortfall**		
	Samples	**R vs. W**	**R vs. T**	**R vs. WT**	**R vs. W**	**R vs. T**	**R vs. WT**
Hist.	Total	**-1.205**	-0.800	**-1.166**	-1.074	-0.848	-1.006
	Post-Crisis	-0.937	**-0.763**	-0.931	-0.818	-0.818	-0.852
Mod.	Total	-0.767	**-1.016**	-0.854	**-1.155**	**-1.784**	**-1.466**
	Post-Crisis	**-0.502**	-0.897	**-0.700**	-0.108	-0.693	-0.543

Notes: The results show the absolute differences of retail banks compared to wholesale banks (R vs. W), retail banks compared to trading banks (R vs. T), and retail banks compared to wholesale and trading banks (R vs. WT) based on Value-at-Risk (VaR) and Expected Shortfall (ES) calculations. The VaR and ES calculations are based on the historical methods (see Table 2) and modified methods (see Table 3). For example, the differences of the historical VaR for 'R vs. W' for the subsample 'Total' is calculated by the VaR (-1.461) of wholesale banks minus the VaR (-0.256) of retail banks (see Table 2). The subsample pre-crisis is not shown due to missing results for retail banks.

Two approaches to design adjusted leverage ratio are presented. One, if the current BCBS leverage ratio of 3% is used as a minimum basis, in our case for lower-risk retail banks, the absolute differences between retail vs. wholesale banks and retail vs. trading banks are added. Thereby, sufficient capital will remain available if the potential loss of a bank exceeds existing leverage ratio requirements. Both, the historical and modified VaR calculations produce sound estimates. To avoid a decision for one over the other method, for which no theoretical consensus prevails, the lowest and the highest absolute differences are chosen. Based on the VaR calculations, the adjusted leverage ratio for wholesale banks should be between 3.50% (+0.502) and 4.21% (+1.205). For trading

[5] Retail banks also show the lowest values for VaR and ES, i.e., are less risky, compared to wholesale and trading bank business models if the Gaussian calculations from Appendix III are used.

banks, the leverage ratios should be between 3.76% (+0.763) and 4.02% (+1.016). A combined wholesale and trading bank ratio should account for 3.70% (+0.700) to 4.17% (+1.166). For additional leverage ratio buffers for periods of significant financial stress, the highest negative values of the ES calculations are chosen to ensure that the likelihood of extreme values and 'tail risks' are captured. Therefore, the leverage ratios including the additional buffers should be 4.16% (+1.155) for wholesale banks, 4.78% (+1.784) for trading banks, and 4.47% (+1.466) for a combined wholesale and trading bank ratio. For wholesale banks, the upper range of the adjusted leverage ratio is 5 basis points over the current leverage ratio plus the additional buffer. For trading banks, the additional buffer would increase the adjusted leverage ratio by 76 basis points (4.78 - 4.02).

Two, as an alternative approach, the highest negative return for each bank business model for the examined timeframe is used as a starting point. On this basis, the highest VaR and ES calculations (historical or modified method of Table 2 or 3) of the individual business model are added. Thereby, the highest historical losses are covered and a security buffer based on VaR or ES ensures that in the event of financial distress a bank can continue to operate without government support. In this case, the adjusted leverage ratio, based on VaR, for retail banks would account for 2.84% (1.80% + 1.04%), for wholesale banks 3.28% (1.74% + 1.54%), for trading banks 4.41% (2.48% + 1.93%), or for the combined W+T sample 4.21% (2.48% + 1.73%). The additional leverage buffer, based on ES, for retail banks would account for 3.76% (1.80% + 1.96%), for wholesale banks 3.81% (1.74% + 2.07%), for trading banks 5.13% (2.48% + 2.65%), or for the combined W+T sample 4.98% (2.48% + 2.50%). In both approaches, sufficient levels of capital will be based on the risk-profile of the individual bank business model. The adjusted leverage ratios may be limited to medium and small banks due to the number of underlying observations, but consider the highest losses of all German and other European banks in the sample. Therefore, the adjusted leverage ratios seem to offer an appropriate starting point to account for the different risk characteristics of bank business models.

An increase of the leverage ratio requirement means that riskier bank business models either have to raise their levels of Tier 1 capital or reduce their on- and off-balance sheet exposure. For wholesale and trading banks in the sample, an increase of the leverage ratio by 50 basis points would mean additional levels of Tier 1 capital of approximately 860

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million euro.[6] To reduce the impact on the operational business of the bank and the real economy, a gradual introduction of higher leverage ratios should take several years with sufficient lead time for the retention of earnings. Despite a long implementation period, higher leverage ratios will strengthen the financial system.

9. Conclusion

The development of the current BCBS leverage ratio focuses mainly on severely stressed banks, but sets requirements for all banks no matter of the chosen business model. Regardless of the size, banks with lower business model risks are treated the same way as banks with higher business models risk. Against this backdrop, established risk measurement methods that consider the characteristics of a coherent risk measure are used as estimators for sufficient capital for banks to withstand financial distress. VaR and ES calculations illustrate the differences between business models. The negative tails of a return distribution are smaller for retail banks than for wholesale and trading banks. These differences are used to adjust the leverage ratio requirement and will help cover business model risk. The adjustments tighten the safety net, e.g., the floor to the risk-weighted capital requirements, for riskier bank business models in normal times as well as in periods of financial stress. The adjusted leverage ratios and the additional buffers will most likely have an impact on the balance sheets of riskier business models, but higher capital requirements can strengthen the individual bank and the financial stability at the same time. To reduce the impact on the real economy, a sufficiently long transition period for the implementation is desirable. Future research could concentrate on the impact of different business model requirements on the real economy and could also consider size dependencies for G-SIB to increase the applicability of the analysis. Overall, we conclude that the focus on bank business models allows differentiating capital requirements for an internationally harmonized Pillar 1 capital framework.

[6] The calculation is based on 385 wholesale and trading banks that disclose data for Tier 1 capital. Based on data for equity (i.e., CET1, AT1 and T2) for all 580 wholesale and trading banks in the sample, an increase of 50 basis points would mean additional levels of equity of approximately 959 million euro.

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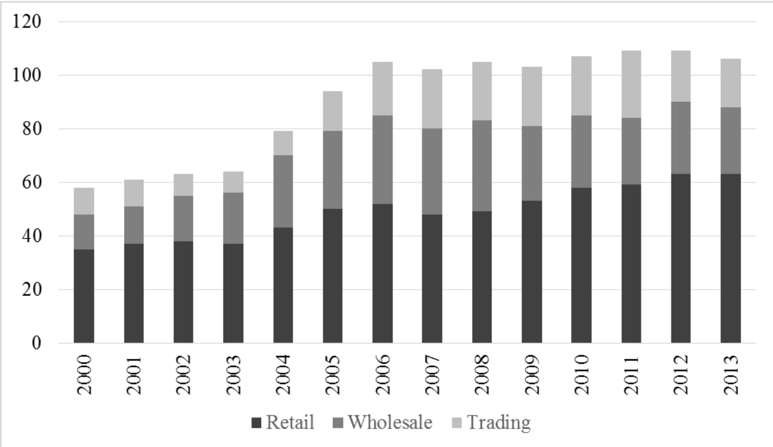
Appendix I.

Yearly Observations



Appendix II.

Descriptive Statistics

Net Return on Non-Risk-Weighted Assets

Sample	All Banks	Retail	Wholesale	Trading	W+T
Observations	1265	685	350	230	580
Mean	0.37%	0.47%	0.26%	0.25%	0.26%
Minimum	-2.48%	-1.80%	-1.74%	-2.48%	-2.48%
Maximum	2.71%	2.50%	2.71%	2.12%	2.71%
Median	0.35%	0.42%	0.21%	0.25%	0.23%
Standard Deviation	0.46%	0.37%	0.55%	0.48%	0.53%
Skewness	-0.055	0.749	0.074	-0.417	-0.067
Kurtosis	8.348	9.381	6.456	9.225	7.348

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Appendix III.

Value-at-Risk and Expected Shortfall for Normal Distribution

Gaussian	**Method**	**All Banks**	**Retail**	**Wholesale**	**Trading**	**W+T**
Total	VaR 99%	-0.70%	-0.40%	-1.02%	-0.87%	-0.97%
	ES 97.5%	-0.71%	-0.40%	-1.03%	-0.88%	-0.97%
	Obs.	1,265	685	350	230	580
Pre-Crisis < 2007	VaR 99%	-0.56%	-0.30%	-0.92%	-0.59%	-0.82%
	ES 97.5%	-0.56%	-0.30%	-0.93%	-0.60%	-0.82%
	Obs.	524	292	152	80	232
Post-Crisis ≥ 2007	VaR 99%	-0.78%	-0.46%	-1.07%	-0.96%	-1.03%
	ES 97.5%	-0.79%	-0.46%	-1.08%	-0.97%	-1.03%
	Obs.	741	393	198	150	348

Notes: Value-at-Risk (VaR) and Expected Shortfall (ES) calculations for retail, wholesale, and trading bank business models. The methods are based on normal distributions of the net return on non-risk-weighted assets. The timeframe for the examination of the returns is one year. The confidence levels are based on current BCBS (2016) guidelines of 99% for the VaR and 97.5% for the ES. The subsamples account for different periods of time.

Appendix IV.

Value-at-Risk and Expected Shortfall for GER and EU Banks

German Banks

Historical	**Method**	**All Banks**	**Retail**	**Wholesale**	**Trading**	**W+T**
Total	VaR 99%	-1.21%	-0.09%	-1.46%	-1.32%	-1.43%
	ES 97.5%	-1.11%	-0.24%	-1.51%	-1.47%	-1.52%
	Obs.	995	594	278	123	401
Pre-Crisis < 2007	VaR 99%	-0.59%	n/a	-1.53%	-0.30%	-1.46%
	ES 97.5%	-0.71%	n/a	-1.35%	-0.52%	-1.21%
	Obs.	449	269	128	52	180
Post-Crisis ≥ 2007	VaR 99%	-1.29%	-0.32%	-1.42%	-1.70%	-1.42%
	ES 97.5%	-1.28%	-0.44%	-1.46%	-1.93%	-1.62%
	Obs.	546	325	150	71	221

Other European Banks

Historical	**Method**	**All Banks**	**Retail**	**Wholesale**	**Trading**	**W+T**
Total	VaR 99%	-0.77%	-0.87%	-0.98%	-0.66%	-0.74%
	ES 97.5%	-0.98%	-0.98%	-1.13%	-0.68%	-0.86%
	Obs.	270	91	72	107	179
Pre-Crisis < 2007	VaR 99%	-0.06%	n/a	n/a	-0.07%	-0.07%
	ES 97.5%	-0.07%	n/a	n/a	-0.07%	-0.07%
	Obs.	75	23	24	28	52
Post-Crisis ≥ 2007	VaR 99%	-0.81%	-1.11%	-1.15%	-0.68%	-0.76%
	ES 97.5%	-1.11%	-1.29%	-1.13%	-0.70%	-0.91%
	Obs.	195	68	48	79	127

Notes: Value-at-Risk (VaR) and Expected Shortfall (ES) calculations for retail, wholesale, and trading bank business models for German banks and all other European banks in the sample. The methods are based on the distribution of historical data of the net return on non-risk-weighted assets. The timeframe for the examination of the returns is one year. The confidence levels are based on current BCBS (2016) guidelines of 99% for the VaR and 97.5% for the ES. The subsamples account for different periods of time.

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Appendix V.

List of Banks

Bank	Location	Years of Observation
HSBC Holdings Plc	GB	2004-2013
BNP Paribas SA	FR	2005-2013
Crédit Agricole	FR	2004-2013
Deutsche Bank AG	GER	2006-2013
Barclays Bank Plc	GB	2004-2013
Société Générale SA	FR	2005-2013
The Royal Bank of Scotland	GB	2004-2013
BPCE Group	FR	2008-2013
Banco Santander SA	ES	2004-2013
ING Groep NV	NL	2005-2013
Lloyds Banking Group Plc	GB	2005-2013
UniCredit SpA	IT	2005-2013
Rabobank	NL	2004-2013
Credit Mutuel	FR	2005-2013
Groupe Caisse d'Epargne	FR	2005-2008
Nordea Bank AB	SE	2005-2013
Intesa Sanpaolo	IT	2006-2013
Goldman Sachs International	GB	2000-2013
Banco Bilbao Vizcaya Argentaria SA	ES	2004-2013
Commerzbank AG	GER	2000-2013
Natixis SA	FR	2005-2013
Standard Chartered Plc	GB	2005-2013
HypoVereinsbank	GER	2000-2004
KfW Bankengruppe	GER	2007-2013
Danske Bank A/S	DK	2004-2013
Dresdner Bank AG	GER	2000-2008
Groupe Banques Populaires SAS	FR	2005-2008
DZ Bank AG	GER	2006-2013
ABN AMRO	NL	2009-2013
Credit Suisse International	GB	2005-2013
CaixaBank	ES	2004-2013
Nomura International Plc	GB	2009-2013
Merrill Lynch International Bank Limited	IE	2005-2013
SANPAOLO IMI	IT	2005-2006
SEB AB	SE	2005-2013
Svenska Handelsbanken	SE	2005-2013
Landesbank Baden-Wuerttemberg	GER	2006-2013
JP Morgan Securities Plc	GB	2000-2013
Bayerische Landesbank	GER	2006-2013
Hypothekenbank Frankfurt AG	GER	2003-2004
Deutsche Postbank AG	GER	2000-2009

Norddeutsche Landesbank	GER	2006-2013
Landesbank Hessen-Thueringen	GER	2006-2013
NRW.BANK	GER	2002-2013
Hypo Real Estate Holding AG	GER	2003-2013
DekaBank Deutsche Girozentrale AG	GER	2004-2013
HSH Nordbank AG	GER	2006-2013
Landesbank Berlin Holding AG	GER	2004-2013
Portigon AG	GER	2005-2013
Volkswagen Financial Services AG	GER	2001-2013
WGZ-Bank AG	GER	2006-2013
Landwirtschaftliche Rentenbank	GER	2006-2013
Landeskreditbank BW	GER	2000-2013
Sachsen Bank	GER	2000-2006
Aareal Bank AG	GER	2001-2013
HASPA Finanzholding	GER	2001-2012
Dexia Kommunalbank Deutschland AG	GER	2000-2013
Münchener Hypothekenbank eG	GER	2000-2013
Deutsche Apotheker- und Aerztebank eG	GER	2000-2013
Sparkasse KölnBonn	GER	2005-2013
IKB Deutsche Industriebank AG	GER	2000-2013
Kreissparkasse Köln	GER	2010-2013
LFA Förderbank Bayern	GER	2006-2013
BMW Bank GmbH	GER	2000-2013
Investitionsbank Berlin	GER	2008-2013
Sal. Oppenheim Jr. & Cie. AG & Co. KGAA	GER	2004-2008
Mercedes-Benz Bank AG	GER	2000-2013
Landesbank Saar-SaarLB	GER	2006-2013
Stadtsparkasse München	GER	2000-2013
State Street Bank GmbH	GER	2000-2013
Oldenburgische Landesbank - OLB	GER	2004-2013
Frankfurter Sparkasse	GER	2000-2004
Citigroup Global Markets Deutschland AG	GER	2000-2013
Mittelbrandenburgische Sparkasse in Potsdam	GER	2010-2013
Duesseldorfer Hypothekenbank AG	GER	2000-2013
Stadtsparkasse Düsseldorf	GER	2004-2013
HSBC Trinkaus & Burkhardt AG	GER	2000-2003
Die Sparkasse Bremen	GER	2000-2013
Nassauische Sparkasse	GER	2000-2013
Berliner Volksbank eG	GER	2010-2013
Sparkasse Nürnberg	GER	2000-2013
Kreissparkasse Muenchen Starnberg Ebersberg	GER	2000-2013
Santander Consumer Bank AG	GER	2000-2003
Sparkasse Aachen	GER	2000-2013
Kreissparkasse Ludwigsburg	GER	2000-2013
Investitions- und Strukturbank Rheinland-Pfalz	GER	2004-2012

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Sparkasse Münsterland Ost	GER	2000-2013
Bank für Sozialwirtschaft Aktiengesellschaft	GER	2000-2013
Landessparkasse zu Oldenburg	GER	2000-2013
Kreissparkasse Esslingen Nuertingen	GER	2000-2013
Sparkasse Krefeld	GER	2000-2013
Saechsische AufbauBank Forderbank	GER	2000-2013
Sparkasse Dortmund	GER	2000-2013
Stadtsparkasse Essen	GER	2000-2013
BBBank eG	GER	2000-2013
Kreissparkasse Boeblingen	GER	2000-2013
Kreissparkasse Waiblingen	GER	2000-2013
Sparkasse Mainfranken Würzburg	GER	2000-2013
M.M. Warburg & CO Gruppe KGaA	GER	2002-2013
Stadtsparkasse Wuppertal	GER	2000-2013
Sparkasse Heidelberg	GER	2000-2013
Volksbank Mittelhessen eG	GER	2000-2013
Sparkasse Paderborn - Detmold	GER	2000-2013
Sparkasse Saarbrücken	GER	2000-2013
Sparkasse Westmünsterland	GER	2002-2013
Foerde Sparkasse	GER	2000-2013
Sparkasse Neuss	GER	2000-2013
Kreissparkasse Biberach	GER	2000-2013
Nord-Ostsee Sparkasse	GER	2000-2013
Sparkasse Vorderpfalz	GER	2000-2013
COREALCREDIT BANK AG	GER	2000-2013
ProCredit Holding AG & Co. KGaA	GER	2004-2013
Dortmunder Volksbank eG	GER	2000-2013
Sparkasse Osnabrück	GER	2000-2013
Sparkasse Bochum	GER	2000-2013
Sparkasse Vest Recklinghausen	GER	2000-2013
Degussa Bank Ag	GER	2010-2012
Sparkasse Bielefeld	GER	2000-2013
Siemens Bank GmbH	GER	2011-2013
Sparkasse Freiburg-Nordlicher Breisgau	GER	2000-2013
Sparkasse Duisburg	GER	2000-2013

Notes: The sample selection is based on the bankscope database. The listing is based on the balance sheet volume at the end of 2013 or the last known. The last given name of the bank is considered.

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Part III

THE GOLDEN RULE OF BANKING: FUNDING COST RISKS OF BUSINESS MODELS

*

Abstract

The liquidity regulation of banks in Pillar 1 of the Basel framework does not consider longer-term funding cost risks of different bank business models. Therefore, we assemble a data set of balance sheet positions including maturities and use the method of Value-Liquidity-at-Risk to explore 118 European retail, wholesale, and trading banks. When examining liquidity-induced equity risks, trigged by exemplary rating shifts, we find that retail banks bear significantly lower funding cost risks than wholesale and trading banks. Consequently, a prudential regulation, which simultaneously considers the funding cost risk and the diversification of the banking system, is recommended.

JEL classification: G21, G28

Keywords: Bank Business Models, Funding Cost Risk, Liquidity Requirements, Value-Liquidity-at-Risk, Value Liquidity Expected Shortfall

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1. Introduction

After the financial crisis of 2007, the liquidity and funding situation of banks has been affected differently. Bank business models with inappropriate funding structures (EBA, 2015) were hit harder than business models, which relied less on unstable funding sources. As a result, all banks have been asked to return toward the golden rule of banking as expressed by the net stable funding ratio (NSFR), which supports that long-term assets are refinanced through long-term liabilities (e.g., Deutsche Bundesbank, 2008). However, the different liquidity risk-profiles and diverse funding cost risks of business models are not thoroughly considered within the regulatory liquidity framework. For that reason, we examine the risk of higher refinancing costs on three bank business models with different underlying funding structures to assess whether they are subject to diverse funding cost risks and need to be regulated differently.

In the case of the NSFR in Pillar 1, the goal is to promote sufficiently stable funding for at least one year (BCBS, 2014). However, when compared to the components of the funding liquidity risk, the NSFR considers the risk of the availability of funding, but neglects the risk of future funding costs. Even if the funding cost risk is considered within the European Pillar 2 approach for significant institutions (EBA, 2014), the handling of banks' cost of funding can vary across regulatory jurisdictions. If market stress occurs, the funding obviously needs to be available, but higher funding costs can have diverse impacts on banks' solvency. In addition, the NSFR gives no statement about how balanced the refinancing of a bank is if a potential funding stress lasts longer than one year. Hence, it might be advisable for a Pillar 1 approach to regulate the parameters for the availability and quality of funding sources and at the same time restrict the medium- to long-term liquidity-induced risk of equity for different business models.

An increasing string of literature portrays the demand to generally include business models into the prudential objectives of the regulatory framework to consider the different risk characteristics within the banking system more adequately (e.g., Altunbas et al., 2011, Ayadi et al., 2016). The demand expressed is based on the differences of banks regarding the impact on financial stability (Van Oordt and Zhou, 2014), the risk and default (Koehler, 2015), the performance and profitability (Roengpitya et al., 2014, Mergaerts and Vander Vennet, 2016), the reaction to higher equity ratios (Grossmann and

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Scholz, 2017), and the systemic impact of liability structures (Hryckiewicz and Kozlowski, 2017). In addition, Grossmann and Scholz (2017, p. 1) state that the business model "*can be viewed as an additional indicator of emerging risks*". Since 2015, the EBA (2014) has started to include the business model analysis in its Pillar 2 approach to cover different risk-profiles and risk appetites, strategic risks, dependencies, and concentrations. However, as Grossmann (2017) expresses, the EBA analysis is for significant European institutions only, which excludes non-European or less significant institutions. Therefore, standardized Pillar 1 requirements for business models are suggested to promote an internationally consistent and comparable regulatory framework (Grossmann, 2017). Against this background, we expand the field of research about business models with the assessment of liquidity-induced equity risks due to rating shifts. To the best of our knowledge, we are the first to analyze the longer-term funding cost risk with respect to the potential change in solvency for retail, wholesale, and trading bank business models. The idea is based on the BCBS (2008, p. 11) principles for sound liquidity risk management and supervision, which ask banks to identify, measure, and manage funding shortfalls over different time horizons, e.g., "*longer-term liquidity needs over one year*" under normal and stress scenarios. Overall, we find that shifts in funding costs can have diverse impacts on bank business models. Wholesale and trading banks bear significantly higher funding cost risks relative to equity than retail banks in the sample. The reasons are driven by the balance sheet structure and the choice of funding sources, the mismatch of assets and liabilities, as well as banks' ratings. For that reason, we propose that funding cost risks of business models can be reduced differently in Pillar 1 by limiting the incurred funding gaps or by restricting the potential loss in relation to banks' equity to ensure that appropriate levels of regulatory equity are maintained.

The analysis is separated into two steps. In step one, we assemble a unique data set of balance sheet positions with maturities of assets, liabilities, and securities for three bank business models from 2000 to 2013 to calculate funding gaps. Since data on maturities for balance sheet positions are rarely published, the data are derived from statistics of the Deutsche Bundesbank. In addition, funding spreads are derived by comparing yields of iBoxx bond indices for different ratings and maturities to yields of risk-free rates. We do not aim to calculate exact funding costs, but to show the impact once the rating grade shifts. In step two, the impact of the funding cost risk on solvency of different bank business models is examined. Therefore, the methods of the Value-Liquidity-at-Risk (VLaR) and the corresponding Value Liquidity Expected Shortfall (VLES) are used. The differences between normal funding situations and stressed funding situations in relation to banks' equity are used to generate a distribution curve and to examine the left-hand tail of it. Building on that, a baseline scenario and a stress scenario are analyzed.

2. Theoretical Background

2.1 Definition of Liquidity Risk

The risk of liquidity is caused by different cash flows of revenues and payments that are neither matched to each other in time nor amount. Due to the transformation function of banks to convert short-term deposits into long-term loans, banks are particularly exposed to liquidity risks (BCBS, 2008). The risk that banks take could affect other banks and whole financial markets for an extended time period (BCBS, 2008), which makes a sound liquidity risk management indispensable. In general, liquidity can be divided into three categories. First, the market liquidity risk displays the inability to quickly buy or sell assets at any time, in different volumes, and without changes in price due to inadequate depth in financial markets or market disruption (Deutsche Bundesbank, 2008, BCBS, 2008, Adalsteinsson, 2014). Second, the funding liquidity at a certain point in time shows the short-term ability to immediately settle obligations in order to prevent illiquidity (Drehmann and Nikolaou, 2013). Third, the funding liquidity risk shows the longer-term ability to immediately and efficiently settle expected and unexpected obligations without affecting present bank activities or conditions over a predefined timeframe. It considers present and upcoming cash flows as well as collateral needs, which are based on management decisions about the medium- to long-term structure of the balance sheet (Soprano, 2015) and can have a straight impact on the current short-term funding liquidity (BCBS, 2008, Drehmann and Nikolaou, 2013). The funding liquidity risk can, therefore, be split into the risk of availability of funding sources and the funding cost risk (e.g., BCBS, 2008, Adalsteinsson, 2014). The former risk describes a bank's difficulties to find available funding and to become illiquid, e.g., due to stressed or mistrustful market participants not willing to invest. The availability of funding sources on the liability side is therefore closely connected to the risk of market liquidity on the asset side

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(Adalsteinsson, 2014). On the other hand, the funding cost risk illustrates that a bank will have to pay more for its refinancing even if the funding in principle is available, e.g., due to rating downgrades, which can trigger bank failures (e.g., Aikman et al., 2009). In this context, Adalsteinsson (2014, p. 25) describes that banks in practice "*assume that the main problem is not getting the liabilities but rather the price needed to attract them*". Hence, the price for liquidity that banks are willing to pay can be seen as an indicator for increased individual funding liquidity risks (Adalsteinsson, 2014). Obviously, both types of risk are closely related. Especially when it is considered that funding liquidity risks can be influenced by various other types of risks (BCBS, 2008), e.g., credit, market price, or operational risk, the combined consideration of the availability of funding sources and the funding cost risk can avoid a liquid bank to become insolvent and a solvent bank to become illiquid (based on Goodhart, 2009).

2.2 Research on Liquidity

The introduction of regulatory liquidity standards after the financial crisis aims to control for the different categories of liquidity risk more adequately. The liquidity coverage ratio is meant to cover a short-term funding liquidity panic, in which banks might be unable to obtain funding regardless of the refinancing costs, by promoting *"sufficient high quality liquid resources to survive an acute stress scenario lasting for one month*" (BCBS, 2011, p. 8). Complementary, the NSFR is meant to cover parts of the funding liquidity risk to detect disproportionate maturity mismatches and to reduce the likelihood of declining funding positions as well as bank failures due to market stress or longer-term liquidity shocks, e.g., due to a wave of liquidations following a crisis (BCBS, 2011 and 2014). The financial crisis illustrates that many banks have not followed the golden rule of banking and refinanced long-term assets with unstable short-term liabilities. Especially banks that mainly used funding instruments from repo markets, unsecured interbank markets, securitization markets, and currency swap markets became stressed (Deutsche Bundesbank, 2008). After comparatively low funding costs before the crisis, the cost for unsecured refinancing instruments increased tremendously with more than 200 basis points between secured and unsecured interest rates in 2009, which shows how quickly financial markets can dry out (BCBS, 2008, Nagel, 2013). In addition, banks had problems to issue long-term refinancing instruments because market participants mistrusted each other due to minor or even no information regarding risky subprime mortgage exposures (Deutsche Bundesbank, 2008). Depending on the balance sheet structure and the source of funding, banks may have determined the funding liquidity risk in different phases, e.g., unable to borrow unsecured long-term instruments, unable to borrow short-term unsecured instruments, unable to borrow in the interbank market, or unable to borrow secured instruments except from central banks. Besides the benefits and costs of the NSFR[1], the EBA (2015, p. 15) states "*that the NSFR is the best available instrument to address structural liquidity and maturity transformation by banks*".

In addition to the regulatory perspective, contemporary studies examine the funding liquidity risk. Diamond and Dybvig (1985) discover that banks with high shares of deposits and an existing deposit insurance face lower funding liquidity risks and are less likely to experience a bank-run. Vazquez and Federico (2015) find, among other results, that banks with weaker funding liquidity before 2007 were exposed to a higher risk of default after the financial crisis and that a stable funding ratio can increase banks' stability. However, the investment in sufficient levels of liquidity comes with the disadvantage of higher costs and lower profits due to a premium for liquidity in the term structure of interest rates, which increases with maturity (Handorf, 2014). Khan et al. (2016) show that higher deposit funding with a decrease in funding liquidity risk can reduce the distance to default of banks due to higher lending activities at lower refinancing rates. In normal times, banks with lower funding liquidity risk are incentivized to increase risks, but capital buffers can prevent banks from taking the additional risk (Khan et al., 2016). In other research, the funding cost risk is portrayed as the relationship between liquidity and solvency. Aymanns et al. (2016) find a significant negative impact of solvency shocks on banks' funding cost, which is stronger for interbank funding cost and more sensitive in periods of stress. In addition, the relationship seems to be more sensitive to lower levels of solvency. On the other side, Schmitz et al. (2017) find that increased funding costs can reduce regulatory capital. The effects to a bank's cost of funding, i.e., the funding cost risk, are shown by the Bank of England (2014). If the refinancing costs increase, a bank can either pass the higher interest rate

[1] For arguments against the NSFR see, e.g., King (2013), IFF et al. (2014), GFMA and IFF (2014), ICMA (2016), or BBVA (2016). Arguments for the NSFR are presented by, e.g., Gobat et al. (2014), Bologna (2015), Lallour and Mio (2016), Schmitt and Schmaltz (2016), or Schupp and Silbermann (2017).

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onto their customers, for existing loans with floating rates or new loans, or leave the interest rates for customers untouched and absorb the higher costs. The latter will decrease the profitability directly. The former could impact the default rates of customers and increase credit losses, decrease the number of new loans, or lead to the adverse selection of customers with higher default risks, which again can decrease the profitability. A reduction in profitability over time can jeopardize solvency (Bank of England, 2014).

Compared to the above given definition of the funding liquidity risk, the NSFR focuses primarily on the risk of availability of funding sources and the coherent market liquidity risk in order to assess a "*bank's cash inflows against its outflows and the liquidity value of its assets* (and liabilities) *to identify the potential for future net funding shortfalls*" (BCBS, 2008, p. 11). However, the NFSR neglects the funding cost risk and its possible impact on a bank's solvency. For that reason, and complementary to the NSFR, our focus is explicitly on refinancing costs with a time period longer than 365 days in order to consider longer-term funding cost risks. In contrast to the above-displayed studies, we do not focus on the relationship between credit risk or solvency on banks' funding costs, or the stability of deposit funding. Instead, we contribute by examining the impact of higher refinancing costs on different bank business models.

3. Creation of the Data Set

Our unique data set for the analyses consists of several components derived from different sources such as balance sheet positions, rating grades, maturities of assets, liabilities, and securities, as well as funding spreads. Due to a lack of published information regarding maturities of balance sheet positions and funding spreads of individual banks, we have to make several assumptions, which are explained below.

3.1 Bank Sample

The data of 1,238 observations, which includes 118 European banks for the years 2000 to 2013, are compiled from the bankscope database Bureau van Dijk Electronic Publishing (2015). We use the bank sample from Grossmann (2017), excluding two banks with 25 observations due to non-existing data for rating grades. The sample is composed of eighty-seven mostly unlisted small- and medium-sized German banks and is supplemented with the thirty-one largest European banks. The initial selection of German banks is driven by publicly available information for the data set as well as the circumstance that the banking sector in Germany belongs to the biggest in Europe (ECB, 2015, Grossmann, 2017). Subsidiaries of European bank holding companies in the sample operating in Germany are not taken into account to avoid duplications. Furthermore, in the event that a competitor has taken over a bank in the data set, the data points for the examined year as well as the years following the merger are not taken into account. The unbalanced panel is built on yearly data because, for the majority of banks, financial data for the total period are not disclosed.

The bankscope database offers data for assets, liabilities, and rating grades. As for the long-term rating, the information is provided from Fitch, Moody's, and Standard and Poor's. Since all three rating agencies have different rating grades, the Markit (2012) iBoxx rating methodology as displayed in Appendix II is used for the transition into ten standardized rating grades. The classification of an investment grade considers the ratings AAA, AA, A, and BBB. Non-investment grades are defined as BB, B, CCC, CC, C, and D. However, several bank observations in the sample are not provided with a rating. Therefore, the data are supplemented with additional information: First, information based on press releases from rating agencies for rating up- or downgrades of individual banks. Second, if a rating grade for a subsidiary of an international bank operating in Europe is not provided, the rating grade from the bank holding company is used. Third, German public banks in the sample available before 2005 are given the rating of the Federal Republic of Germany minus one notch, i.e., AA, because of the former public guarantee obligation. Fourth, if a bank has a rating grade, but not for the total examined timeframe, the average rating of a bank's last known year plus one year is used for the previous missing year. The higher the number of missing years, the longer the timeframe to calculate the average rating. For example, if a bank has a rating from 2004 until 2013, but is missing the rating grades from 2000 to 2003, the average rating from 2004 to 2005 is used for 2003, the average rating from 2004 to 2006 is used for the year 2002, et cetera. In the case of borderline decisions, which are not present in the data set, the rating is downgraded to the lower grade. Overall, 158 observations, mostly for savings banks with a share of 84%, are affected by this supplementation. However, it should be noted that

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the above-mentioned public guarantee obligation applied also to savings banks before the group rating of the German Savings Bank Association started in 2004 with a rating grade of AA. Hence, it can be assumed that German savings banks had a rating grade of at least AA between 2000 and 2003.

In order to reach a deeper understanding of the field of interest, the sample is split into two subsample-pairs: an annual subsample-pair for the years 2000 to 2006 (pre-crisis) and for the years 2007 to 2013 (post-crisis), as well as a regional subsample-pair for German and other European Banks. The latter subsample-pair is created to check for influences due to a large number of German banks in the data selection. If more data on global systemically important banks (G-SIB) would be available, a detailed distinction between the size and systemically importance of banks could be made since G-SIB can have an advantage over smaller banks regarding the funding costs due to implicit state guarantees (Ueda and Weder di Mauro, 2013).

3.2 Bank Business Models

The European banking sector, as other business sectors, has a structure within the sector, which is built upon competitive business models (or strategic groups, Porter, 1979) with similarities in strategy and profitability. The differences between business models are based on long-term strategic decisions of a bank's management regarding the balance sheet structure, business activities, the risk appetite, and the willingness to take liquidity risks (Soprano, 2015, Mergaerts and Vander Vennet, 2016). Hence, the separation of the bank sample is focused on business models to reflect the chosen strategy, the risk-return-profile, and dependencies of the capital structure. Other than ownership structures of two- or three-pillar banking systems in Europe, the business model approach can be used for international banking systems or different regulatory jurisdictions.

The sample is split into three business models of banks as suggested by Roengpitya et al. (2014). For each examined year, a bank is allocated to either a retail, wholesale, or a trading bank, which allows for possible changes over time. Both, retail and wholesale banks concentrate on loan activities, but use diverse funding strategies. Retail banks focus on a high share of customer deposits, whereas, wholesale banks use more banking and non-current liabilities for the refinancing. Trading banks, on the other hand, focus on trading and investment activities and use capital market-oriented funding strategies (cf. Hull, 2015, Roengpitya et al., 2014). Therefore, the identification of a business model is built on balance sheet structures of assets, funding structures of liabilities, and a bank's business activities. For that reason, a procedure by Grossmann and Scholz (2017) is used, which focuses on three key ratios and five supportive ratios, identified by Roengpitya et al. (2014), as well as two additional supportive ratios. An overview of the ratios with the respective shares and the defined procedure can be found in Appendix I. Altogether, 661 retail bank, 345 wholesale bank, and 232 trading bank observations are considered for the analyses.

Other methods for a business model approach can be used, but require different key variables of other databases. Most recently, for example, Ayadi et al. (2016) define five business models or Mergaerts and Vander Vennet (2016) explore two different model types. In addition, a more granular separation of the banking sector could be made by supervisory authorities, who have access to detailed internal information with respect to, e.g., the balance sheet, data regarding the strategic orientation, or target ratios for future balance sheet structures.

3.3 Maturity of Balance Sheet Positions

The maturities of single balance sheet positions for assets and liabilities are derived from banking statistics of the Deutsche Bundesbank (2017) because banks in the sample, in particular smaller banks, rarely publish data on maturity dates. The banking statistics provide information about realized and reported balance sheet positions and the corresponding maturity buckets, which are based on the originally agreed maturity. The maturity buckets of the Deutsche Bundesbank (e.g., short-term, medium-term, or long-term) for a balance sheet position (e.g., lending to banks) are placed in relation to the respective balance sheet position in order to abstract information about the underlying maturity, e.g., 36% of lending to banks have a short-term maturity (see Table 1). The monthly relationship for each relevant position is observed to calculate the average for each year from 2000 to 2013. The yearly average for each maturity bucket is allocated to a time bucket for the later calculation of funding gaps.

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The banking statistics of the Deutsche Bundesbank do not differentiate between the utilized bank business models. For that reason, the available statistics for different categories of banks are used. The time series for the bank categories ‘savings banks’ and ‘credit cooperatives’ are used as a proxy for retail banks because most savings and cooperative banks in the sample are classified as retail banks. Based on the list of financial institutions included in the bank categories of the Deutsche Bundesbank (2017c), we find that most wholesale and trading banks in the sample are included in the bank categories ‘big banks’, ‘federal state banks’, ‘regional institutions of credit cooperatives’, and ‘banks with special, development and other central support tasks’. Hence, the mentioned categories are used as a proxy for wholesale and trading banks. Due to the availability and scope of the Deutsche Bundesbank data, a further subdivision is not realizable. The differences between the two business models therefore result from the individual share of each balance sheet position.

3.3.1 Maturity of Assets

The results for the derived maturities of assets for the total timeframe are given in Table 1. The varying averages for every year are given in Appendix IV. The bankscope data for balance sheet positions are not as granular as the statistics of the Deutsche Bundesbank. Therefore, the banking statistics of the Deutsche Bundesbank are mapped to the available bankscope positions. For example, the bankscope database provides data for loans and advances to banks, which can be subdivided into the Bundesbank balance sheet positions for lending to banks, money market papers, and securities issued by banks. Based on the Deutsche Bundesbank statistics, 7% percent of lending to banks from the category ‘savings banks’ and ‘credit cooperatives’ have a medium-term period. Hence, it is assumed that 7% of loans and advances to banks from retail banks have a medium-term maturity.

Table 1

Maturity of Assets

Bankscope Balance Sheet Position (% of sample)	**Bundesbank Balance Sheet Position**	**Maturity Bucket (% of Bundesbank Position - All Banks)**	**Retail**	**Wholesale & Trading**	**Time Bucket for Funding Gaps**
Loans and advances to banks (14%)	Lending to banks	Short-term (36%)	21%	37%	≤ 1 year
		Medium-term (9%)	7%	9%	2-3 years
		Long-term (27%)	9%	34%	6-7 years
	Money market	Short-term (1%)	1%	1%	≤ 1 year
	Securities by banks	n/a (27%)	62%	19%	1-10 years
Gross loans (47%)	Loans to households (64%)		51%	26%	
	of which: consumption loans (32%)	Up to 1 year (15%)	16%	26%	≤ 1 year
		1-5 years (15%)	10%	10%	2-3 years
		Over 5 years (69%)	74%	64%	6-7 years
	of which: housing loans (68%)	Up to 1 year (1%)	1%	0%	≤ 1 year
		1-5 years (3%)	3%	1%	2-3 years
		5-10 years (55%)	56%	57%	6-7 years
		Over 10 years (41%)	41%	42%	≥ 10 years
	Loans to non-financial corporations (36%)		49%	74%	
	of which: loans	Up to 1 year (20%)	17%	25%	≤ 1 year
		1-5 years (14%)	8%	12%	2-3 years
		Over 5 years (66%)	75%	63%	6-7 years
Other securities (28%)	Money market	Short-term (2%)	0%	4%	≤ 1 year
	Securities by corp.	n/a (74%)	83%	70%	1-10 years
	Securities by public	n/a (24%)	17%	26%	1-10 years
Other earning assets (2%)	n/a	n/a	n/a	n/a	≤ 1 year
Fixed assets (1%)	n/a	n/a	n/a	n/a	6-7 years
Non-earning assets, cash, balances with central banks (8%)	Cash	n/a (Overnight)	n/a	n/a	≤ 1 year

Notes: The shown percentages for bankscope balance sheet positions of assets are calculated averages of the total sample. The percentages for the maturity buckets of the Deutsche Bundesbank are based on statistics reported from 2000 to 2013. The maturity of 1-10 years of securities for banks and non-banks is based on average outstanding debt securities as presented in Table 3. Derivatives are not considered.

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For the calculation of funding gaps, six time buckets are designed: up to and including 1 year (short-term), 2-3 years (medium-term), 4-5 years, 6-7 years (long-term), 8-9 years, and greater or equal 10 years. The selection of time buckets is determined by available statistics for securities and funding spreads (see below) of the Deutsche Bundesbank. The time buckets represent intervals of up to 2 years in order to integrate the different maturity inputs. For example, the Deutsche Bundesbank (2017) definition of medium-term (1 to 5 years) is operationalized by using the average of 1 to 5 years for the 2-3 years' time bucket. The definition of long-term is challenging because the Bundesbank only defines a period of 5 years or more. Since the available data for yields on German bank debt securities ends with 10 years, the long-term definition is operationalized by using the down rounded average of 5 to 10 years under consideration of the previous categorized two-year intervals. The only sources offering maturities greater 10 years are other securities and private housing loans. In our opinion, the operationalized long-term definition seems to be appropriate for lending to banks, corporate investment loans, and consumer loans as the maturities in practice rarely exceed 10 years. Nevertheless, a more granular breakdown of time buckets is desirable in order to calculate more precise funding gaps, e.g., 10 time buckets for 10 years, but would require more detailed statistics of balance sheet positions.

For the determination of maturity buckets for gross loans, the MFI interest rate statistics of the Deutsche Bundesbank (2017b) for the maturity of loans to households and loans to non-financial corporations are used supportively. Again, the relative proportion of each category is taken into account. Revolving loans, overdrafts, and credit card debt are not considered because it is not stated how much these credit lines are claimed. Furthermore, prepayment factors (e.g., special termination, extraordinary termination, unscheduled repayment) are not considered due to missing data. If more data are available, the probabilities for the renewal of revolving credit lines (e.g., evergreen loans) as well as implied options for prepayment factors could be calculated to consider the impacts on the maturity of loans. It is expected that the former would have an increasing and the latter would have a decreasing impact on the relevant time buckets. For private housing loans, the relative share of all housing loans with a maturity over 5 years is on average 96%. In order to separate the maturities more precisely, the new business volume of German banks is taken into account as well, i.e., loans to households with a floating rate or an initial rate fixation above 5 years. It is assumed that the new business volume can reflect the average outstanding amounts of loans to non-banks. Therefore, from all loans above 5 years, the share of loans between 5 to 10 years and the share of loans over 10 years are considered. For example, of all gross loans, it is assumed that 64% are loans to households of which 68% belong to housing loans. Based on the housing loans, 55% have a maturity between 5 to 10 years and 41% have a maturity over 10 years. At this point, it has to be considered that the maturity of loans can be longer than the rate fixation. The MFI interest rate statistics start in 2003. Hence, we use the average of the years 2003 to 2013 for the years 2000, 2001, and 2002.

The maturities of securities held by banks are given in Table 3 (see below). For other earning assets, which have an average share of 2% of the total sample, a short-term maturity is conservatively assumed because no further data are available. For fixed assets such as mortgages, with an average share of 1% of the bank sample, it is assumed that the average holding period is long-term and the 6-7 year time bucket is assumed. As a robustness check of the assumptions, other maturities are used for the calculation of funding gaps, i.e., short or longer time buckets, but due to the overall small average share, the effects on the funding gaps are marginal.

3.3.2 Maturity of Liabilities

The maturities of liabilities are shown in Table 2. Overall, the time buckets display shorter maturities, which can reflect banks' economic function of term transformation of short-term deposits into long-term loans. The statistics of the Deutsche Bundesbank are again mapped to the liability positions of the bankscope database. The varying averages for every year are shown in Appendix V. For the following specifications, the legal term of liquidity positions is assumed. Sight deposits, which can be withdrawn at any time, are assigned to the shortest time bucket of up to and 1 year. For time deposits and savings bonds with a maturity bucket of up to 2 years, the average of 1 year is chosen for the time bucket. For the low shares of savings deposits and savings bonds for wholesale and trading banks, it has to be considered that only data from the category of big banks is available. For the maturity buckets of deposits over 2 years including the medium- to long-term positions, a time bucket of 4-5 years is selected, which is comparable to the

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BCBS (2016b) treatment of core deposits for the interest rate risk in the banking book. Early cancellations of core deposits are not considered due to missing data. If more data are available (e.g., historical run-off rates), the probabilities for the cancellation of deposits could be calculated to consider the impacts on the maturities of liabilities. A decreasing impact on the relevant time buckets is expected.

Table 2

Maturity of Liabilities and Capital

Bankscope Balance Sheet Position (% of sample)	**Bundesbank Balance Sheet Position**	**Maturity Bucket (% of Bundesbank Position - All Banks)**	**Retail**	**Wholesale & Trading**	**Time Bucket for Funding Gaps**
Deposits from banks (17%)	Sight deposits	Overnight (17%)	6%	21%	≤ 1 year
	Time deposits	Short-Term (34%)	6%	37%	≤ 1 year
		Medium- to Long-Term (49%)	88%	41%	4-5 years
Customer deposits (37%)	Sight deposits	Overnight (32%)	35%	29%	≤ 1 year
	Time deposits	Up to 2 years (15%)	11%	22%	1 year
		Over 2 years (27%)	3%	43%	4-5 years
	Savings deposits	Up to 1 year (21%)	43%	6%	≤ 1 year
	Savings bonds	Up to 2 years (1%)	2%	0%	1 year
		Over 2 years (3%)	6%	0%	4-5 years
Other deposits and short-term borrowings (5%)	n/a	n/a	n/a	n/a	≤ 1 year
Long-term funding (19%)	Bearer debt securities	Up to 2 years (12%)	12%	13%	≤ 1 year
		Over 2 years (88%)	88%	87%	2-10 years
Trade liabilities (7%)	n/a	n/a	n/a	n/a	≤ 1 year
Non-interest bearing liabilities incl. provisions (9%)	n/a	n/a	n/a	n/a	≤ 1 year
Other provisions (1%)	n/a	n/a	n/a	n/a	≤ 1 year
Equity (5%)	n/a	n/a	n/a	n/a	≥ 10 years

Notes: The average percentages for bankscope balance sheet positions of liabilities and capital are based on the total sample. The percentages for the maturity buckets of the Deutsche Bundesbank are calculated on statistics reported from 2000 to 2013. The maturity of 2-10 years of securities for banks and non-banks are based on average outstanding debt securities as presented in Table 3. Derivatives are not considered.

Long-term funding is assigned to the Deutsche Bundesbank position for bearer debt securities. Two maturity buckets of up to 2 years and over 2 years are designed. For the former, a 1 year time bucket as described above is selected. For the latter, maturities of 2 to 10 years based on debt securities in Table 3 are chosen. Due to the nature of trade liabilities, e.g., securities held for trading or available for sale, a time bucket of up to 1 year is chosen. For short-term borrowings (5%), non-interest bearing liabilities (9%), and other provisions (1%), a time bucket of 1 year is assumed. These assumptions seem to be sufficiently conservative as no further information is available. Own equity is considered for the calculation of funding gaps because of the long-term availability to refinance assets and is therefore integrated into the longest, 10-year time bucket. We also present calculations without own equity sources.

3.3.3 Maturity of Securities

The maturities of securities either held (asset) or issued (liability) by banks are based on the relative proportion of amounts of all debt securities outstanding issued by residents in Germany, which can be extracted from Deutsche Bundesbank (2017b) statistics. Since only little or even no information is published about portfolio maturities of banks,[2] we use the amounts of outstanding debt securities with the subdivision by maturity as offered by the Deutsche Bundesbank as a proxy for the maturity structure of banks' securities portfolios. Hence, it is assumed that the structure of securities either held or issued by banks reflects the average maturity structure of all debt securities in Germany.[3] For example, in the year 2000, the amount of all debt securities outstanding with a maturity between 2 and 3 years was 26% (see Table 3). Consequently, for the analyses, 26% of

[2] For example, the German Savings Bank Association with over 400 member banks or the German Cooperative Financial Network with about 1,000 members display no statements in their annual reports about maturities of securities portfolios. The Deutsche Bank started to disclose the term structure of covered bonds, but not for the examined years and not for securities held as assets.

[3] This assumption might neglect different maturity structures of bank's securities portfolios. As a robustness check, the time buckets in Table 3 and Appendix VI are mirrored for the calculation of alternative funding gaps, e.g., in 2000, 7% (instead of 33%) of all debt securities have a maturity of up to 1 year, respectively, 33% (instead of 7%) of securities have a maturity over 10 years. As a result, the mean VLaR-Ratios in the baseline scenario (see Table 5) increase for all banks to -0.02% (prior -0.01%) and for wholesale banks to -0.04% (-0.02%), remain the same for retail banks (0.01%), and decrease for trading banks to -0.03% (-0.07%). If only the maturity structure of securities held as assets are mirrored, the VLaR-Ratios remain at -0.01% for all banks, increase for wholesale banks (-0.03%), decrease for retail banks (0.02%) and for trading banks (-0.01%). Overall, the necessary underlying assumption might underestimate the latter results of some wholesale banks and overestimate the results of some retail and trading banks in the sample.

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securities on banks' balance sheet, with a time bucket of 1-10 years, are given a maturity of 2-3 years in 2000. The monthly data are collected from the Deutsche Bundesbank (2017b) and the average for each year is calculated. Table 3 shows the averages for the examined years for all debt securities. Separate tables for maturities of debt securities issued by banks, corporates, and public authorities are presented in Appendix VI. For the calculation of banks' assets in Table 1, securities issued by banks are used for the bankscope position lending to banks. In addition, securities issued by corporates and public as well as money market papers issued by non-banks are used for the balance sheet position 'other securities'. The Deutsche Bundesbank statistics for securities issued by corporates, which are held by banks, include corporate debt securities, bonds and debt securities issued by foreign non-banks, domestic and foreign mutual fund shares, and domestic and foreign shares. However, only the total share of public and corporate securities, as well as money market papers relative to the overall security portfolio, is used. For banks' liabilities in Table 2, debt securities issued by banks are used for long-term funding.

Table 3

Maturity of Debt Securities

Time Buckets	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
≤ 1 year	33	36	37	36	35	34	35	37	39	40	39	39	38	38
2-3 years	26	23	24	23	23	23	23	23	21	21	22	23	25	24
4-5 years	16	16	15	16	16	16	15	14	14	13	16	15	13	13
6-7 years	9	10	10	10	9	9	9	9	11	9	6	6	7	9
8-9 years	9	9	8	7	8	8	10	9	6	5	5	6	6	7
≥ 10 years	7	6	6	7	8	10	8	9	10	11	12	11	10	11

Notes: The maturities of securities are based on the amounts outstanding of all debt securities including bank debt securities, corporate bonds, and public debt securities of issuers domiciled in Germany and are based on statistics of the Deutsche Bundesbank (2017b). The values are shown in percentages. The time buckets serve to calculate the funding gaps.

The maturity buckets of the Deutsche Bundesbank (2017b) statistics for the amounts of outstanding debt securities are transformed into the six time buckets used for the analyses, i.e., up to 2 years (≤ 1 year time bucket), 2 to 4 years (2-3 years), 4 to 6 years (4-5 years), 6 to 8 years (6-7 years), 8-10 years (8-9 years), and 10 to 15, 15 to 20, and over 20 years

(≥ 10 years). Overall, the consideration of maturities for all debt securities issued by residents in Germany enables to separate bankscope's balance sheet positions more accurately.

Overall, the chosen approach and the underlying assumptions show the restrictions of the analyses, but are necessary because detailed information on maturities is not available for the examined timeframe. The Deutsche Bundesbank statistics include more than 1,700 banks operating in Germany. Hence, we believe, that the described approaches serve as reasonable and conservative proxies for maturities of balance sheet positions for German and other European banks. If data are available, future research could focus on a more detailed separation of maturities and time buckets.

3.4 Funding Spreads

Banks can use diverse instruments such as deposits, wholesale funding, or capital market transactions for the refinancing of banking activities. The individual refinancing costs depend on the current market situation for the instrument as well as the individual funding spread. Funding spreads can be influenced by different components, such as the quality of a bank's capital or the rating grade. Particularly for rating grades, a high correlation with funding spreads is found (cf. Hu and Cantor, 2006). The lower the rating, the higher the funding spread. For the purpose of this study, refinancing costs of a bank are calculated with the risk-free interest rate plus a funding spread, which will be influenced by the individual rating grade. Conversely, the funding spread of a bank can be withdrawn from the comparison of a bank's refinancing costs with a risk-free rate. Doing so, other interest rate components such as the market credit spread, market liquidity spread, or market duration spread (cf. BCBS, 2016b) are included.

For the risk-free rate, Euro 6-month interest rate swap curves with different maturities are used because the time series date back until 2000. In practice, European interest rate swaps are frequently used as benchmark instruments for hedging and positioning due to large liquid markets (Remolona and Wooldridge, 2003). As an alternative, overnight index swap curves could be used, but the time series for some maturities are not available before 2005. For the refinancing instrument, iBoxx bond indices for financials with

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different rating grades and maturities are exemplary chosen.[4] The different bond indices include secured and unsecured bonds with ratings of AAA, AA, A, BBB, BB, B, and CCC, each with maturity clusters of 1-3, 3-5, 5-7, 7-9, and ≥ 10 years. In addition, rating indices without separated maturities are considered.

The funding spreads are derived by comparing the daily yields of iBoxx bond indices for different rating grades and maturity clusters to daily end-of-day-yields of the risk-free rates, i.e., swap curves with different maturity clusters. The differences between the realized yields are interpreted as the additional premium a bank with a higher risk has to pay for the refinancing. Due to the balance sheet data, the yearly average of the yields is calculated. For the maturity clusters of the indices, the equivalent maturity of a swap curve is used, i.e., for the cluster 1-3, a 2-year swap curve is applied. For the above 10 year clusters, if available, the duration of the indices based on October 2017 is considered. For indices without available durations, a 10-year swap curve is chosen. For some bond indices, data are missing between the years 2003 and 2005. In these cases, we use the average of a rating index without separated maturities. This approach seems to be appropriate since the differences between the maturities are rather small before 2007.

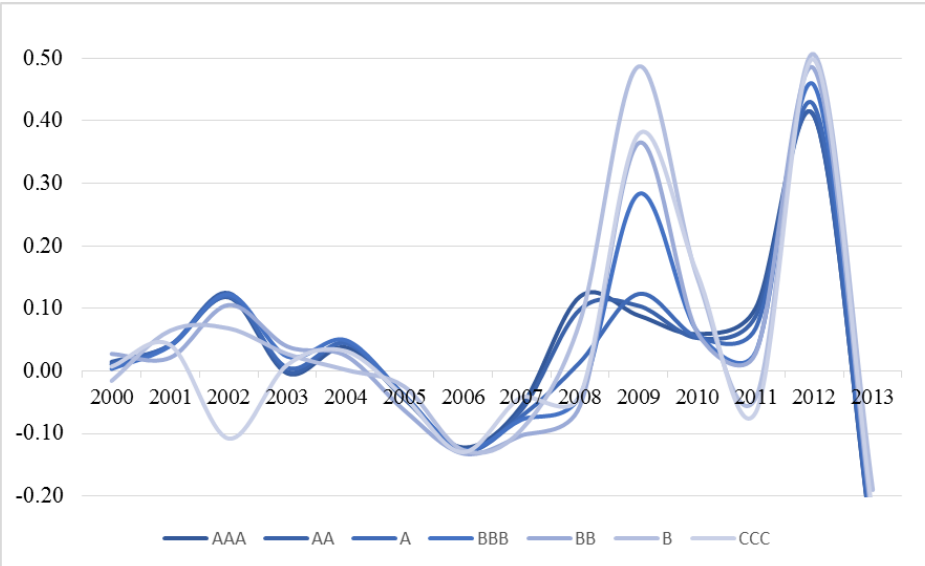

Figure 1

Funding Spreads for Different Rating Grades

[4] The data are provided as part of a cooperation with the University of Applied Sciences Kiel.

The calculated spreads are mapped to the above-described time buckets (see Section 3.3), i.e., 1-3 (to the ≤ 1 and 2-3 year time bucket), 3-5 (4-5), 5-7 (6-7), 7-9 (8-9), and ≥ 10 (≥ 10). Figure 1 shows the average spreads for different rating grades based on the indices without separated maturities.

The funding spreads change over the examined timeframe. After comparatively low overall funding spreads and small spreads between rating grades at the beginning of the decade, the spreads peaked during the financial crisis and continued at a higher level with also higher spreads between different ratings. Central bank interventions in 2009, e.g., quantitative easing in the U.S. and UK, led to a gradual easing on the financing markets with reduced funding spreads. The renewed increase of funding spreads starting in 2011 seems to be related to the European sovereign debt crisis. In this context, realized negative spreads indicate that the refinancing took place below the swap rate. Surprisingly, the spreads for sub-investment grades after 2010, especially for CCC, are relatively small compared to lower-risk rating grades. A possible explanation could be failed bonds that are excluded in subsequent index values or synthetic quotations for high-risk indices. Therefore, a stress scenario, which assumes that no market interventions took place, is designed for the analyses. Therefore, the worst spreads for each individual rating grade after 2009 are considered, i.e., the spreads from 2009 are used for 2010 as well as 2011 and the spreads from 2012 are used for 2013. If more data are available for the total timeframe, different secured and unsecured instruments could be observed for a more in-depth calculation of banks' refinancing costs.

4. Methodology

Using the method of the Value-Liquidity-at-Risk, the assessment of the funding cost risk with its impact on the capital adequacy of different bank business models is made. The VLaR is based on Fiedler (2007, 2012) and measures the risk exposure of a potential loss of a bank's own funds due to higher funding costs for a predefined timeframe with a given confidence level. The informative value is comparable to the general approach of the Value-at-Risk (VaR) methodology. As an example, if the $VLaR_{\alpha\,0.99}$ is 5%, then there is a 1% chance to lose 5% or more within the predefined timeframe. In addition, we introduce the Value Liquidity Expected Shortfall, which is based on the coherent expected

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shortfall (ES), to calculate the average expected funding costs beyond the VLaR confidence level (e.g., Yamai and Yoshiba, 2002). Both, the VLaR and VLES, are chosen for the analyses because they enable to measure the funding cost risk of different bank business models. The methods are similar to the VaR and ES approaches, which are accepted risk measures by banks and supervisory authorities. In addition, if integrated into banks risk appetite framework, VLaR and VLES allow a net present value-based management for banks' risk-bearing capacity. The procedure to calculate the VLaR and the corresponding VLES is shown below.

4.1 Determination of Funding Gaps

The funding gap analysis projects mismatches of a bank's portfolio for a certain period in the future. The maturity mismatches can exist between liquidity funds and interest rates, with our focus exclusively on liquidity mismatches, and provide information about investment or refinancing decisions (Bessis, 2015). Assets and liabilities within one examined year are sorted according to the remaining maturity and assigned to time buckets (Fiedler, 2012). The time profile can depend on the existing or the projected future cash flows. Both assets and liabilities decline over time for example through expiring contracts, withdrawals from customers, or the repayment of loans. The projection for new loans and new debts has to be estimated (cf. Bessis, 2015). In practice, banks' estimates are based on historical results. However, we use static funding gaps that depend on the run-off time profile of balance sheet positions (Bessis, 2015) to avoid uncertain forecasts of customer behaviors (Soprano, 2015) and future cash flows. The assumed cash flows of assets and liabilities are based on the above-presented banking statistics and are assigned to six different time buckets. Undrawn credit lines and potential margin calls are not included (cf. Adalsteinsson, 2014) because the future amount of the claim is not known. The funding gap for each time bucket is calculated by subtracting liabilities from assets. If the cumulative assets exceed the cumulative liabilities within a time bucket, the bank is overfunded and can invest the positive difference. However, if the cumulative liabilities exceed the cumulative assets, the bank is underfunded and needs to sell assets or refinance the negative funding gap (Fiedler, 2012).

4.2 Closure of Open Funding Gaps

The over- and underfunded gaps are fictitious closed based on a normal funding situation and a stressed funding situation. The difference between the two funding situations represents the funding cost risk for the examined year. For the first funding situation, which stands for funding conditions at the status quo, a positive funding gap is placed on the risk-free interest rate curve. It is assumed that overfunded gaps can be at least invested into risk-free investments with an equal maturity without additional costs except for the transaction. In contrast to Fiedler (2012), forward interest rate curves are not used. Instead, we can neglect uncertain forecasts by using realized interest rates for the historical data set. For negative funding gaps, the refinancing is based on the risk-free rate plus the individual funding spread, i.e., the liquidity premium (Fiedler, 2012), of the bank for the examined year. For the second funding situation, which assumes an individual rating downgrade, the overfunded gaps are again invested at the risk-free rate because it is assumed that the interest rate curve stays unchanged (Fiedler, 2012). For the underfunded gaps, the liquidity premium rises due to the rating downgrade and the funding costs increase. Overall, two different funding situations are used, which assume a rating downgrade by one or two notches because more rating shifts are unlikely (see Appendix III). Alternatively, other stress funding situations could be applied, which consider, e.g., market stress, an inverse yield curve, high counterparty risk of the investment of positive funding gaps (Fiedler, 2012), interactions among risk categories, or a combination of individual bank and market-wide stress (cf. BCBS, 2013). Future research could focus on alternative funding situations. Overall, the differences between the normal and stress funding situations in every time bucket are discounted with a bank's individual refinancing rates after the rating change for the given time bucket and year (Fiedler, 2007, 2012). Finally, the net present value is set in relation to regulatory equity of the respective bank, which we introduce as the VLaR-Ratio, in order to enable comparability between banks of different sizes. The relation to equity is chosen because equity serves as a risk buffer for the absorption of losses. This approach is comparable to the handling of the interest rate risk in the banking book of the BaFin (2018), which is set in relation to regulatory equity.

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4.3 Generating of a VLaR-Ratio-Distribution

The VLaR-Ratios of different funding situations for every bank/year observation are used to generate a distribution curve (cf. Fiedler, 2012). For the calculation of the VLaR, a confidence level of 99% is used and for the VLES, a confidence level of 97.5% is considered. Both are based on BCBS (2016) guidelines for the calculation of VaR and ES for market risk. In order to address the bank sample best, three different methodical concepts are used for VLaR and VLES calculations. The concepts are derived from different VaR and ES approaches (cf. Zangari, 1996, Yamai and Yoshiba, 2002, Jorion, 2007, Boudt et al., 2008): first, the Gaussian concept that assumes a normal distribution; second, the historical concept based on realized data, which does not have underlying assumptions regarding the distribution curve; third, the modified concept that adjusts the normal distribution curve for skewness and kurtosis.

5. Statistics and Results

The analyses of the funding cost risks with the potential impacts on solvency for retail, wholesale, and trading bank business models are presented in the following section. The calculations are based on the above-developed data set for balance sheet positions, the derived funding spreads, and the described methodology. The VLaR and VLES are calculated with different methodical concepts, for a baseline scenario with realized funding spreads, for a stress scenario with the highest funding spreads, for different rating migration scenarios, with and without the likelihood of a rating downgrade, for changing input parameters, and for different subsamples.

5.1 Descriptive Statistics

The descriptive statistics for the generated distribution curve of the VLaR-Ratios with a migration probability of one rating grade are given in Table 4. The average VLaR-Ratio for the total sample indicates that banks' non-risk-weighted equity ratio will decrease by one basis point if the rating grade migrates by one notch. Wholesale and trading banks have higher mean and minimum values for the examined timeframe, i.e., a higher negative left-tail of the distribution, compared to retail banks, due to lower reported average equity ratios. Moreover, wholesale and trading banks on average have lower rating grades, which have a potential higher influence on the future funding costs after a rating migration.

Table 4

Descriptive Statistics - VLaR-Ratio-Distribution

Sample	All Banks	Retail	Wholesale	Trading	W+T
Observations	1,238	661	345	232	577
Mean	**-0.01%**	**0.01%**	**-0.02%**	**-0.07%**	**-0.04%**
Minimum	-3.80%	-2.20%	-3.80%	-3.60%	-3.80%
Maximum	3.00%	1.30%	3.00%	1.90%	3.00%
Median	0.00%	0.00%	0.00%	0.00%	0.00%
1st Quantile	-0.10%	-0.10%	-0.10%	-0.10%	-0.10%
3rd Quantile	0.10%	0.10%	0.10%	0.10%	0.10%
Standard Deviation	0.40%	0.30%	0.50%	0.50%	0.50%
Skewness	-1.806	-0.669	-1.699	-1.784	-1.728
Kurtosis	23.437	12.988	21.243	14.711	18.509
Average Equity Ratio	5.15%	6.04%	4.34%	3.82%	4.13%
Average Rating (SD)	AA (2.12)	AA (1.54)	A (2.92)	A (2.00)	A (2.59)

Notes: Descriptive statistics for the generated VLaR-Ratio-distribution curve in the baseline scenario with a rating migration probability of one grade. The non-risk-weighted equity ratios are based on the bankscope database. The standard deviations for the rating grades are based on the iBoxx scores for different rating providers as given in Appendix II.

The distribution curves are tested for a normal distribution based on a Jarque-Bera-test. All curves, which are left-skewed (<0) with a kurtosis above 0, are non-normally distributed as the p-values are approximately 0.000 and can reject the null-hypotheses. Therefore, the Gaussian methodical concepts for VLaR and VLES are not examined in detail, but the results are given in Appendix VII. Furthermore, two wholesale bank observations with extremely low (0.22% in 2005) or negative (-0.36% in 2008) equity ratios, which would be settled under normal circumstances, are not considered to avoid an excessive distortion in the subsequent calculations. If both outliers are considered, the mean VLaR-Ratio for all banks would account for -0.02% (min. -5.14% | max. 3.00%).

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5.2 Baseline Scenario

The design of the baseline scenario is built on realized funding spreads derived from iBoxx bond indices. For the VLaR and VLES calculations, a one-year timeframe is used because only annual data are available for the sample. Based on the portrayed effects of the Bank of England (2014), higher funding costs can decrease the profitability over time, which can reduce banks' solvency (see Section 2.2). For the analyses, it is assumed that a bank will not pass higher interest rates onto their customers if refinancing costs increase. Instead, the higher cost of funding will be absorbed directly by equity to estimate the immediate impacts.

Table 5

VLaR - Baseline Scenario

Historical	**Method**	**All Banks**	**Retail**	**Wholesale**	**Trading**	**W+T**
Total	VLaR 99%	-1.50%	-0.88%	-1.81%	-1.50%	-1.50%
	VLES 97.5%	-1.65%	-1.07%	-2.18%	-2.06%	-2.13%
	Observations	1,238	661	345	232	577
Pre-Crisis < 2007	VLaR 99%	-0.59%	-0.10%	-0.45%	-1.39%	-1.01%
	VLES 97.5%	-0.76%	-0.10%	-0.45%	-1.50%	-1.10%
	Observations	515	285	148	82	230
Post-Crisis ≥ 2007	VLaR 99%	-1.58%	-1.23%	-2.24%	-1.50%	-2.06%
	VLES 97.5%	-1.90%	-1.24%	-2.56%	-2.03%	-2.57%
	Observations	723	376	197	150	347

Notes: Value-Liquidity-at-Risk (VLaR) and Value Liquidity Expected Shortfall (VLES) calculations based on a historical VLaR-Ratio-distribution curve with no probability of a rating migration. The timeframe for the examination is one year. The confidence levels are based on BCBS (2016) guidelines. The subsamples examine different time periods.

If the average rating for all banks shifts from AA to A, the potential costs with a confidence level of 99% and a one-year period will not be more than -1.50% of banks' equity. The average expected funding costs beyond the confidence level of 97.5% are -1.65%. At first, the amount seems not to be high, but would mean a reduction in equity of 138 Mio. € for the average bank in the sample. If the refinancing costs increase, roughly 94.85% of debt is affected, e.g., if liabilities are due for renewal. In this context, it should be noted that if two banks have the same refinancing profile, but different levels of equity, the bank with the lower equity ratio bears the higher funding cost risk. Table 5 illustrates a rating downshift for different subsamples within the baseline scenario.[5]

Retail banks have by far the lowest VLaR and VLES compared to wholesale and trading banks, which is caused by different average equity ratios and rating grades as well as the overall funding gaps. For example, trading banks have the highest average funding gaps with the highest reported average balance sheet total of all observed business models in the sample. A possible explanation could be higher shares of long-term loans to banks (34%), which are mainly refinanced with short-term deposits from banks (37%), compared to retail banks (see Table 1 and 2). In addition, trading banks with the lowest average equity ratios display the highest funding gaps relative to equity in all time buckets. Higher funding gaps can lead to potentially higher refinancing costs.

In order to address the years before and after the financial crisis, two subsamples are examined. Before the crisis, the refinancing costs are relatively low. Higher funding cost risks following the crisis trigger the VLaR and VLES results. For all banks, the potential funding costs and average expected funding costs increase by almost 1 percentage point after 2006. Similar results are found for retail banks. In contrast, the VLaR for wholesale banks rises from -0.45% to -2.24%, which might illustrate increased funding cost risks due to market turmoil and dried up wholesale markets following the Lehman Brothers crash. The increased results could also be triggered by the public discussion about new liquidity requirements under Basel III. Wholesale banks, which previously focused intensively on short-term debt for long-term assets, had to adjust their business and funding strategies. Surprisingly, the VLaR for trading banks increases the least from -1.39% to -1.50%, indicating already high levels of funding cost risk before the crisis. However, the VLES for trading banks rise to 2.03%, which is caused by higher tails beyond the confidence level.

For robustness purposes, four alternative models are calculated. One, if the two outliers, as described in Section 5.1, are considered, the VLaR for the total period for all banks would account for -1.50% (VLES -1.95%) and for wholesale banks for -2.63%, which is due to the extremely low equity ratios of the outliers. The VLES for wholesale banks

[5] The results for the Gaussian and modified methodical concepts are presented in Appendix VII. The tendencies of the findings, e.g., the differences between business models, are comparable to the results of the historical concept.

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would be severely distorted with -2.81%. Two, for the calculation of funding gaps, own equity sources are incorporated. If the long-term availability of equity is not considered in the > 10 year time bucket, the VLaR results change up to 22 basis points, i.e., for all banks to -1.40%, for retail banks to -0.94%, and for the combined W+T group to -1.72%. The modest changes are caused by the overall low average equity ratios in the sample. Three, if two rating shifts and the doubled number of observations are assumed, the potential funding costs at a given confidence level of 99% decrease for all banks to -2.10%, for retail banks to -1.80%, and for the combined W+T sample to -2.65%. For a B rated bank, which shifts two notches to CC, an additional rating grade is created because a CC rated bond index is not available. For the additional CC grade, the highest reported values from BB, B, and CCC rating grades in a given year are used. Four, based on Fiedler (2007, 2012), the probability of a shift between rating grades can be considered for the calculation of the VLaR distribution. Therefore, the probabilities to migrate between rating grades based on the average one-year European rating transition rates between 1981 and 2015 of Standard and Poor's (2016), as given in Appendix III, are taken into account, i.e., the net present value is multiplied by the transition rate. If the likelihood of a rating migration is considered, the potential funding costs will not be more than -0.10% for all banks, -0.10% for retail banks, and -0.20% for the combined W+T sample. In contrast to the above-shown set of estimates, the results are lower due to the non-crisis focused shift probabilities. Based on the Standard & Poor's (2016) rates, the corresponding average probability to migrate from AA to A within one year is 10.52%. If longer horizons for rating migrations are considered, the shift probability rises[6] and would increase the calculated results.

5.3 Stress Scenario

The stress scenario is designed to neglect market interventions from central banks and governments following the year 2009 and considers the highest spreads for each rating. The scenario is used to show the impact on banks' equity during extreme financial distress. As Table 6 displays, the VLaR and VLES results are between -0.43% and -1.40%

[6] For example, the global corporate average transition rates of Standard & Poor's (2016) between 1981 to 2015 show a probability to migrate from AA to A in one year of 8.06%, in three years of 18.94%, in five years of 25.09%, and in seven years of 28.16%.

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higher than for the baseline scenario. The potential impact for all banks of -2.16% would jeopardize equity in the amount of 200 Mio. € for the average bank in the sample.

Table 6

VLaR - Stress Scenario

Historical	**Method**	**All Banks**	**Retail**	**Wholesale**	**Trading**	**W+T**
Total	VLaR 99%	-2.16%	-1.60%	-2.86%	-2.68%	-2.90%
	VLES 97.5%	-2.38%	-1.71%	-2.80%	-2.58%	-2.84%
	Observations	1,238	661	345	232	577
Pre-Crisis < 2007	VLaR 99%	-0.59%	-0.10%	-0.45%	-1.39%	-1.01%
	VLES 97.5%	-0.76%	-0.10%	-0.45%	-1.50%	-1.10%
	Observations	515	285	148	82	230
Post-Crisis ≥ 2007	VLaR 99%	-2.76%	-1.65%	-3.22%	-2.95%	-3.11%
	VLES 97.5%	-2.57%	-1.86%	-3.26%	-3.17%	-3.16%
	Observations	723	376	197	150	347

Notes: Value-Liquidity-at-Risk (VLaR) and Value Liquidity Expected Shortfall (VLES) calculations based on a historical VLaR-Ratio-distribution curve. The timeframe for the examination is one year. The confidence levels are based on BCBS (2016) guidelines. The subsamples examine different time periods.

Especially for the post-crisis timeframe, the VLaR results for wholesale and trading banks are nearly twice as high as for retail banks. If portrayed together, the potential refinancing costs for the W+T sample increase for the VLaR by 2.09 percentage points and for the VLES by 2.06 percentage points compared to the pre-crisis findings. Possible explanations for the changes, besides the designed stress scenario, are represented in Section 5.2, e.g., dried up wholesale markets, adapted funding strategies, or changed business activities. The overall findings are comparable to stress test results of the ECB (2017), who estimate a negative impact on CET 1 on average of -2.70% for 111 European banks under a parallel up interest rate shock.

In summary, the baseline scenario, the alternative baseline models, and the stress scenario illustrate that the impacts of higher funding costs differ between bank business models. If higher funding spreads are considered, respectively, derived, the overall VLaR and VLES results increase, but the tendencies of the results, i.e., the differences between

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business models, are not affected due to the different balance sheet structures, equity ratios, and funding gaps.

5.4 German and European Sample

In addition, a subsample-pair for German and European Banks is analyzed due to a large number of German banks in the sample. The results of a baseline scenario with one rating shift are given in Appendix VIII. For large European banks, with a lower number of observations, the VLaR-results for all banks (-1.50%) are higher than for the German banking group (-1.43%), which is mainly driven by the European trading banks. European trading banks display the highest VLaR results of -2.16% compared to the German peers with -1.40%. On the other hand, while German wholesale banks have an overall VLaR of -1.98% with the given confidence level of 99%, European wholesale banks show potential funding costs of -1.19%. In contrast, the results for German (-0.79%) and European (-0.85%) retail banks are similar. Differences between the two subsample-pairs are also found for the pre- and post-crisis timeframe. German and European retail banks have slightly different, but comparable results. While wholesale banks have similar tendencies, the results differ tremendously. German wholesale banks display a pre-crisis VLaR of -0.48%, which quintuples to -2.72%. On the other hand, European wholesale banks show a VLaR of 0.00% before the crisis, which increases to -1.26% after the crisis. Trading banks also display substantial differences. German trading banks display a pre-crisis VLaR in the range of German retail banks, which rises to -1.43% for the post-crisis timeframe. In contrast, the results for European trading banks do not change a lot. Overall, the different results are caused by diverse funding structures, i.e., the share of balance sheet positions, the underlying funding gaps, and the rating grades between small- and medium-sized banks as well as large-sized banks. However, the comparability is limited due to the different numbers of observations.

Recapitulating, the assessment of the German and European subsample-pair illustrates that the above-shown results might be limited to small- and medium-sized banks. Future research seems necessary to obtain more accurate results for large banks and between banks of different sizes. In this sense, a combination of systemic relevance of banks and the business model as proposed by Grossmann (2016) could be a viable option for the

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future regulation of banks. Nevertheless, given the necessary assumptions, the results indicate that the risk of changing refinancing costs can have diverse impacts on banks' solvency and should, therefore, be considered for the liquidity regulation of banks.

6. Conclusion

The golden rule of banking promotes that long-term liabilities are used to fund long-term assets. In this regard, the NSFR with its focus on the availability and quality of funding sources can help to increase financial stability, but should be complemented with the examination of funding cost risks to entirely cover the funding liquidity risk in Pillar 1. For this reason, the unique data set of the analyses provides new insights about the longer-term funding cost risk. We find that the risk of higher refinancing costs, when absorbed by equity, has different impacts on bank business models. Retail banks, especially small- and medium-sized ones, bear significantly lower funding cost risks relative to equity before and after the financial crisis than wholesale and trading banks in our sample.

From a regulatory point of view, the liquidity-induced equity risks can be regulated by limiting open funding gaps or by restricting the potential loss from shifting funding costs in relation to equity. For the calibration of an equity risk requirement, the presented methods could be applied. However, the underlying data for calibrating regulatory standards should contain more detailed information regarding large banks and the maturities of balance sheet positions in order to counter the given limitations. Nonetheless, based on the findings, we propose that the regulation of the funding liquidity risk should be based on a standardized Pillar 1 approach with a possible additional enhanced Pillar 2 approach to ensure a consistent international implementation across regulatory jurisdictions. Furthermore, we recommend that the balance sheet structures as well as liquidity risk-profiles of different bank business models should be systemically included in the regulatory framework to account for the diversification of the banking system.

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Appendix I.

The Allocation of Banks

Variables	All Banks	Retail	Wholesale	Trading
Gross Loans	53% (58%)	**62%** (62%)	**52%** (65%)	29% (26%)
Interbank Lending	15% (11%)	9% (9%)	20% (8%)	**26%** (22%)
Derivative Exposure	5% (n/a)	0.9% (n/a)	3% (n/a)	**18%** (n/a)
Trading Exposure	3% (n/a)	0.5% (n/a)	1% (n/a)	**11%** (n/a)
Interbank Borrowing	22% (11%)	18% (8%)	29% (14%)	23% (19%)
Wholesale Debt	19% (19%)	8% (11%)	**37%** (37%)	24% (18%)
Stable Funding	63% (67%)	71% (74%)	59% (63%)	46% (49%)
Customer Deposits	46% (54%)	**64%** (67%)	24% (36%)	29% (38%)

Notes: Gross Loans: loans relative to balance sheet total. Interbank Borrowing: deposits from banks relative to balance sheet total. Wholesale debt: other deposits plus short-term borrowing plus long-term funding relative to balance sheet total. Interbank Lending: loans and advances to banks relative to balance sheet total. Customer Deposits: customer deposits relative to balance sheet total. Stable Funding: customer deposits plus long-term funding relative to balance sheet total. Derivate Exposure: derivatives relative to balance sheet total. Trading Exposure: trading liabilities relative to balance sheet total. Balance sheet total is net of derivatives. Results in parentheses based on Roengpitya et al. (2014).

The procedure to separate the sample into bank business models is based on Grossmann and Scholz (2017) and follows Roengpitya et al. (2014):

- Retail bank: gross loans ≥ 50% (of balance sheet total net of derivatives) with customer deposits ≥ 50%, or gross loans ≥ 35% with customer deposits ≥ wholesale debt and interbank borrowing, and investment activities < 20%.
- Wholesale bank: gross loans ≥ 50% with wholesale debt and interbank borrowing ≥ customer deposits, or gross loans ≥ 35% with wholesale debt and interbank borrowing ≥ customer deposits, and investment activities < 20%.
- Trading bank: investment activities ≥ 20%, or if interbank lending and investment activities ≥ gross loans.

For borderline-decisions, additional (internal) data can be used to allocate banks, e.g., strategic orientation, financial and common reporting data, domestic characteristics, as well as recovery and resolution planning (Grossmann, 2017).

Appendix II.

Applied Rating Grades

Fitch	Moody's	Standard and Poor's	Score	Applied Rating Grades	
AAA	Aaa	AAA	1	AAA	Investment Grade
AA+	Aa1	AA+	2	AA	
AA	Aa2	AA	3		
AA-	Aa3	AA-	4		
A+	A1	A+	5	A	
A	A2	A	6		
A-	A3	A-	7		
BBB+	Baa1	BBB+	8	BBB	
BBB	Baa2	BBB	9		
BBB-	Baa3	BBB-	10		
BB+	Ba1	BB+	11	BB	Non-Investment Grade
BB	Ba2	BB	12		
BB-	Ba3	BB-	13		
B+	B1	B+	14	B	
B	B2	B	15		
B-	B3	B-	16		
CCC+	Caa1	CCC+	17	CCC	
CCC	Caa2	CCC	18		
CCC-	Caa3	CCC-	19		
CC	Ca	CC	20	CC	
C	C	C	21	C	
D/RD		D	22	D	

Notes: Rating transition based on Markit (2012) iBoxx rating methodology.

Appendix III.

Rating Migration Matrix

From/to	AAA	AA	A	BBB	BB	B	CCC/C	D	NR
AAA	82.74	11.23	0.62	0.21	0.00	0.00	0.21	0.00	4.99
AA	0.30	84.73	10.52	0.60	0.00	0.00	0.00	0.00	3.85
A	0.01	1.98	86.44	6.19	0.20	0.01	0.00	0.04	5.12
BBB	0.00	0.11	4.43	83.32	4.07	0.40	0.11	0.09	7.48
BB	0.00	0.00	0.10	5.44	71.95	7.98	0.46	0.46	13.62
B	0.00	0.00	0.05	0.43	7.28	70.73	4.19	2.60	14.71
CCC/C	0.00	0.00	0.00	0.00	0.00	14.49	38.16	28.02	19.32

Notes: Standard and Poor's (2016) average one-year corporate transition rates in % for Europe from 1981 to 2015.

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Appendix IV.

Maturity of Loans and Advances to Banks

Maturity Bucket	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Retail Banks														
Short-term	22	23	24	24	22	21	20	24	28	21	17	18	20	17
Medium-term	6	6	6	6	7	6	7	8	8	9	10	9	9	7
Long-term	5	5	6	6	8	9	11	11	10	10	9	9	9	11
Money market	0	0	0	1	1	1	1	2	3	3	0	1	1	0
Securities by banks	67	66	65	63	63	63	61	56	50	57	64	63	61	65
Wholesale and Trading Banks														
Short-term	31	32	34	39	40	42	41	41	39	33	35	35	37	36
Medium-term	10	9	9	8	7	7	8	8	10	13	12	11	11	10
Long-term	38	37	38	35	34	31	31	29	29	32	33	36	36	38
Money market	2	1	0	0	0	1	1	1	2	1	1	0	0	0
Securities by banks	19	21	19	17	18	19	20	21	20	20	18	17	16	16

Notes: The values are shown in percentages and are based on banking statistics of the Deutsche Bundesbank (2017). For more information, see Table 1.

Maturity of Other Securities

Maturity Bucket	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Retail Banks														
Money market	3	3	3	3	3	2	3	3	5	4	6	9	4	3
Securities by corp.	18	22	26	30	34	29	22	18	19	21	28	32	40	42
Securities by public	82	78	74	70	66	71	78	82	81	79	72	68	60	58
Wholesale and Trading Banks														
Money market	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Securities by corp.	23	14	13	15	16	17	17	14	11	13	17	18	22	23
Securities by public	77	86	87	85	84	83	83	86	89	87	83	82	78	77

Notes: The values are shown in percentages and are based on banking statistics of the Deutsche Bundesbank (2017). For more information, see Table 1.

Maturity of Gross Loans

Maturity Bucket	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Retail Banks														
To households	50	50	50	51	52	53	53	53	52	51	51	50	50	50
For consum. loans	28	27	27	26	26	25	24	23	22	22	22	21	21	19
Up to 1 year	21	21	21	19	17	16	15	15	15	14	13	12	12	11
1-5 years	15	14	13	11	10	10	10	9	9	9	9	9	9	9
Over 5 years	64	65	66	69	72	74	75	76	76	77	78	79	79	79
For housing loans	72	73	73	74	74	75	76	77	78	78	78	79	79	81
Up to 1 year	1	1	1	1	1	1	0	0	0	0	0	0	0	0
1-5 years	4	4	4	3	3	3	3	2	2	2	2	2	2	2
Over 5 years	55	55	55	61	60	56	54	53	55	60	54	54	53	56
Over 10 year	40	40	40	34	36	41	42	44	43	37	44	43	44	42
To corporations	50	50	50	49	48	47	47	47	48	49	49	50	50	50
Up to 1 year	22	23	22	21	19	18	17	16	16	15	14	13	13	12
1-5 years	9	9	8	8	8	8	7	7	7	8	8	8	8	8
Over 5 years	69	69	70	71	73	75	76	77	77	77	78	79	79	80
Wholesale and Trading Banks														
To households	26	25	26	26	27	30	29	28	25	24	24	24	23	24
For consum. loans	20	19	18	17	17	18	17	17	17	18	18	18	18	18
Up to 1 year	27	26	24	24	24	22	23	23	24	26	28	30	30	30
1-5 years	14	14	13	12	11	10	10	9	9	8	8	8	7	7
Over 5 years	59	59	63	64	65	69	67	67	67	66	64	63	63	62
For housing loans	80	81	82	83	83	82	83	83	83	82	82	82	82	82
Up to 1 year	1	0	0	0	0	0	0	0	0	0	0	0	0	0
1-5 years	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Over 5 years	57	57	57	63	61	57	56	54	56	61	54	55	54	56
Over 10 year	41	41	42	35	37	42	43	45	43	38	44	44	45	42
To corporations	74	75	74	74	73	70	71	72	75	76	76	76	77	76
Up to 1 year	25	25	24	23	21	22	24	25	27	28	26	28	31	25
1-5 years	10	10	10	10	11	11	11	12	12	14	13	12	12	13
Over 5 years	65	65	66	67	68	67	66	64	60	59	61	60	57	62

Notes: The values are shown in percentages and are based on banking statistics of the Deutsche Bundesbank (2017). For more information, see Table 1.

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Appendix V.

Maturity of Deposits from Banks

Maturity Bucket	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Retail Banks														
Sight overnight	3	3	3	3	3	2	3	4	9	9	9	9	10	9
Time short	5	5	5	5	6	5	6	6	5	6	7	8	7	7
Time medium/long	92	92	92	91	92	92	91	90	86	85	84	83	83	84
Wholesale and Trading Banks														
Sight overnight	17	18	18	20	19	20	19	21	19	21	26	26	27	28
Time short	40	42	42	41	40	41	42	43	44	35	30	28	27	26
Time medium/long	43	39	40	40	40	39	39	36	37	44	44	46	46	46

Notes: The values are shown in percentages and are based on banking statistics of the Deutsche Bundesbank (2017). For more information, see Table 2.

Maturity of Customer Deposits

Maturity Bucket	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Retail Banks														
Sight overnight	23	25	27	29	31	32	33	33	33	39	44	44	47	51
Time ≤ 2 years	13	14	13	12	11	10	10	12	16	12	8	8	7	6
Time > 2 years	3	3	3	3	3	3	3	3	3	3	3	3	3	2
Savings ≤ 1 year	51	48	47	47	47	46	45	42	37	37	39	38	37	36
Savings bonds ≤ 2y	1	2	2	2	1	1	2	3	5	4	2	2	2	1
Savings bonds > 2y	10	9	8	8	8	7	7	6	5	5	5	5	4	4
Wholesale and Trading Banks														
Sight overnight	19	20	20	22	25	27	29	30	28	31	35	37	38	42
Time ≤ 2 years	18	21	21	22	20	21	22	24	30	25	22	23	24	20
Time > 2 years	58	56	56	52	50	45	42	39	36	37	35	33	30	29
Savings ≤ 1 year	4	3	3	3	4	8	7	6	6	6	7	7	7	8
Savings bonds ≤ 2y	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Savings bonds > 2y	0	0	0	0	0	0	0	0	1	1	1	1	1	1

Notes: The values are shown in percentages and are based on banking statistics of the Deutsche Bundesbank (2017). For more information, see Table 2.

Maturity of Long-Term Funding

Maturity Bucket	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Retail Banks														
Up to 2 years	11	12	13	12	10	10	12	20	23	17	9	8	7	5
Over 2 years	89	88	87	88	90	90	88	80	77	83	91	92	93	95
Wholesale and Trading Banks														
Up to 2 years	13	14	14	15	11	9	10	13	18	15	12	11	11	11
Over 2 years	87	86	86	85	89	91	90	87	82	85	88	89	89	89

Notes: The values are shown in percentages and are based on banking statistics of the Deutsche Bundesbank (2017). For more information, see Table 2.

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Appendix VI.

Maturity of Bank Debt Securities

Time Buckets	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
≤ 1 year	36	39	40	40	39	37	38	41	45	47	44	42	42	42
2-3 years	27	25	26	26	26	26	26	25	23	24	25	26	30	29
4-5 years	17	16	15	16	16	15	14	13	12	12	16	17	13	13
6-7 years	9	10	9	8	7	7	8	7	10	9	5	5	6	7
8-9 years	8	7	5	5	5	6	10	8	3	3	3	4	4	4
≥ 10 years	3	3	4	5	6	8	5	6	6	6	6	6	6	6

Notes: The maturities of securities are based on the amounts outstanding of bank debt securities of issuers domiciled in Germany and are based on statistics of the Deutsche Bundesbank (2017b). The values are shown in percentages.

Maturity of Corporate Bonds

Time Buckets	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
≤ 1 year	15	17	14	28	28	28	28	22	18	13	15	21	22	24
2-3 years	14	21	33	29	25	17	16	20	19	16	16	23	19	16
4-5 years	43	37	23	14	13	17	20	19	16	16	14	10	15	14
6-7 years	18	3	6	12	16	12	12	17	12	4	6	6	6	9
8-9 years	6	15	21	12	10	16	11	5	3	2	3	3	3	6
≥ 10 years	4	6	4	6	9	10	13	16	32	49	45	39	35	31

Notes: The maturities of securities are based on the amounts outstanding of corporate bonds of issuers domiciled in Germany and are based on statistics of the Deutsche Bundesbank (2017b). The values are shown in percentages.

Maturity of Public Debt Securities

Time Buckets	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
≤ 1 year	26	31	33	31	30	30	31	31	32	36	37	39	37	36
2-3 years	24	20	19	18	19	20	20	20	20	19	19	20	22	21
4-5 years	15	14	14	17	17	16	16	16	15	14	15	14	13	13
6-7 years	9	11	12	12	12	12	11	11	11	10	8	7	8	10
8-9 years	12	13	12	12	11	11	11	11	9	8	8	8	8	9
≥ 10 years	14	11	11	11	11	12	12	12	13	12	12	11	11	12

Notes: The maturities of securities are based on the amounts outstanding of public debt securities of issuers domiciled in Germany and are based on statistics of the Deutsche Bundesbank (2017b). The values are shown in percentages.

Appendix VII.

VLaR - Baseline Scenario (Gaussian)

Gaussian	Method	All Banks	Retail	Wholesale	Trading	W+T
Total	VLaR 99%	-0.96%	-0.66%	-1.20%	-1.26%	-1.23%
	VLES 97.5%	-0.97%	-0.67%	-1.21%	-1.27%	-1.23%
	Observations	1,238	661	345	232	577
Pre-Crisis < 2007	VLaR 99%	-0.44%	-0.10%	-0.29%	-1.04%	-0.66%
	VLES 97.5%	-0.44%	-0.10%	-0.29%	-1.04%	-0.66%
	Observations	515	285	148	82	230
Post-Crisis ≥ 2007	VLaR 99%	-1.21%	-0.88%	-1.58%	-1.37%	-1.50%
	VLES 97.5%	-1.22%	-0.89%	-1.58%	-1.38%	-1.50%
	Observations	723	376	197	150	347

Notes: Value-Liquidity-at-Risk (VLaR) and Value Liquidity Expected Shortfall (VLES) calculations based on a normal VLaR-Ratio-distribution curve. The timeframe for the examination is one year. The confidence levels are based on BCBS (2016) guidelines. The subsamples examine different time periods.

VLaR - Baseline Scenario (Modified)

Modified	Method	All Banks	Retail	Wholesale	Trading	W+T
Total	VLaR 99%	-2.97%	-1.40%	-3.49%	-2.76%	-3.19%
	VLES 97.5%	-1.55%	-1.79%	-1.86%	-3.30%	-2.49%
	Observations	1,238	661	345	232	577
Pre-Crisis < 2007	VLaR 99%	-3.61%	-0.10%	-0.72%	-2.50%	-2.85%
	VLES 97.5%	-1.34%	-0.06%	-1.04%	-2.93%	-1.23%
	Observations	515	285	148	82	230
Post-Crisis ≥ 2007	VLaR 99%	-2.84%	-1.36%	-3.33%	-2.65%	-3.16%
	VLES 97.5%	-2.90%	-1.85%	-4.01%	-4.22%	-3.85%
	Observations	723	376	197	150	347

Notes: Value-Liquidity-at-Risk (VLaR) and Value Liquidity Expected Shortfall (VLES) calculations based on a modified VLaR-Ratio-distribution curve. The timeframe for the examination is one year. The confidence levels are based on BCBS (2016) guidelines. The subsamples examine different time periods.

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Appendix VIII.

VLaR - German and European Banks - Baseline Scenario (Historical)

German Banks

Historical	Method	All Banks	Retail	Wholesale	Trading	W+T
Total	VLaR 99%	-1.43%	-0.79%	-1.98%	-1.40%	-1.71%
	VLES 97.5%	-1.56%	-0.95%	-2.40%	-1.43%	-2.10%
	Observations	968	570	273	125	398
Pre-Crisis < 2007	VLaR 99%	-0.10%	-0.10%	-0.48%	-0.10%	-0.42%
	VLES 97.5%	-0.45%	-0.10%	-0.45%	-0.10%	-0.45%
	Observations	440	262	124	54	178
Post-Crisis ≥ 2007	VLaR 99%	-1.67%	-1.19%	-2.72%	-1.43%	-2.14%
	VLES 97.5%	-2.11%	-1.21%	-2.78%	-1.50%	-2.40%
	Observations	528	308	149	71	220

Other European Banks

Historical	Method	All Banks	Retail	Wholesale	Trading	W+T
Total	VLaR 99%	-1.50%	-0.85%	-1.19%	-2.16%	-1.65%
	VLES 97.5%	-1.81%	-0.97%	-1.25%	-2.90%	-2.04%
	Observations	270	91	72	107	179
Pre-Crisis < 2007	VLaR 99%	-1.46%	0.00%	0.00%	-1.93%	-1.69%
	VLES 97.5%	-1.70%	0.00%	0.00%	-2.20%	-1.70%
	Observations	75	23	24	28	52
Post-Crisis ≥ 2007	VLaR 99%	-1.50%	-0.97%	-1.26%	-1.96%	-1.50%
	VLES 97.5%	-1.86%	-1.30%	-1.25%	-3.60%	-2.00%
	Observations	195	68	48	79	127

Notes: Value-Liquidity-at-Risk (VLaR) and Value Liquidity Expected Shortfall (VLES) calculations based on a historical VLaR-Ratio-distribution curve. The timeframe for the examination is one year. The confidence levels are based on BCBS (2016) guidelines. The subsamples examine different time periods.