UNIVERSITY OF TWENTE

MASTER THESIS

Basel III, does one size fit all?

The implications of Basel III for different banking business models

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Abstract

The new Basel III regulation, which came in place after the recent financial crisis, limits the scope of banking activities (Mergaerts and Vander Vennet, 2016). It moves from allowing banks to use internal risk models to a one-size-fits-all approach (Ayadi, Arbak, and De Groen, 2012; Ayadi et al., 2016). However, a multi-dimensional view on the effects of this approach on systemic diversity and the risk-return performance of different banking business models is missing. Therefore, the goal of our research is to get a deeper understanding of the performance of different banking business models under the new restrictions of Basel III.

To obtain this understanding, we have built a model that predicts business model risk-return performance and investigates improvement directions, while considering the requirements of Basel III. The three banking business models that are investigated are the retail, wholesale and investment business models. The model transform the average balance sheet composition of the three banking business models over time according to the macro-financial scenario of the EBA 2018 EU-wide stress test. The average balance sheet compositions of these business models will be determined by using three samples of banks with the same business model. To create distinct samples for each business model, the business models of banks are classified according to our own developed business-model-score methodology, which is derived from the statistical clustering results of Ayadi et al. (2016). Additionally, we will perform a sensitivity analysis to determine the optimal improvement direction.

Combining the findings of our research, leads to confirmation of earlier conclusions that including more retail products on the balance sheet will make individual banks more resilient in times of stress. However, if this occurs on a large scale this might reduce systemic diversity and therefore increase systemic risk. We found that migrations towards activities other than retail activities can be (even more) feasible from both the risk and return perspective. The optimal migration direction is different for every bank and is dependent on a bank's maturity profile, counterparty credit rating profile and its business-typical-activities. This opposes the neoclassical assumption that firms can optimize uniformly across a sector and indicates that one size might not fit all.

Therefore, we recommend regulators to further investigate the acknowledgement, followed by the inclusion, of systemic diversity and banking business models in banking regulation. A first concrete step to realise this could be to make banking business models a regulatory concept.

Keywords - Banking business models, Basel III, systemic diversity, stress testing, banking business model classification, risk-return trade-off

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List of Abbreviations

BCBS	Basel Committee on Banking Supervision
bp	basis points
DNB	De Nederlandse Bank (Dutch Central Bank)
D-SIB	Domestic Systemically Important Bank
EBA	European Banking Authority
ECB	European Central Bank
ESRB	European Systemic Risk Board
EVE	Economic Value of Equity
GDP	Gross Domestic Product
G-SIB	Global Systemically Important Bank
HQLA	High Quality Liquid Assets
IRP	Individual Risk Premium
LCR	Liquidity Coverage Ratio
LTV	Loan-To-Value
NII	Net Interest Income
NSFR	Net Stable Funding Ratio
NTI	Net Trading Income
PD	Probability of Default
RoA	Return on Assets
RoE	Return on Equity
SME	Small & Medium Enterprises

Chapter 1

Introduction

I wrote my thesis during an internship at Zanders in Bussum. Zanders provides finance and treasury solutions for its clients. I was located at the Financial Institutions team, this team provides all kinds of financial risk management services to banks, insurers and asset managers.

In the post-crisis period, banks have to deal with a new reality that entails low growth, low interest rates, and new regulation. The new Basel III regulation that came in place after the crisis uses a one-size-fits-all approach and forces banks to hold higher liquidity and capital buffers to increase the resilience of the financial sector. Now that the implementation phase of Basel III has passed, Zanders wants to know more about the strategic choices that can be made regarding banking business models, balance sheet activities and regulatory requirements.

1.1 Problem context

Banking is a business of transformation of credit, maturity, and liquidity. To create margins that generate revenue, mismatches are created in these transformations. One of the key aspects of banking is managing the mismatches that result from balance sheet activities.

To manage this mismatch, banks are constantly trying to improve their balance sheets to meet the conflicting needs of stakeholders. The most important stakeholders of banks are customers, shareholders, and regulators. It is impossible to fully meet the needs of all three stakeholders, therefore it is key for banks to balance in the decision space limited by the minimum requirements of each stakeholder (Choudry, 2017). The place that a bank takes within this decision space is a trade-off that is based on a bank's business model, competitive position and market share (Caruana and Van Rixtel, 2013; Dumičić and Rizdak, 2013).

A bank's business model describes how it generates profit, what customers it serves, and which distribution channels it uses (Köhler, 2015). Many theories use a uniform, traditional description of a bank's business model: converting liquid, short term liabilities (e.g. deposits) to illiquid, long term assets (e.g. mortgages) (Cassola, Hortaçsu, and Kastl, 2013; De Haan and End, 2013).

In the 1970s/1980s, financial de-regulation and innovation took place. This created space for banks to exploit additional revenue sources, to achieve higher economies of scope and risk diversification (Allen et al., 2012; Altunbas, Manganelli, and Marques-Ibanez, 2011; Diamond and Dybvig, 1983; Mergaerts and Vander Vennet, 2016). As a result, banks diversified from the traditional banking business model along several dimensions like size,

non-interest income, corporate governance and funding practices (Allen et al., 2012; Altunbas, Manganelli, and Marques-Ibanez, 2011; Ayadi, Arbak, and De Groen, 2011; Diamond and Dybvig, 1983; Mergaerts and Vander Vennet, 2016). Thus, many of them do not fit the traditional business model anymore (Farnè and Vouldis, 2017).

The deregulation in the late 20th century led to a situation where there was a large availability of funding on the wholesale and retail market and the sky seemed the limit(Allen et al., 2012). However, there is a major drawback to the financial de-regulation and innovation, because it increases vulnerability to runs, bank interdependency and income volatility (Altunbas, Manganelli, and Marques-Ibanez, 2011; Ayadi, Arbak, and De Groen, 2011; Diamond and Dybvig, 1983). In 2007, this resulted in clients reclaiming their short-term deposits in large numbers after a series of events that decreased the generally perceived solvency of the financial sector (Hull, 2012). These runs resulted in illiquidity in the market and the funding costs for banks rose sharply (Beau et al., 2014). This marked the start of a global financial crisis which led to many defaults among financial institutions and corporates.

In 2010, in response to the flaws that became visible during the financial crisis, the Basel Committee on Banking Supervision (BCBS) announced a set of new capital and liquidity measures to strengthen the financial sector, called 'Basel III: A global regulatory framework for more resilient banks and banking system' (hereafter referred to as Basel III). Basel III aims to increase transparency and quality of capital (BCBS, 2011). Additionally, Basel III moves away from internal risk models to a one-size-fits-all approach and from a bottom-up to a top-down approach (Ayadi, Arbak, and De Groen, 2012).

To meet the Basel III standards, banks have to restructure their balance sheet and hold higher liquidity and capital buffers. Additionally, banks must change their strategies from asset-driven to liability-driven (Ayadi et al., 2016). There is a debate in the literature on how big the impact of the required restructuring is and will be. However, it is clear that the new liquidity regulations will put significant pressure on the profit of banks (KPMG, 2011; Härle et al., 2010), whereas it improves the bank's resilience to external shocks, reduces systemic risk and reduces the probability of default (PD) (Giordana and Schumacher, 2012; KPMG, 2011).

1.2 Core problem

Basel III limits the scope of banking activities and adopts a one-size-fits-all approach. It stimulates banks to incorporate regulation as a dominant driver, and to move towards more safe and stable balance sheet structures (Ayadi, Arbak, and De Groen, 2012). This requires restructuring and can lead to migration towards a different business model. If many banks migrate to the same business model, this might reduce competitive inequality and systemic diversity, which will lead to increased systemic risk (Ayadi, Arbak, and De Groen, 2011; Ayadi et al., 2016; Mergaerts and Vander Vennet, 2016).

However, different banking business models and systemic diversity are not explicitly incorporated in the Basel III framework (Altunbas, Manganelli, and Marques-Ibanez, 2011), neither in many economic theories (Farnè and Vouldis, 2017). Nevertheless, it is important from both the regulators' and the banks' perspectives to have a proper understanding of the different banking business models, the underlying incentives towards risk and return, and how this changed under Basel III. Additionally, it is important to investigate how the one-size-fits-all approach influences systemic diversity (Farnè and Vouldis, 2017; Ayadi, Arbak, and De Groen, 2012; Ayadi et al., 2016; Köhler, 2015).

This deeper understanding will help to identify hidden risks, to make banks' risk-return profiles more resilient, and to ensure systemic diversity and structural stability in the financial sector (Altunbas, Manganelli, and Marques-Ibanez, 2011; Ayadi, Arbak, and De Groen, 2011; Ayadi et al., 2016; Farnè and Vouldis, 2017; Köhler, 2015; Martel, Rixtel, and González Mota, 2012; Mergaerts and Vander Vennet, 2016; Prabha and Wihlborg, 2014).

In academic literature on the performance of banks, the traditional business model is often preferred and heterogeneity among banking business models is ignored (Farnè and Vouldis, 2017). Academic literature that does include different banking business models often takes a one-dimensional perspective on performance (either risk (e.g. Köhler (2015)) or return (e.g. Farnè and Vouldis (2017)) and is often based on empirical research (e.g. Ayadi, Arbak, and De Groen (2011) and Roengpitya, Tarashev, and Tsatsaronis (2014)). Additionally, literature on Basel III does not look at the impact of Basel III on the performance of different banking business models and systemic diversity (e.g. Allen et al. (2012) and BCBS (2010)).

1.3 Research objective

The goal of our research is to get deeper understanding of the performance of different banking business models under the new restrictions of the Basel III framework. Additionally, we want to investigate the optimal improvement direction for different banking business model and if this confirms with the neoclassical assumption that firms can optimize uniformly across a sector (Farnè and Vouldis, 2017).

To obtain this understanding, we will develop a model in Excel. The model takes the balance sheet composition and associated characteristics of a bank, transforms them over time according to scenarios retrieved from the 2018 EU-wide stress test (hereafter, EBA stress test) published by the European Banking Authority (EBA) and predicts the risk-return performance of the bank over time. We will also include a migration analysis in the model. This migration analysis shows what would happen to the risk-return profile if the bank under investigation moderately migrates towards business-model-typical activities of a certain business model at the expense of business-model-typical activities of another business model.

The Excel tool will be built in such a way that the user can insert his own input. Therefore, the tool can be applied and used beyond the scope of our research. It can be used to get a deeper understanding of the performance and potential improvements of any bank under the new restrictions of the Basel III framework. However, for our research, the average balance sheet profiles of different banking business models will serve as input for the model. The results of the stress test and the migration analysis will give insight in the predicted performance of different banking business models and how banks can improve their business model and their position on the risk-return plane under the restrictions of Basel III.

Our research aims to fill the knowledge gap described in Section 1.2. Additionally, our research differs from earlier investigations for several reasons. First, most articles have a time frame that ends just after the financial crisis (e.g. Altunbas, Manganelli, and Marques-Ibanez (2011) and Demirgüç-Kunt and Huizinga (2010)). Our thesis includes the most recent developments in the banking sector, e.g. low interest rates, and can therefore give new insights. Second, literature often presents a one-dimensional view on performance (e.g. Farnè and Vouldis (2017) and Köhler (2015)) while in reality there is a constant trade-off between risk and return. Our thesis includes both risk and return in the same analysis and therefore gives more insight on the risk-return trade-off. Last, most literature on performance and

migration of banking business models has an empirical approach (e.g. Ayadi, Arbak, and De Groen (2011) and Roengpitya, Tarashev, and Tsatsaronis (2014)). Our thesis takes a theoretical approach, therefore it is a valuable addition to empirical findings because we show theoretical best practices.

The geographical scope of the thesis will be on banks in the Eurozone. We chose this scope because banks in the Eurozone face the same economic, monetary and regulatory regime, which increases the validity of the results.

1.4 Research question

To reach the research goal, the following main research question must be answered:

How do different banking business models perform in the risk-return plane under the restrictions of Basel III and how can this performance be improved?

To answer the main research question we defined the following sub-questions:

1. What does existing literature state on banking business models and bank performance?
   - **a** Which business models can be identified among banks and what are their characteristics?
   - **b** How can banking business models be quantified?
   - **c** Which bank performance measures are used in literature?
2. Which components, procedures, and input are needed to construct a model that measures banking performance in terms of risk and return while considering the regulations of Basel III?
3. How can the model be used to analyse banking business model performance and banking business model improvements?
4. What results can be drawn from the model?
   - **a** How do different business models perform under stressed conditions?
   - **b** How can different banking business models improve their risk-return performance?
5. How can the results of the model be used to obtain a deeper understanding of the performance of different banking business models under the Basel III framework and how should the regulator adapt?

1.5 Thesis outline

The remainder of this thesis is structured as follows.

In Chapter 2 we will describe the context of the subject. Context is given on Basel III, banking business models, bank performance and stress testing. In this chapter, Sub-question 1 is answered.

In Chapter 3 we treat the components and procedures of the model. The developed model, the input of the model, the stress scenarios and the migration analysis are described. In this chapter, Sub-question 2 is answered.

We describe in Chapter 4 how the model is used to analyse banking business models. This will entail the method we developed for classification of banking business models. Additionally, per banking business model, a sample of banks in the Eurozone is constructed. Finally, the average balance sheet composition of the sample is transformed into input for the model. In this chapter, Sub-question 3 is answered.

In Chapter 5, the results retrieved from the model with the input created in Chapter 4 are described and interpreted. First, the current performance of different banking business models will be investigated. Then the migration possibilities for different banking business models will be analysed. Finally, the results will be compared to the actual results of the EBA stress test. In this chapter, Sub-question 4 is answered.

In the final chapter, Chapter 6, we will draw conclusions from the results and place them in the research context. An overview is given of the main conclusions and discussion points. Additionally, the research limitations and recommendations for future research are described. In this chapter, Sub-question 5 is answered.

Chapter 2

Literature review

In this chapter we will describe the research context by giving a holistic view on related topics. Therefore, in this chapter the following sub-question is answered:

What does existing literature state on banking business models and bank performance?

a Which business models can be identified among banks and what are their characteristics?

b How can banking business models be quantified?

c Which bank performance measures are used in literature?

The information in this chapter is gathered from empirical and theoretical academic literature and working papers.

2.1 Banking

2.1.1 Evolution of banking & regulation

A bank's business model describes how it generates profit, what customers it serves, and which distribution channels it uses (Köhler, 2015). Many theories use a uniform, traditional description of a bank and its activities. This traditional description states that banks are set up to solve information asymmetry for their clients because they have information advantages. Banks funnel their clients' household deposits into residential mortgage loans and in return for the yields resulting from this funnelling banks accept the credit risk, monitor the market and hold capital to cover unexpected risks (Ayadi, Arbak, and De Groen, 2011).

In the 1970s/1980s a global financial de-regulation took place that aimed to create space for banks to achieve better economies of scope and better risk diversification (Barth, Brumbaugh, and Wilcox, 2000). As a result, banks became more competitive and diversified from the traditional banking business model along several dimensions like size, non-interest income, corporate governance and funding practices (Allen et al., 2012; Altunbas, Manganelli, and Marques-Ibanez, 2011; Ayadi, Arbak, and De Groen, 2011; Diamond and Dybvig, 1983; Mergaerts and Vander Vennet, 2016).

Another trend in the financial sector in the late 20th century was product innovation. New financial instruments came into existence that were different from traditional banking products (Altunbas, Manganelli, and Marques-Ibanez, 2011; Ayadi, Arbak, and De Groen, 2011). Hence, only a bank's banking book was not sufficient anymore to provide a picture of the bank's activities and performance since the trading book and other non-traditional sources of income became of increasing importance (Ayadi, Arbak, and De Groen, 2011).

The deregulation and financial innovation led to a large availability of funding on the wholesale & retail market (Allen et al., 2012; Ayadi, Arbak, and De Groen, 2011). This resulted in growth and economic gains, which led to a collective euphoria that increased the demand for loans and decreased the market's risk monitoring incentive. Banks were willing to meet this demand and this resulted in low cost of debt which led to higher leveraging (Altunbas, Manganelli, and Marques-Ibanez, 2011; Ayadi, Arbak, and De Groen, 2011).

However, it also made the banking sector more complex, interconnected, larger and therefore less transparent. The expectation was that bank diversification would lead to reduced overall risk, but with the knowledge of hindsight this is arguable because non-interest income has proven to be more volatile than interest income (Altunbas, Manganelli, and Marques-Ibanez, 2011; Ayadi, Arbak, and De Groen, 2011). According to Ayadi, Arbak, and De Groen (2011), profitability in that period did not increase because of superior banking performance but because of increased risk-taking. At the same time, the low cost of capital did not reflect that increased risk.

To create a one-level playing field, the BCBS introduced the first international regulatory framework (Basel I) in 1988 (Hull, 2012). It focused on common minimum capital requirements related to a bank's credit risk exposure. Because more and more banks diversified from the traditional banking model it became harder to fit banks into the same regulatory framework. Therefore, the BCBS introduced Basel II in 2006, which did not focus on common standards but allowed banks to use their own internal risk models (Altunbas, Manganelli, and Marques-Ibanez, 2011).

The lower reliance on rules and stronger dependence on self-regulation led to a build-up of risk and left banks more vulnerable to runs (Altunbas, Manganelli, and Marques-Ibanez, 2011; Diamond and Dybvig, 1983)). The market relied excessively on unstable market funding instead of stable funding, like deposits (Ayadi, Arbak, and De Groen, 2011).

In 2007, the collective euphoria bubble burst, as clients reclaimed their short-term deposits in large numbers after a series of events that decreased the generally perceived solvency of the financial sector, like the default of the Lehman Brothers (Hull, 2012). These runs resulted in illiquidity in the market and the funding costs for banks rose sharply (Beau et al., 2014). This marked the start of a global financial crisis which led to many defaults among financial institutions and corporates. During the crisis, credit growth slowed down for all banks, in some cases it even resulted in credit decline, and the Return on Equity dropped for almost all banks (Ayadi, Arbak, and De Groen, 2012; Roengpitya, Tarashev, and Tsatsaronis, 2014).

2.1.2 Basel III

In 2010, in response to the flaws that became visible during the crisis, the BCBS announced a set of capital and liquidity requirements to strengthen the financial sector: Basel III. With Basel III, the BCBS aims to increase transparency and quality of capital (BCBS, 2011). The capital requirements increased and two liquidity regulations were introduced (BCBS, 2011; BCBS, 2013; BCBS, 2014). Additionally, Basel III moves away from internal risk models to a one-size-fits-all approach (Ayadi, Arbak, and De Groen, 2012). According to several empirical and theoretical sources, compliance with Basel III improves banks' resilience to external shocks, reduces systemic risk, and reduces banks' PD (Ayadi, Arbak, and De Groen, 2011; Giordana and Schumacher, 2012; KPMG, 2011; Härle et al., 2010). Basel III is implemented stepwise between January 1st, 2013 and January 1st, 2019 (BCBS, 2011)).

Various studies have been performed since the announcement of Basel III on the possible

impact that it might have on a bank's strategy and risk-return profile. To begin, banks have to change their strategies from asset-driven to liability-driven and are stimulated by regulators to operate with less complex business structures (Ayadi, Arbak, and De Groen, 2011). A liability-driven strategy means that asset volumes will be constrained by a bank's ability to attract funding instead of their ability to find assets (Allen et al., 2012). Additionally, banks have to restructure their balance sheets and hold higher liquidity and capital buffers to meet the new requirements (Ayadi, Arbak, and De Groen, 2012).

2.2 Banking business models

2.2.1 Definition

For a bank, its business model is defined by the set of activities that it performs (Farnè and Vouldis, 2017). The business model that a bank exploits is a result of strategic choices by the bank's management and is reflected in the composition of the balance sheet (Amel and Rhoades, 1988; Ayadi, Arbak, and De Groen, 2011; DeSarbo and Grewal, 2008; Farnè and Vouldis, 2017; Mehra, 1996; Roengpitya et al., 2017). We will also use this definition for banking business models in the remainder of this research.

Factors that are a results of the business model exploited by a bank are e.g. efficiency, pricing policy, credit rating, client satisfaction, effectiveness, revenues and costs (Ayadi, Arbak, and De Groen, 2011; Farnè and Vouldis, 2017; Mergaerts and Vander Vennet, 2016; Roengpitya et al., 2017).

Non-financial factors like corporate governance mechanisms and ownership structures are also results of strategic choices by the bank's management (Ayadi, Arbak, and De Groen, 2011). However, we do not see them as determinants for business models in this definition. We chose this because some of these factors do not have an unambiguous definition or are not publicly available, and therefore do not contribute to the unambiguous identification of banking business models. This is supported by (Ayadi et al., 2016). (Mergaerts and Vander Vennet, 2016) state that the influence that these factors have on banking business models is ultimately reflected in the balance sheet composition. Which indicates that leaving these factors out of the definition will not lead to significantly different results.

2.2.2 Types of banking business models

In academic literature, three main business models can be identified amongst banks: the retail, wholesale, and investment business models. The business-model-typical activities for these business models are described below, and more specifically in Section 3.5. The business models are described in their most traditional sense, however, various forms of diversification within, between and outside these three business models exist.

Retail business model

Of the three business models mentioned above, the retail business model looks most like the traditional banking model described in Section 2.1.1. Retail banks focus on basic deposit accounts, residential mortgages, consumer credits, and simple payment services. Additionally, retail banks only have modest trading and interbank activities (Martel, Rixtel, and González Mota, 2012). They rely substantially more on interest income and stable funding sources than other business models (Ayadi et al., 2016; Farnè and Vouldis, 2017). The retail

business model is the most common banking business model worldwide (Roengpitya, Tarashev, and Tsatsaronis, 2014; Roengpitya et al., 2017)).

Wholesale business model

Wholesale banks focus on institutional clients, e.g. large corporates, (semi) public entities, and financial institutions. Although wholesale banks have a substantial loan book, they have more trading exposure than retail banks (Farnè and Vouldis, 2017). To attract funding, wholesale banks are more active in the debt and wholesale market instead of the customer deposit market. Therefore, they have a high share of interbank liabilities and wholesale debt, which are considered less stable (Hull, 2012). Wholesale banks have a larger share of non-interest income than retail banks (Ayadi et al., 2016; Farnè and Vouldis, 2017). The wholesale business model is mainly present in Europe and Asia and almost not present in North America and emerging countries (Roengpitya, Tarashev, and Tsatsaronis, 2014; Roengpitya, Tarashev, and Tsatsaronis, 2014).

Investment business model

Investment banks focus mainly on trading activities. Therefore, they have a small loan book compared to the other two business models and rely more heavily on their trading book. Balance sheet and non-balance sheet related activities associated with the investment business model are securities issuance, mergers & acquisition advice, sales, trading activities, brokerage services, and asset management services (Mergaerts and Vander Vennet, 2016). On the funding side, investment banks rely mostly on unstable funding sources like issued debt, repurchase agreements, and wholesale funding. Additionally, investment banks rely substantially on non-interest earnings like fees, trading returns and insurance earnings (Altunbas, Manganelli, and Marques-Ibanez, 2011; Martel, Rixtel, and González Mota, 2012). The investment business model is present in all continents, but mainly in North America (Roengpitya, Tarashev, and Tsatsaronis, 2014; Roengpitya et al., 2017).

2.2.3 Evolution of banking business models

Banking business models' performance during the financial crisis

In the recent crisis period, retail banks outperformed the other two business models on both risk and return (Ayadi, Arbak, and De Groen, 2011; Ayadi, Arbak, and De Groen, 2012; Ayadi et al., 2016; Mergaerts and Vander Vennet, 2016; Roengpitya, Tarashev, and Tsatsaronis, 2014). Because of their high reliance on stable funding, their loan growth decline was the lowest and since retail banks only have a small trading book, the trading losses did not impact their profit as much as the profits of the other business models (Ayadi, Arbak, and De Groen, 2012; Demirgüç-Kunt and Huizinga, 2010; Köhler, 2015; Prabha and Wihlborg, 2014; Roengpitya, Tarashev, and Tsatsaronis, 2014). Compared to other business models, retail banks faced lower liquidity risk and largest distance to default, since they have a strong deposit base, i.e. stable funding, and they have the highest risk-absorbing capacity (Ayadi, Arbak, and De Groen, 2011; Ayadi, Arbak, and De Groen, 2012; Mergaerts and Vander Vennet, 2016).

Wholesale banks have reported the worst return performances during the crisis with substantial losses (Altunbas, Manganelli, and Marques-Ibanez, 2011; Ayadi, Arbak, and De Groen, 2011; Ayadi, Arbak, and De Groen, 2012; Ayadi et al., 2016; Köhler, 2015). Their loan book shrunk dramatically during the crisis years because of unstable funding and therefore endured the most deleveraging of all banking business models (Ayadi, Arbak, and De

Groen, 2012). Additionally, they also suffered trading losses on their substantial trading books and faced increased cost of capital because of the illiquidity in the wholesale market (Ayadi, Arbak, and De Groen, 2012; Prabha and Wihlborg, 2014). In terms of risk, wholesale banks had the smallest distance to default. They carry more risk because of a shortage of liquidity, a high reliance on short-term funding and insufficient capital buffers to absorb shortfalls (Ayadi, Arbak, and De Groen, 2011; Ayadi, Arbak, and De Groen, 2012).

Investment banks have suffered low profits and losses during the crisis, but these were not as extremely as for wholesale banks (Ayadi, Arbak, and De Groen, 2011; Ayadi et al., 2016). Investment banks' losses were mainly caused by trading losses (Ayadi, Arbak, and De Groen, 2012; Prabha and Wihlborg, 2014). Like wholesale banks, investment banks faced substantial liquidity risk because of their earnings volatility (Ayadi, Arbak, and De Groen, 2012; Ayadi et al., 2016). However, they were on average less leveraged which made their capacity to absorb losses better. Therefore, investment banks performed in general worse than retail banks but better than wholesale banks in terms of risk (Ayadi, Arbak, and De Groen, 2011; Ayadi et al., 2016).

Changes within business models over time

Roengpitya, Tarashev, and Tsatsaronis (2014) state that banking business models are organic: even though their main scope often stays the same, the corresponding average balance sheet composition evolves over time and responds to changes in the economic and regulatory environment. On average, European banks increase their equity and have moved towards retail activities at the expense of interbank lending and increased their equity, regardless of their business model (Ayadi, Arbak, and De Groen, 2012; Ayadi et al., 2016; Martel, Rixtel, and González Mota, 2012). This show that banks in Europe made a collective shift in their balance sheet composition whereas for banks worldwide those shifts occurred on an individual bank/business model level.

Migration between banking business models

Migration occurs when a bank moves to another business model. When looking at empirical migration data of the past 15 years, it shows that the vast majority of the banks are persistent and stay with the same business model over time (Ayadi, Arbak, and De Groen, 2012; Ayadi et al., 2016; Roengpitya, Tarashev, and Tsatsaronis, 2014; Roengpitya et al., 2017). However, for some banking business models it occurred more than for others.

During the pre-crisis period, a substantial amount of retail banks increased their share of wholesale funding to a point that they could be re-classified as wholesale banks. The opposite trend is witnessed in the period during the crisis when a substantial amount of the wholesale banks worldwide migrated to the retail business model (Roengpitya, Tarashev, and Tsatsaronis, 2014; Roengpitya et al., 2017). Another worldwide trend is that before and during the crisis nearly none of the retail and wholesale banks migrated towards the investment business model and vice versa, showing a higher persistence of the investment business model (Ayadi, Arbak, and De Groen, 2012; Roengpitya et al., 2017).

Roengpitya, Tarashev, and Tsatsaronis (2014) empirically showed that banks that migrated to another business model, regardless of their original and new business model, did not report significantly higher profits in the majority of the cases. Assuming that migration to another business model is a conscious decision, this could imply that the decision to migrate to another business model has been made from a regulatory perspective and not from a profit perspective.

2.2.4 Quantification of banking business models

Now that the concept of banking business models is clear, the next question that arises is how to quantify banking business models. There are three methods used in literature studies that try to quantify business models: consultation of databases, factor analysis, and statistical clustering.

Databases

The first method to derive a bank's business model is by consulting existing databases. This method is followed by e.g. Martel, Rixtel, and González Mota (2012) who consult Bankscope. The advantage of this method is that it is easy and quick. However, the disadvantage is that the classification method of the databases is not transparent and that not all business models are properly identified. For example, Bankscope does not distinguish between retail and wholesale banks but classifies them together as commercial banks (Martel, Rixtel, and González Mota, 2012).

Factor analysis

The second method is factor analysis. In this method, individual business model characteristics are used to describe the underlying banking business model and directly relating them to bank performance. Examples of these individual business model characteristics that are used in literature are share of non-deposit funding (e.g. Demirgüç-Kunt and Huizinga (2010)), income diversification (e.g. Mergaerts and Vander Vennet (2016)), wholesale funding ratio (e.g. Altunbas, Manganelli, and Marques-Ibanez (2011)) and gross derivative position (e.g. Prabha and Wihlborg (2014)).

The advantage of this method is that the individual characteristics do not leave much room for interpretation (Altunbas, Manganelli, and Marques-Ibanez, 2011). The disadvantage of this method is that it is not clearly defined how the individual characteristics are interrelated to constitute the underlying business model since it produces continuous variables instead of discrete groups (Mergaerts and Vander Vennet, 2016).

Statistical clustering

The third method is statistical clustering. Statistical clustering combines the information from a set of variables to construct discrete groups that are as homogeneous as possible (Ayadi, Arbak, and De Groen, 2012).

One of the disadvantages of this method is that it requires inexact science because it depends on the definition used, choice of instruments and choice of procedures (Ayadi et al., 2016). Additionally, the method relies on the assumption that clearly separable business models exist and that no intermediate strategies are possible (Mergaerts and Vander Vennet, 2016).

Figure 2.1 shows statistical clustering results of empirical studies. What is conspicuous are the results of Farnè and Vouldis (2017), who find different clusters as well as significantly different performances of the clusters compared to the other studies. This may be caused by the fact that they were the only study that did not control the dataset for asset size. This is also reflected in the fact that their business model descriptions are, more than in the other studies, dominated by size. Additionally, it is the only study that used a dataset containing data of one year instead of multiple years. Except for Farnè and Vouldis (2017), all studies are able to identify at least the three banking business models as described in Section 2.2.2. Additionally, some universal/diversified business models are identified that can be placed somewhere between the retail and investment business models.

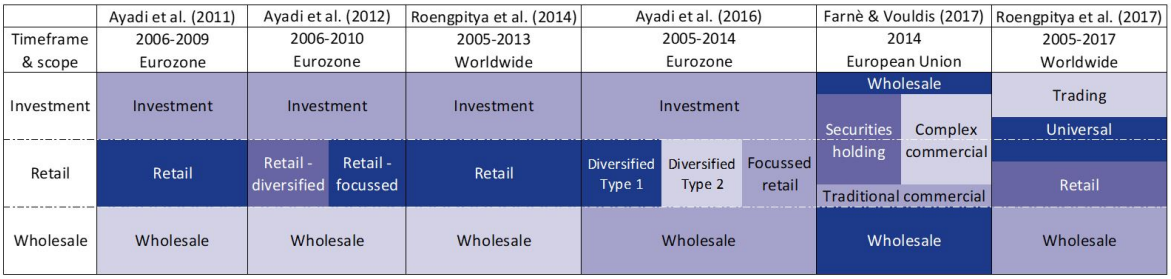


FIGURE 2.1: Comparison clustering literature
This figure shows statistical clustering results of empirical studies. It shows how the clusters relate to each other and to the three business models as described in Section 2.2.2. The business model with the darkest colour is the best performing business model according to that study, and for the lightest colour the opposite holds.

2.3 Bank performance measures

Bank performance can be measured in terms of risk and return. In this section, the most common risk and return performance categories will be explained.

2.3.1 Return

Net Interest Income

The NII is the difference between interest income and interest expenses, therefore it focusses mainly on the traditional banking activities. NII is the main source of income for all banks regardless of their business model and is calculated by adding up all the positive and negative interest cash flows over the period under inspection (Hull, 2012). This is often done over a short-term period (one to three years) (Hull, 2012). The NII is used in various recent studies to measure bank performance (e.g. Ayadi et al. (2016) and Farnè and Vouldis (2017)).

Return on Equity

RoE is the profit of a bank as a share of the total equity (Hull, 2012). It is an indicator of the benefits of shareholders, therefore RoE is an important measure of performance (Hillier et al., 2014). This is backed up by the fact that it is used by various studies regarding bank performance (e.g. Ayadi et al. (2016), Farnè and Vouldis (2017), and Roengpitya et al. (2017)).

Return on Assets

The RoA is the profit of a bank as a share of total asset. It is calculated by dividing net income by total assets (Hull, 2012). Just like RoE, RoA is also a commonly used performance measure (e.g. Ayadi, Arbak, and De Groen (2011), Mergaerts and Vander Vennet (2016), and Roengpitya, Tarashev, and Tsatsaronis (2014)).

2.3.2 Risk

Basel III capital regulations

In Basel III the sum of the capital has to be at least 10.5% of the risk-weighted assets supplemented with an individual risk premium (IRP). This Total Capital requirement is defined by the (BCBS, 2011) as follows

$$Total\ Capital\ Ratio = \frac{Tier\ 1 + Tier\ 2\ Capital}{Risk\ Weighted\ Assets} \geq 10.5\% + IRP \tag{1}$$

IRPs apply to banks that have a G-SIB or D-SIB status[1]. The IRP can vary between 0.25% and 3.5% and is decided by the BCBS (in the case of G-SIBs) or by national regulators (in the case of D-SIBs) (Hull, 2012).

Another capital-related measure introduced in Basel III is the Leverage Ratio. The Leverage Ratio aims to decrease excessive leverage. To comply with the Leverage Ratio requirement, the amount of Tier 1 capital should always be more than 3% of the total assets. The Leverage Ratio requirement is defined by the (BCBS, 2011) as follows

$$Leverage\ Ratio = \frac{Tier\ 1\ Capital}{Total\ Assets} \geq 3\% \tag{2}$$

Basel III liquidity regulations

To promote resilience of banks to liquidity shocks and to manage liquidity risk, Basel III introduces two liquidity standards; the Liquidity Coverage Ratio (LCR) (BCBS, 2013) and the Net Stable Funding Ratio (NSFR) (BCBS, 2014).

The LCR promotes short-term resilience and prescribes the amount of high quality liquid assets (HQLA) required to cover for a 30-day stress period. HQLA are low-risk and can be converted into cash easily. To calculate the net cash outflow, the cash inflow (up to 75% of the cash outflow) is subtracted from the cash outflow. To meet the LCR requirement, the amount of HQLA should completely cover the total net cash outflow in the 30-day stress period. The LCR requirement is defined as follows:

$$LCR = \frac{Stock\ of\ HQLA}{Total\ net\ cash\ outflow\ over\ the\ next\ 30\ calendar\ days} \geq 100\% \tag{3}$$

The LCR requirement is implemented stepwise and banks completely have to meet the LCR requirement since the beginning of 2019.

The NSFR promotes a stable funding profile that is in line with the required stable funding. This means that in order to meet the NSFR requirement, the available amount of stable funding should completely cover the required amount of stable funding for a time horizon of one year. The NSFR requirement is defined as follows

$$NSFR = \frac{Available\ amount\ of\ stable\ funding}{Required\ amount\ of\ stable\ funding} \geq 100\% \tag{4}$$

The NSFR was implemented on the 1st of January, 2018 (BCBS, 2014).

Economic Value of Equity

A measure that reflects performance in terms of long-term economic value is the ΔEVE. The EVE is the amount of future earnings capacity that is residing in the balance sheet of the bank (Payant, 2007) and is calculated by adding up all the present values of positive and

[1]G-SIB and D-SIB stand for global systemically important bank and domestic systemically important bank, respectively. The systemic importance of a bank is dependent on the effect that its default could have on the global or domestic financial system.

negative cash flows from existing activities based on a run-off balance sheet assumption (BCBS, 2016).

The ΔEVE measures the sensitivity of this future earnings capacity for shocks in interest rates. These shocks can be parallel and non-parallel. The ΔEVE formula is defined as follows

$$\Delta EVE_i = \sum_{1}^{k} CF_0(t_k) * DF_0(t_k) - \sum_{1}^{k} CF_i(t_k) * DF_i(t_k) \tag{5}$$

where *CF* is the cash flow, *DC* is the discount factor, t_k is the time bucket midpoint, scenario *0* is the base scenario and scenario *i* is the shocked interest rate scenario.

Banks are required to report their risk appetite regarding the ΔEVE (BCBS, 2016). It is not possible to optimize earnings risk (related to NII) and economic risk (related to EVE) at the same time (Hull, 2012). Therefore, this metric ensures that managers do not optimize their short term returns at the expense of the future earnings capacity (Hull, 2012).

Altman's Z-score

Another more comprehensive way used to calculate risk performance in literature is Altman's Z-score. The Z-score is an estimate of a bank's distance to default and is used in various studies to indicate risk performance of a bank (e.g. Demirgüç-Kunt and Huizinga (2010) and Köhler (2015)). The Z-score was first developed by Altman (1968) and uses discriminant analysis to predict defaults based on five accounting ratios. After the introduction of Altman's Z-score, the methodology has been revised, extended and improved (Hull, 2012) and various forms of the Z-score are used, e.g. Z-score based on market data instead of accounting data (e.g. Prabha and Wihlborg (2014) and incorporation of more accounting ratios (e.g. Pompe and Bilderbeek (2005)).

The detailed explanation and underlying formulas for all risk metrics covered by this section can be found in Appendix A

2.4 Stress testing

Stress testing is the evaluation of how financial institutions would perform under extreme, yet plausible, scenarios. Mechanistic risk measures like Value at Risk and Expected Shortfall are backward looking, they do not include scenarios that did not occur yet. Stress testing tries to overcome this weakness (Hull, 2012).

Bank managers have little incentives to create extreme scenarios because banks want to keep their regulatory capital as low as possible. Therefore, regulators themselves often provide the stress scenarios (Hull, 2012). One of these stress tests provided by regulators is the EU-wide stress test created by the EBA in cooperation with the European Systemic Risk Board (ESRB). All banks under the authority of the EBA with systemic importance are subjected to it. According to the EBA, "The EBA's EU-wide stress tests are conducted in a bottom-up fashion, using consistent methodologies, scenarios, and key assumptions developed in cooperation with the ESRB, the European Central Bank (ECB) and the European Commission" (EBA, 2019).

Chapter 3

Model

To meet the research goals, we have built a model in Excel that predicts banking performance in terms of risk and return considering the regulations of Basel III. The model takes the balance sheet composition, and associated characteristics, and transforms them over time based on a stress test scenario. The model can be applied to any bank regardless of their business model or balance sheet composition.

We chose to use stress testing in the model because it tests banks in an extreme situation and will therefore give a clear insight into the differences between banks. We will use the EBA stress test to integrate market risk and interest rate risk in the model because the study region of our research is the same as the scope of the EU-wide stress test and some banks in the samples are subjected to the EBA stress test. Since the actual results of the EBA stress test have already been published, these can be used to make a comparison with the results of the model. This will be done in Chapter 5.

In this chapter we will describe the components, procedures, and input of the model. This will answer the following sub-question:

Which components, procedures, and input are needed to construct a model that measures banking performance in terms of risk and return while considering the regulations of Basel III?

3.1 Components

The components that are modelled are asset and liability classes of the balance sheet. Therefore, we distinguished eight general asset and ten general liability classes, shown in Table 3.1. These asset and liability classes are common balance sheet classes for banks. The exact definition of all asset and liability classes can be found in Appendix B.

The asset and liability classes are divided into several sub-classes. The classes can be divided based on initial maturity, credit rating and loan-to-value (LTV). Since it is not workable and desirable to include all possible subclasses in the model, we made a selection. The choice for the different subclasses is an interplay, and sometimes a trade-off, between functionality, completeness, workability, and information that is needed to determine the risk and return performance. This has resulted in the creation of 40 asset classes and 19 liability classes; the complete set of subclasses and the assumptions about the model components can be found in Appendix C. For each asset and liability class there are five remaining maturity buckets, as shown in Appendix F.

TABLE 3.1: Balance sheet classes included in the model

Balance sheet	
Assets	Liabilties & Equity
1. Residential mortgage loans	1. Current retail deposits
2. Other retail loans	2. Saving retail deposits
3. Corporate loans	3. Term retail deposits
4. Bank loans	4. Corporate deposits
5. Bonds	5. Bank deposits
6. Trading assets	6. Debt securities
7. Cash	7. Trading liabilities
8. Other assets	8. Subordinated liabilities
	9. Other liabilities
	10. Equity

3.2 Scenarios

In the model we will test two scenarios: the base scenario and the stressed scenario. In the base scenario[2] the balance sheet exposures, remaining maturities, and interest rates are assumed to stay constant over time and no risks will be considered. This scenario will show the risk-free risk-return performance. In the stressed scenario, the developments of the exposures and interest rates are assumed to change over time. The changes are based on credit risk, interest rate risk and market risk scenarios. The credit risk scenarios are derived from the PD estimations and the market risk and interest rate risk scenarios are derived from the EBA stress test scenarios. This scenario will show the stressed risk-return performance.

The EBA prescribes a static balance sheet assumption for the EBA stress test. Which means that when an exposure matures, it should be replaced by a similar financial instrument (EBA, 2018a). When an asset matures revaluation of the interest rate or principal can take place, otherwise the rates of the previous revaluation are used. An asset matures when the remaining maturity bucket that it resides in matures. Each bucket matures at its midpoint.

The remainder of this section describes how credit risk, market risk, and interest rate risk are included in the stressed scenario.

3.2.1 Credit risk

The impact of credit risk on the asset exposures over time is based on the PDs. For every asset class subjected to credit risk, a yearly PD needs to be given by the user. This is calculated into a monthly PD and the resulting exposure loss in month t caused by credit risk is calculated as follows

$$Exposure\,loss_{t,cr} = Exposure_{t-1} * PD_{month} \tag{6}$$

3.2.2 Interest rate & market risk

The scenarios for market risk and interest rate risk are derived from the adverse scenario of the EBA stress test. The adverse scenario starts with a shock to bond yields and equity

[2]The base scenario in this research is not the same as the baseline scenario in the EBA stress test.

TABLE 3.2: Eurozone rates 2018 EU-wide stress test

Rates	2017 *(t=0)*	2018 *(t=12)*	2019 *(t=24)*	2020 *(t=36)*	
Interest rates	1.1%	1.9%	2.2%	2.5%	Absolute
Interest rates growth rate	0%	+72.73%	100%	+127.27%	Relative to *t=0*
EURIBOR – overnight	-0.37%	0.09%	0.22%	0.48%	Absolute
EURIBOR – 6M	-0.30%	0.29%	0.39%	0.59%	Absolute
EURIBOR – 1Y	-0.24%	0.39%	0.50%	0.70%	Absolute
Residential real estate prices	100%	91.80%	83.91%	83.49%	Relative to *t=0*
Stock prices	100%	68.60%	71.30%	77.40%	Relative to *t=0*

prices in global financial markets. This results in domestic confidence shocks triggered by global turmoil. Several macro-economic variables are included in the scenarios, like Gross Domestic Product (GDP), inflation, unemployment, asset prices, and interest rates. In Appendix D, an extensive summary of the adverse scenario of the EBA stress test can be found. The EBA stress test covers a 36-month period, starting from January 1st, 2018 and ending on December 31st, 2020 (ESRB, 2018). Therefore, the time frame of the model is also set to these dates. An overview of the monthly rates from the adverse scenario that are used in the model can be seen in Table 3.2. All the monthly rates between *t=0*,*t=12*,*t=24* and *t=36* are calculated based on linear interpolation, as prescribed by the EBA (EBA, 2018a).

The interest rate growth and EURIBOR rates are used to determine the interest rate risk scenarios. When an asset or liability matures, the interest rates are revalued by multiplying the interest rates at *t=0* with the interest growth rate of the corresponding month. For the interest rate revaluation of the classes bank loans and bank deposits, the absolute monthly EURIBOR rates are directly copied when these classes mature.

The residential real estate prices and stock prices are used to determine the market risk scenarios. If real estate prices decrease, the average LTV increases, therefore the residential real estate prices determine how the mortgage exposures are divided between the LTV classes. In the model, it is assumed that the LTVs of individual mortgages are equally distributed along the LTV range. This means that if the real estate prices decrease with x%, that x% of the exposure of a mortgage asset class is transferred to a similar class with a higher LTV classification if it matures in that month. The trading asset and trading liability classes are revalued when they mature, meaning that if a trading asset or liability matures at time t, that the exposure of that class at time t is calculated by multiplying the exposure at *t=0* by the stock price relative to *t=0*. For example, if a trading asset first matures at *t=12*, the exposure at *t=0* is multiplied with 68.60%. The difference between the exposures at t and *t-1* is the exposure loss caused by revaluations in month t.

3.3 Return metrics

To measure return, we include the NII and a profit function in the model. The calculation of the NII is described in Section 2.3.1. The NII is also included in the profit function, however, we chose to report is separately because it is the most important source of income for all banks, regardless of their business model. Since the data is controlled for size the RoE cannot be calculated and the result of the profit function is equal to the RoA. The profit derived between *t-1* and t is in the model defined as follows

$$Profit_t = NII_t + NTI\% * TBSize_t - OperExp * TotalAssets_{t=0} - ExpLoss_t \tag{7}$$

where NII_t is the NII derived between *t-1* and *t*, *NTI%* is the net trading income (NTI) percentage and is a constant, $TBSize_t$ is the average trading book size between *t-1* and *t*, *OperExp* is the operating expenses percentage and is a constant, $TotAssets_{t=0}$ is the total assets at *t=0*, and $ExpLos_t$ is the Exposure loss between *t-1* and *t* caused by defaults and revaluations as described in Section 3.2.2

We chose to only include NII and NTI as sources of income in this profit function, where in reality there are more sources of income for banks. These other sources of income are excluded from this model because they are hard to predict from only the balance sheet. Additionally, these other sources of income have proven to be very volatile, especially under stressed conditions (Ayadi, Arbak, and De Groen, 2011; Ayadi, Arbak, and De Groen, 2012). To illustrate; some banks under investigation of Ayadi, Arbak, and De Groen (2011) saw their non-interest income vanish almost completely during the recent crisis years.

The retained earnings resulting from the profit are reimbursed monthly. When profit is positive, tax and dividends are paid, which is not the case is profit is negative. The retained earnings are added to (in case of profit) or subtracted from (in case of loss) the cash and equity position of the bank. The retained earnings between *t-1* and *t* are calculated as follows

$$Retained\ earnings_t = \begin{cases} Profit_t & \text{if } Profit_t \leq 0 \\ Max(0, Profit_t * (1 - Tax) - Div * Equity_t & \text{if } Profit_t > 0 \end{cases} \tag{8}$$

where *Tax* is the tax rate percentage and is a constant, *Div* is the dividend percentage and is a constant, and $Equity_t$ is the total equity at time *t*.

The variables *Div* and *OperExp* could also be reported as percentage of turnover. However, under stressed conditions turnover drops drastically. Banks are not able to reduce their operating expenses by a similar amount since they have for example employees and properties that they cannot get rid of on short notice. As for dividends, banks are often not willing to reduce their dividends because of the signalling theory[3], which is proven to be applicable for banks by Aivazian, Booth, and Cleary (2003). Therefore, to replicate the pressure that banks endure under stressed conditions as accurately as possible, we chose to report *Div* and *OperExp* as a percentage of total equity and total assets, respectively.

3.4 Risk metrics

The model calculates the monthly risk position of the bank by calculating the LCR, NSFR, Leverage Ratio and Total Capital Ratio[4] position for *t=1* to *t=36*. The exact formulas for these ratios can be found in Appendix A. In some calculations, risk weights apply to subclasses. But since a trade-off is made between the included subclasses, not all risk weights included in these ratios can be unambiguously applied to each of the asset and liability subclasses.

[3]The signalling theory states that dividends are a tool to signal information to investors. It gives investors an indication about a firm's own thoughts on their results or prospects (Black, 1976). Therefore managers will only raise dividends if the economic prospects are good enough to maintain the new dividend level for some time and will only lower dividends if the economic prospects for a quick recovery are poor (Simiyu, 2014)

[4]For the Total Capital Ratio, the IRP (as described in Section 2.3.2) is not included in the model

Therefore, a trade-off is made and the weights that are most suitable to the included asset and liability subclasses are applied.

Additionally, the ΔEVE is calculated to complete the risk position. The ΔEVE is calculated based on the exposures and interest rates at *t=36* and under the assumption of a run-off balance sheet, meaning that matured assets and liabilities are not replaced. To calculate the ΔEVE, the EVE is computed twice; one time for the stressed or base scenario as described in Section 3.2 and one time for the same scenario but with a parallel +200 basis point (bp) shock applied to the interest rates. Then the EVE of the shocked interest rate scenario is subtracted from the EVE of the non-shocked scenario. The BCBS prescribes that the cash flows included in the calculations should be discounted using either 'a risk-free rate or a risk-free rate including commercial margins and other spread components (only if the bank has included commercial margins and other spread components in its cash flows)' (BCBS, 2016, p. 15). In our research, we chose to use the risk-free rate including commercial margins and spread components.

3.5 Migration analysis

To investigate how the bank under investigation can improve its business model, we performed a migration analysis. In Chapter 2 we described that if a bank moves to another business model this is called migration. However, in reality, it is not realistic for most banks to migrate towards a completely different business model on short notice. Therefore, migration in this analysis is seen as a moderate movement towards business-model-typical activities of a certain business model at the expense of business-model-typical activities of another business model, for example, more retail activities at the expense of investment activities. The model analyses the bank's sensitivity to these migrations. The migration analysis can be best described as:

How does the risk-return performance change when i% more X activities are performed at the expense of Y activities?

Where *i=[0.1%,0.2%,...,9.9%,10%]*, *X* can be 'retail', 'wholesale' or 'investment', and *Y* can be 'retail', 'wholesale', 'investment', 'retail & wholesale', 'retail & investment' and 'investment & wholesale'. The business model that is chosen for *X* cannot be (partly) included in *Y*. Table 3.3 shows the business-model-typical activities per business model, based on the balance sheet components described in Section 3.1. In the analysis, the amounts that are being migrated will be subtracted or added proportionally among the subclasses, meaning that the maturity, credit and LTV profile stay intact. Costs related to changing the composition of the balance sheet are not taken into account.

TABLE 3.3: Business-model-typical activities per banking business model

	Assets	Liabilities
Retail activities	- Residential mortgage loans - Other retail loans	- Current retail deposits - Savings retail deposits - Term retail deposits
Wholesale activities	- Corporate loans - Bank loans	- Corporate deposits - Bank deposits
Investment activities	- Bonds - Trading assets	- Debt securities - Trading liabilities

3.6 Input

Based on the components and procedures described the previous sections of this chapter, the following balance sheet figures at *t=0* are needed in the model[5]:

- The exposures for the 40 asset and 19 liability classes;
- The remaining maturity distribution per applicable asset and liability class among the maturity buckets. Remaining maturity applies to all asset and liability classes except *other assets*, *other liabilities* and *equity*;
- The interest rates per applicable asset and liability class. Interest rates apply to all asset and liability classes except *bank loans*, *trading assets*, *other assets*, *bank deposits*, *trading liabilities*, *other liabilities* and *equity*;
- The PDs per applicable asset class. PDs apply to all asset classes except *cash* and *other assets*.

Additional input figures that are needed are the assumptions on which the profit function is based:

- Trading income as percentage of the trading book;
- Dividend pay-out ratio as percentage of equity;
- Tax rate as percentage of total profit before taxes;
- Operating expenses as percentage of total assets at *t=0*.

[5]The model has been created under the assumption that at *t=0* the market value is equal to the par value for both the balance sheet exposures and the interest rates.

Chapter 4

Business model analysis

In the previous chapter, we described the model that measure banking performance in terms of risk and return, while considering the regulations of Basel III. The model can be used to analyse the risk-return performance of any bank. To explain how the model will be used in our research, this chapter will answer the following sub-question:

How can the model be used to analyse business model performance and business model improvements?

For this research, we will draw up three balance sheets profiles of banks, one per banking business model that is described in Section 2.2.2. This will be done based on three samples which consist of banks with the same business model. These samples will be used to create an average balance sheet profile per banking business model. These three balance sheet profiles will serve as input for the model. This chapter will explain and discuss the business model classification method used in this study, the sample selection, summary statistics of the samples, the resulting average balance sheet compositions per banking business model and how this will be inputted in the model.

4.1 Business model classification method

In order to create distinct samples of banks per business model, we need to select an appropriate method to classify which bank has which business model. As explained in Section 2.2.4, there are three methods used in banking business model literature; via databases, factor analysis, and statistical clustering. Of these three methods, the factor analysis method is least appropriate for this study because it does not result in discrete groups of business models. Additionally, the database method is also not suitable because it does not identify between retail and wholesale banks and the underlying methodology is unclear. Statistical clustering results in discrete business model groups and is able to identify several banking business models. Therefore, the clustering method is the most suitable business model classification method for our thesis.

Since the statistical clustering method is very time consuming and out of the scope for our research, we use the clustering results of the most relevant study to derive a business model classification for this study. The most relevant study from the studies described in Figure 5.10 is found to be the research of Ayadi et al. (2016) since it has the same geographical scope as our research and is currently the most recent study in the field. Before we explain our method, first a summary of the results of Ayadi et al. (2016) is given.

4.1.1 Ayadi et al. (2016) methodology

In Ayadi et al. (2016), the following seven balance sheet indicators are used for the business model clustering: three from an asset standpoint and four from a liability standpoint.

Asset balance sheet indicators:

- *Customer loans (as % of assets)*, which is defined as the sum of loans, advances, and receivables to customers divided by total assets.
- *Bank loans (as % of assets)*, which is defined as loans, advances, and receivables to banks and other financial institutions divided by total assets.
- *Trading assets (as % of assets)*, which is defined as the sum of all non-cash assets except for intangible assets, customer and bank loans, divided by total assets.

Liability balance sheet indicators:

- *Customer deposits (as % of assets)*, which is defined as the sum of all sorts of deposits to customers divided by total assets.
- *Bank deposits (as % of assets)*, which is defined as the sum of all sorts of deposits to banks and other credit institutions divided by total assets.
- *Derivative exposure (as % of assets)*, which is defined as the sum of all negative derivative exposures at fair value divided by total assets.
- *Debt liabilities (as % of assets)*, which is defined as the sum of non-equity liabilities other than derivative exposure, customer and bank deposits divided by total assets.

Ayadi et al. (2016) identify five banking business models with statistical clustering: the focused retail, diversified retail type I, diversified retail type II, wholesale and investment business model. For our research, we will only focus on the focused retail, wholesale and investment business models. This is done for two reasons. First, these three business models are clearly distinguished in nearly all academic literature, in contrast to the two diversified retail business models. Second, the three retail business models are rather similar and therefore the method described in Section 4.1.2, which is a derivative from the method and results of Ayadi et al. (2016), might not be accurate enough to distinguish these three business models. The descriptive statistics for all indicators per business model in Ayadi et al. (2016) are given in Table 4.1.

TABLE 4.1: Statistical clustering results Ayadi et al. (2016)

		Asset indicators			Liability indicators			
		Customer loan	Bank loans	Trading asset	Customer deposit	Bank liabilities	Derivative exposure	Debt liabilities
Retail	Mean	78.5%	7.0%	11.8%	69.5%	12.3%	0.3%	10.1%
	SD	7.9%	5.7%	7.1%	15.3%	14.1%	0.8%	7.8%
Wholesale	Mean	20.7%	52.2%	17.1%	51.8%	22.4%	0.8%	10.4%
	SD	15.1%	20.1%	12.6%	32.1%	26.5%	2.6%	19.3%
Investment	Mean	23.5%	11.4%	60.2%	49.3%	14.9%	5.2%	19.9%
	SD	13.3%	9.2%	15.8%	31.1%	18.9%	12.5%	21.4%

This table shows the results of the statistical clustering exercise of Ayadi et al. (2016). It shows the mean and standard deviation per banking business model and per business model indicator, described in percentage points.

4.1.2 Business-model-score methodology

For our study, we created the business-model-score methodology, which is a derivative from the methodology an results of Ayadi et al. (2016). To classify a bank's business model, seven business model indicators described by Ayadi et al. (2016) are calculated based on data from the bank's annual report of 2017. For all seven indicators, the Z-score is calculated with the standard deviations (SDs) and mean indicator scores of the business model as described in Table 4.1. Then the Z-scores are summed per business model and this results in the business model score. The business-model-score formula is defined as follows

$$Business\ model\ score_x = \sum_{i=1}^{7} \frac{\sqrt{(Mean_{x,i} - Indicator\ score\ bank_i)^2}}{SD_{x,i}} \tag{9}$$

where x is one of the three banking business models, i is one of the seven business model indicators, $Mean_{x,i}$ is the mean reported in Ayadi et al. (2016) for business model indicator i and business model x, $Indicator\ score\ bank_i$ is the score of the bank under inspection for business model indicator i, and $SD_{x,i}$ is the standard deviation reported in Ayadi et al. (2016) for business model indicator i and business model x. For all three business models, a score is calculated and the business model that returns the lowest score is the business model of the bank.

To illustrate the classification method described above, the classification of De Volksbank is shown as a numerical example. First, the indicator scores for all seven indicators are calculated, based on the 2017 annual report of De Volksbank. Then Equation (9) is applied to all three business models. An example of this application for the retail business model is shown below

$$Business\ model\ score_{retail} = \frac{\sqrt{(0.785 - 0.81)^2}}{0.079} + \ldots + \frac{\sqrt{(0.101 - 0.105)^2}}{0.078} = 2.38 \tag{10}$$

Table 4.2 shows De Volksbank's business model score for the three business models. In this case, the retail business model gives the lowest business model score and therefore De Volksbank is classified as a retail bank.

As can be seen in Table 4.1, for the indicator derivative exposure, the data of Ayadi et al. (2016) are very skewed for the investment business model. This has resulted in a very high standard deviation, especially when compared to the standard deviation of derivative exposure of other business models. In the business-model-score methodology, this would lead to very skewed results with excessive weight on derivative exposure. Therefore, the three standard deviations of the indicator derivative exposure are replaced with the standard deviation of the entire sample of Ayadi et al. (2016), which is 4.4%.

TABLE 4.2: Business-model-score methodology – numerical example

	Asset indicators			Liability indicators				
	Customer loans	Bank loans	Trading assets	Customer deposits	Bank deposits	Derivatives exposure	Debt liabilities	Business model score
Indicator scores	81.0%	4.3%	11.1%	76.9%	4.4%	2.1%	10.5%	
SDs to retail	0.32	0.47	0.10	0.49	0.56	0.40	0.05	2.38
SDs to wholesale	3.99	2.38	0.48	0.78	0.68	0.29	0.00	8.61
SDs to investment	4.32	0.77	3.11	0.89	0.56	0.71	0.44	10.80

4.2 Sample

4.2.1 Sample selection

Per business model, a sample of 10 banks is created. First, banks are randomly selected from all listed banks in the Eurozone other than central banks, then they are classified and if the sample restrictions are met, they are added to the appropriate business model sample until each sample is filled with 10 banks. If a sample is already full and an additional bank is classified with the same business model, the latter is discarded. The following four sample restrictions are in place:

1. The sample should not contain banks that have the same parent company or banks that are subsidiaries from one another, regardless of their business models, to reduce correlation within and between the samples.
2. Per business model sample, no more than three banks from the same country are allowed and in the complete sample, no more than five banks from the same country are allowed. This is arbitrarily chosen and included because the sample should be a proper representation of the whole geographical area covered by the study.
3. Banks that do not have a publicly available annual report or only have a summarized balance sheet available are excluded from the sample. Even though the summarized balance sheet often provides enough information to calculate the seven indicators, it does not provide the information that is needed to construct the input as described in Section 4.3.
4. A bank for which the difference between the lowest business model score and the second-lowest business model score is less than 1, is excluded from the sample. This is done because our business-model-score methodology is a derivative from the statistical clustering method, therefore our method is not perceived as accurate enough when business model scores are that close.

4.2.2 Descriptive statistics

This has resulted in three samples with each 10 banks. The descriptive statistics of our samples can be seen in Table 4.3, as well as the descriptive statistics of the sample of Ayadi et al. (2016). The entire list of banks in the sample, as well as the appointed business model, the indicator scores and the country of residence per bank, can be found in Appendix E.

When comparing the means of the different business model samples of our research, the results are in line with how the business models are described in Section 2.2.2. The investment business model has a considerable amount of trading assets and derivative exposure, the retail business model has a large amount of consumer loans and deposits and the wholesale business model has a substantial amount of bank loans and bank deposits. The only remarkable point is that the mean for debt liabilities, which is considered an investment activity, is higher in the wholesale sample than in the investment sample. This indicates that the banks in the wholesale sample have a considerable amount of trading activities, however, their share in the wholesale market is substantial which still classifies them as wholesale banks.

When comparing the means of the business model samples of our research to the means of the business model samples of (Ayadi et al., 2016), it can be seen that the banks in the non-retail business model samples in our research on average have moved towards a higher

TABLE 4.3: Descriptive statistics sample - business model indicators

Panel A – Retail business model sample								
	Research sample				Ayadi et al. (2016) sample			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Customer loans	75.7%	8.0%	61.9%	91.7%	78.5%	7.9%	54.9%	99.2%
Bank loans	3.5%	2.5%	0.0%	6.8%	7.0%	5.7%	0.0%	40.2%
Trading assets	14.9%	4.9%	7.5%	26.5%	11.8%	7.1%	0.1%	27.8%
Customer deposits	72.1%	7.1%	56.5%	80.1%	69.5%	15.3%	0.0%	98.3%
Bank deposits	9.9%	4.4%	3.1%	17.6%	12.3%	14.1%	0.1%	34.5%
Debt liabilities	9.4%	7.8%	2.7%	31.4%	10.1%	7.8%	0.0%	92.3%
Derivative exposure	1.0%	1.2%	0.0%	2.8%	0.3%	4.4%	0.0%	16.0%
Panel B – Wholesale business model sample								
	Research sample				Ayadi et al. (2016) sample			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Customer loans	38.6%	28.7%	0.0%	73.5%	20.7%	15.1%	0.0%	55.7%
Bank loans	33.6%	18.2%	14.6%	66.7%	52.2%	20.1%	0.0%	100.0%
Trading assets	23.2%	14.4%	1.2%	45.4%	17.1%	12.6%	0.0%	52.7%
Customer deposits	25.6%	20.0%	0.0%	63.5%	0.8%	4.4%	0.0%	97.5%
Bank deposits	31.0%	24.9%	1.6%	88.9%	51.8%	32.1%	0.0%	99.8%
Debt liabilities	36.3%	31.0%	2.0%	91.4%	10.4%	19.3%	0.0%	98.1%
Derivative exposure	2.9%	4.3%	0.0%	14.2%	22.4%	4.4%	0.0%	38.4%
Panel C – Investment business model sample								
	Research sample				Ayadi et al. (2016) sample			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Customer loans	51.4%	7.1%	33.3%	62.1%	23.5%	13.3%	0.0%	48.0%
Bank loans	6.5%	3.3%	1.1%	12.5%	11.4%	9.2%	0.0%	40.9%
Trading assets	35.8%	6.9%	27.6%	52.4%	60.2%	15.8%	21.2%	100.0%
Customer deposits	49.8%	16.4%	12.5%	69.7%	49.3%	31.1%	0.0%	97.3%
Bank deposits	14.7%	9.4%	6.9%	40.6%	14.9%	18.9%	0.0%	100.0%
Debt liabilities	19.2%	6.9%	9.4%	30.9%	19.9%	21.4%	0.0%	97.7%
Derivative exposure	10.2%	8.8%	1.2%	29.9%	5.2%	4.4%	0.0%	90.8%

This table shows the mean, standard deviation, minimum, and maximum value per balance sheet indicator for the samples of our research and the samples of (Ayadi et al., 2016). Panel A, B, and C represent the retail, wholesale, and investment business model samples, respectively. The definition of all the indicators included can be found in Section 4.1.1 and the complete sample can be found in Appendix E.

share of retail activities. This indicates that there are fewer 'pure' investment or wholesale banks. This is in line with the new reality and regulations that banks face nowadays and the collective shift of European banks towards retail activities, as explained in Section 2.2.3.

4.2.3 Bank size

As explained in Section 2.2.4, size is an unwanted dominant factor when performing the statistical clustering method to classify banking business models. Because our research focusses on banking activities rather than size, the sample is controlled for total asset size. Nevertheless, this section gives a brief analysis of the sizes of the in the samples. The descriptive statistics of the sizes can be found in Table 4.4. The total asset size and G-SIB/D-SIB status per bank in the samples can be found in Appendix E.

Regarding the sizes of G-SIB/D-SIB banks, G-SIBs have on average the highest total assets, they are followed by D-SIBs and lastly, other banks have on average the lowest total assets. Additionally, also differences in size per business model can be observed. In the investment bank sample, all banks have either a G-SIB or D-SIB status, while in the retail and wholesale bank samples, only 4 and 5 banks have a G-SIB/D-SIB status, respectively. Investment banks also have the highest average total assets. Additionally, the data of the wholesale and retail samples are skewed and both dominated by one bank. This is not the case for the investment sample.

TABLE 4.4: Descriptive statistics sample - size

€bn		Total	G-SIB	D-SIB	Other
Total	Count	30	4	15	11
	Mean	€ 274.37	€ 1283.75	€ 186.52	€ 27.11
	Min	€ 1.10	€ 836.79	€ 23.15	€ 1.10
	Max	€ 1763.20	€ 1763.20	€ 796.86	€ 71.33
Retail	Count	10	0	4	6
	Mean	€ 94.08	€ -	€ 195.18	€ 26.67
	Min	€ 1.10	€ -	€ 23.60	€ 1.10
	Max	€ 602.99	€ -	€ 602.99	€ 71.33
Wholesale	Count	10	1	4	5
	Mean	€ 226.91	€ 1763.20	€ 91.92	€ 27.64
	Min	€ 4.00	€ 1763.20	€ 25.71	€ 4.00
	Max	€ 1763.20	€ 1763.20	€ 214.52	€ 70.45
Investment	Count	10	3	7	0
	Mean	€ 502.12	€ 1123.94	€ 235.63	€ -
	Min	€ 23.15	€ 836.79	€ 23.15	€ -
	Max	€ 1275.13	€ 1275.13	€ 796.86	€ -

This table shows the mean, minimum, and maximum value of the total asset sizes of the banks in the samples. Additionally, the table shows how many banks have a G-SIB/D-SIB status. Total assets are displayed in billions of euros.

4.3 Input model

Now that the samples per business model have been created, the data of banks in the samples are used to construct an average balance sheet composition per business model, which is used as the input for the model. This section explains how the input is constructed, where the data is gathered and which scenarios were run in the migration analysis.

4.3.1 Exposure & maturity estimations

For each of the three business models considered, a distribution among all the asset and liability classes and a corresponding remaining maturity profile per class is made. This distribution is based on the average balance sheet distribution of the banks in the business model samples and is derived from data from the annual reports of 2017 of the banks in the samples.

The distribution per business model amongst the general asset and liability classes is shown in Table 4.5. The distribution per business model amongst remaining maturity classes, initial

TABLE 4.5: Distribution per business model - asset & liability classes

	Retail	Wholesale	Investment
Cash	7.4%	4.5%	6.6%
Residential mortgage loans	40.0%	0.5%	24.5%
Other retail loans	9.4%	10.6%	3.3%
Corporate loans	25.4%	31.0%	25.3%
Bank loans	3.0%	32.2%	6.5%
Bonds	8.5%	13.3%	17.1%
Trading assets	2.6%	5.2%	11.0%
Other assets	3.7%	2.6%	5.7%
Current retail deposits	15.3%	3.2%	20.0%
Savings retail deposits	16.9%	2.6%	11.5%
Term retail deposits	15.3%	2.5%	7.1%
Corporate deposits	23.2%	15.5%	15.4%
Bank deposits	8.2%	33.8%	12.2%
Debt securities	6.8%	30.0%	10.8%
Trading liabilities	0.9%	1.2%	1.3%
Subordinated liabilities	2.0%	2.4%	7.9%
Other liabilities	3.6%	3.8%	7.8%
Equity	7.9%	5.0%	6.0%

maturity classes[6], credit rating classes, and LTV classes can be found in Appendix F. By combining this data an exposure profile and a remaining maturity profile for all 40 asset and 19 liability classes are created for all three business models.

When comparing the maturity, credit, LTV and exposure profile of the different business models, the most striking remark to be made is that nearly all assets classes of the wholesale business model have a substantially higher credit rating than the asset classes of the retail business model, which in turn has a substantially higher credit rating than the investment business model. Second, the distribution of the business models amongst the general asset and liability classes is in line with the description of the business models as in Section 2.2.2. Additionally, the distribution amongst the LTV classes is the same for all business models. Lastly, when comparing the distribution among maturity classes, it is found that the retail business model has a higher share of on-demand assets and liabilities, whereas the other two business models have a higher share of asset and liabilities with maturity between 1 and 3 months. After three months, no significant differences can be distinguished in the maturity profiles.

4.3.2 Interest rates estimations

We appointed an interest rate to the asset and liability classes that yield interest, as presented in Appendix F. We assume that the interest rates are the same for all business models since they are more closely related to the asset and liability classes and less to the business models.

[6]Nearly all banks in the sample only report residual maturity in their annual reports. However, initial maturity is needed to determine the division of the exposures among the asset & liability classes. To estimate the initial maturities, the residual maturities are transformed to initial maturities based on the assumption that the residual maturity distribution stays equal over time. This assumption is tested by comparing the remaining maturities over time of a few banks in the sample and no significant changes in remaining maturities are observed. This implies that this assumption fits with the sample. The remaining maturities and the initial maturities per business model can be found in Table F.4 and Table F.5 in Appendix F

The interest rates are based on the average interest rates of the past 5 years of several proxies that are representative for the specific classes. We derived the data of these proxies from the ECB Statistical Data Warehouse, Bloomberg and Dutch Central Bank (DNB). The interest rate estimations together with their proxies can be found in Appendix G.

4.3.3 Probability of default estimations

To estimate the PDs, an average PD per rating class and per counterparty is calculated based on historical data of S&P, Moody's and Fitch on defaults of sovereigns, corporates, and retail counterparties. In these studies, the following rating classes are included: 1) AAA, 2) AA+ - AA-, 3) A+ - A-, 4) BBB+ - BBB-, 5) BB+ - BB-, 6) B+ - B-, 7) CCC/C. In the subclasses included in our model, these rating classes are clustered in groups of two or three rating classes. Therefore, a weighted average PD per asset class and per business model is calculated. The historical PDs and the weighted average PD inputted in the model, can be found in Appendix H.

4.3.4 Profit function assumptions

The input for *NTI%*, *Div* and *Tax* is set on 4%, 4%, and 40% respectively and is based on general percentages used in literature. The input for *OperExp* is set on 1.5% and is calculated as the average of operating expenses as percentage of total assets in 2017 of 10 randomly selected banks from the samples used during this study. The input used for the profit function is the same for each business model.

4.3.5 Migration analysis scenarios

As explained in Section 3.5, the migration analysis can be described as:

What happens to the risk-return profile when i% more X activities are performed at the expense of Y activities

For this research, the migrations will be performed with *i=1%* change in business-model-typical activities and the migrations that are analysed are shown in Table 4.6.

TABLE 4.6: Migration analysis scenarios

Applied to	X	Y
Retail business model	Retail	Investment & wholesale
	Wholesale	Retail
	Investment	Retail
Wholesale business model	Retail	Wholesale
	Wholesale	Investment & retail
	Investment	Wholesale
Investment business model	Retail	Investment
	Wholesale	Investment
	Investment	Retail & Wholesale

Chapter 5

Results

The stress test and migration analysis are performed with the use of the model as described in Chapter 3, with the input as described in Chapter 4. It has to be remembered that the model is a simplified version of reality based on assumptions. The assumption with the biggest impact is that exclusion of income sources other than income related to the balance sheet. This chapter presents and discusses the main results of the stress test, the migration analysis and the EBA stress test, and will answer the following sub-question:

What results can be drawn from the model?

a How do different business models perform under stressed conditions?

b How can different banking business models improve their risk-return performance?

5.1 Stress test

In this section, the results of the stress test for each of the three banking business models are presented. For each business model, a base scenario and a stressed scenario are run. The base scenario is the scenario in which financial risks are excluded and the stressed scenario is the scenario in which credit risk, interest rate risk and market risk are included. First, the general results will be discussed and subsequently the risk and return results will be discussed in more detail.

5.1.1 Summary

None of the business models are able to make profit, both in the base and stressed scenario. This is partly caused by our decision to leave out sources of income that are not related to the balance sheet, as explained in Section 3.3. However, the sources of income that are included cover the majority of bank income and therefore the profit is still rather low, especially in the base scenario. This is probably partly caused by the low interest rate, and therefore low margin, environment that banks face. If banks do not make much profit during the non-distressed periods (i.e. the base scenario) they are not able to increase their capital and liquidity buffers that they need when periods of distress occurred. This could indicate that in the current low growth and low interest rate environment, banks are not able to increase their buffers and prepare for the next crisis.

In the base scenario, both the retail and investment business models are compliant with all the risk ratios where the wholesale business model fails the LCR and Total Capital Ratio requirements. In the stressed scenario, only the retail business model stays compliant with

TABLE 5.1: Results - summary stress tests

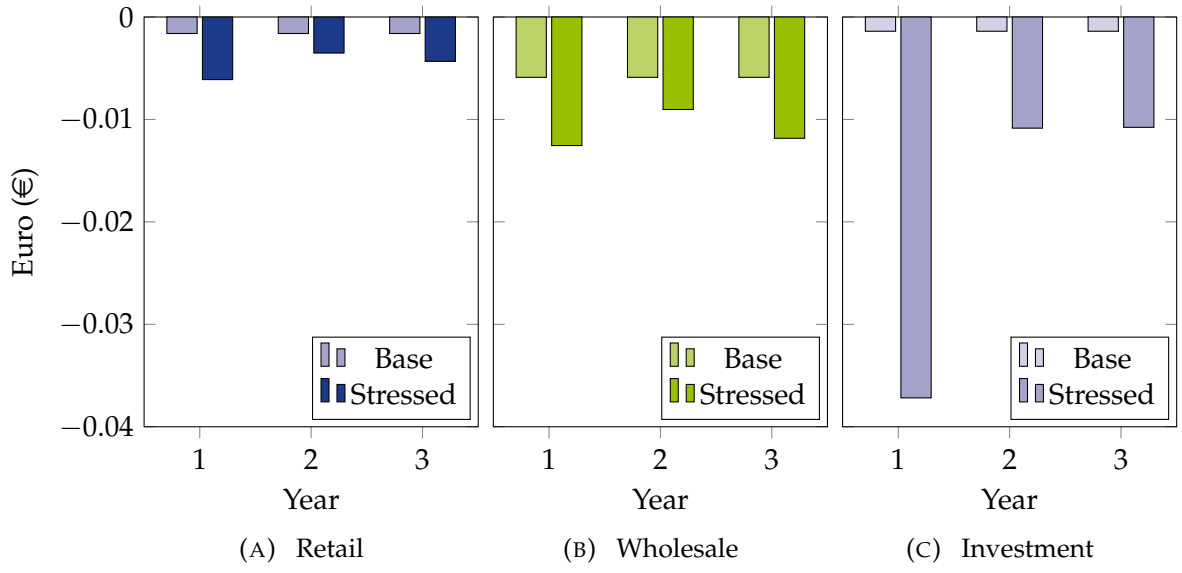
	Total NII	Total profit	Min LCR	Min NSFR	Min LR	Min TCR	ΔEVE
Retail - base	€ 0.0493	€ -0.0048	151.12%	135.00%	7.25%	19.43%	-0.364%
Retail - stressed	€ 0.0384	€ -0.0140	145.73%	132.97%	6.61%	17.27%	-0.362%
Investment - base	€ 0.0276	€ -0.0042	115.85%	128.77%	5.64%	21.71%	-0.292%
Investment - stressed	€ 0.0164	€ -0.0588	84.89%	122.82%	0.24%	9.98%	-0.281%
Wholesale - base	€ 0.0211	€ -0.0177	82.14%	108.62%	3.24%	10.22%	-0.138%
Wholesale - stressed	€ 0.0162	€ -0.0334	72.97%	107.08%	1.85%	7.13%	-0.132%

The table above displays the summary of the results of the base and stressed scenario generated by the model. The summary consists of the following variables; Total NII is the total NII over a period of 36 months per euro of total assets at *t=0*, Total profit is the total profit over a period of 36 months per euro of total assets at *t=0*, Min LCR is the minimum LCR reported in a period of 36 months, Min NSFR is the minimum NSFR reported in a period of 36 months, Min LR is the minimum leverage ratio reported in a period of 36 months, Min TCR is the minimum total capital ratio reported in a period of 36 months and ΔEVE is the difference between the EVE of the original scenario (either base or stressed) and the EVE after a parallel +200 bp interest rate shock for the same scenario.

all risk ratios. The investment and wholesale business models both fail the LCR, Leverage Ratio, and Total Capital Ratio requirements. All business models meet the NSFR requirement in both scenarios. The difference between the base scenario and the stressed scenario is largest for the investment business model. The differences between the ΔEVE in the base and stressed scenarios are rather small since the maturity profile in both scenarios does not significantly differ.

5.1.2 Return

Profit



(A) Retail (B) Wholesale (C) Investment

FIGURE 5.1: Results - yearly profit per euro of total assets at *t=0*

In Figure 5.1, the profits in the base and in the stressed scenario for the three business models are shown. In the base scenario, the investment business model makes the smallest loss

and the wholesale business model the biggest loss. For the investment business model, this is caused by relatively high income from the trading book, which is higher than most interest rates on fixed income products (as shown in Appendix G). For the wholesale business model, the loss in the base scenario is mainly caused by the negative EURIBOR rates that are applicable for bank loans and deposits.

In the stressed scenario, the investment business model suffers the biggest losses and also is most impacted when looking at the relative difference between the stressed and base scenario. The big loss for investment business models is mainly caused by a big loss in the trading book. This is caused by the development of the stock market, which shows a large decrease in year 1 (as shown in Table 3.2). On the other hand, the wholesale business model also has a considerable trading book (as shown in Table 4.5) but is least impacted when looking at the relative difference between the base and stressed scenarios. This indicates that the losses that the investment business model suffers are also caused by maturity profile and counterparty credit ratings.

In absolute terms, the retail business model is least impacted by the stress test and also shows the lowest absolute loss in the stressed scenario. This is according to expectation because this business model has the highest share of fixed income products. These products are less impacted by market risk, which plays a big role in this stress test.

Net Interest Income

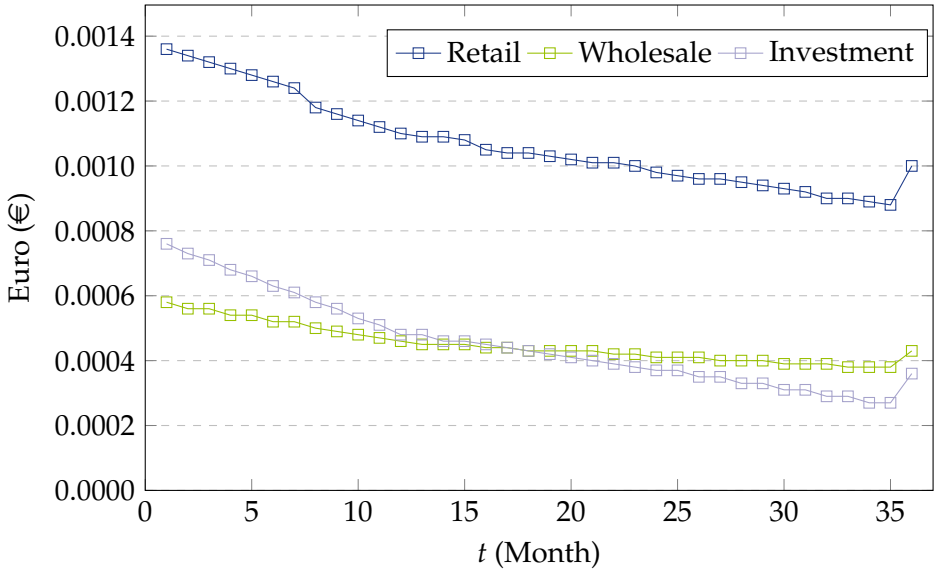


FIGURE 5.2: Results - monthly Net Interest Income per euro of total assets at *t=0*

The development of the NII under the stressed scenario for the banking business models is shown in Figure 5.2. The seemingly abnormal movement of the NII at *t=36* for all business models is caused by the fact that one of the maturity buckets (the '1 year – 5 year' bucket) has 36 months as midpoint. Therefore, this bucket matures at *t=36*, which means that the interest rates increase. This makes that the interest rate mismatch caused by the maturity mismatch decreases significantly, which causes the NII to increase.

The retail business model has the highest NII, which is in line with expectations because it has the highest share of products that yield interest and it has the smallest trading book,

which is not included in the NII. The development of the NII for the retail and investment business model seem similar, this is in line with expectations since they are subjected to the same interest rate movements.

The NII of the wholesale business model is least impacted by the stress test. This is caused by the reliance on loans and deposits on which EURIBOR rates apply. The EURIBOR rates increase slower than the other interest rates, therefore it is less impacted by the negative impact of maturity mismatch when interest rates increase.

5.1.3 Risk - Liquidity risk

In this section and in Section 5.1.4, only the risk results of the stressed scenarios are included. This is done because in the base scenario, all financial risks are eliminated and therefore an extensive risk performance analysis for the base scenario beyond the results presented in Table 5.1 does not make sense.

Liquidity Coverage Ratio

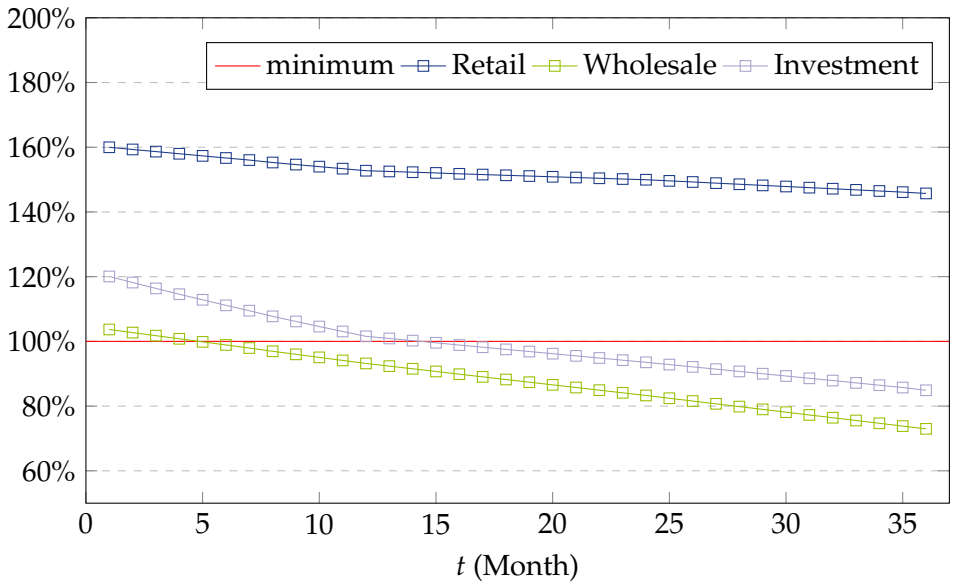


FIGURE 5.3: Results - monthly Liquidity Coverage Ratio position

Figure 5.3 shows the LCR development of the three business models over time. The retail business model is the only business model that is compliant with the LCR requirement over the entire test period, its LCR level can even be seen as risk-averse. The wholesale business model fails the LCR requirement after 5 months and the investment business model after 15 months. The differences between the business models are partly caused by each business model's initial level of cash (which is not a business model indicator in our study) since cash is a big part of the numerator of the LCR formula. However, this does not completely explain the differences, because the initial level of cash of the investment business model is much closer to the retail business model than to the wholesale business model, while this is not reflected in the LCR results. This indicates that for the investment business model the low LCR is also caused by a relative higher value of the denominator of the LCR formula, which is more related to the business model activities. This shows that the low LCR for the wholesale business model is mainly caused by the low initial level of cash while the problems for the investment business model are more inherent to the business model activities.

Net Stable Funding Ratio

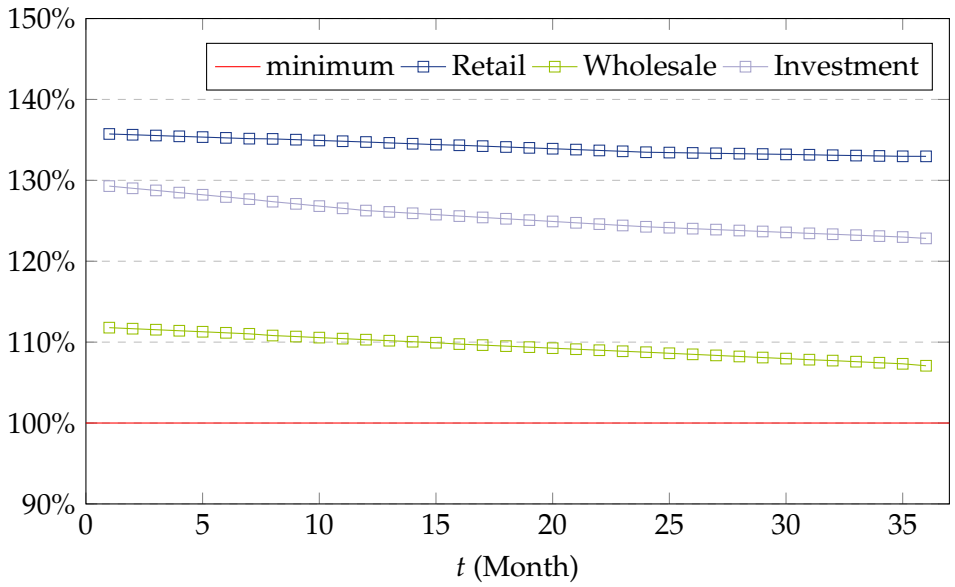


FIGURE 5.4: Results - monthly Net Stable Funding Ratio position

In Figure 5.4 the development of the NSFR over time for all business models is shown. All business models are compliant with the NSFR requirement over the entire study period. For the retail and investment business models, it can be stated that their NSFR levels are risk-averse, and the NSFR level of the wholesale model can be seen as risk-neutral. These results are in line with the collective shift towards retail activities (as explained in Section 2.2.3), which are seen as stable. The need for stable funding was an important lesson learned from the crisis (as explained in Section 2.1.1).

5.1.4 Risk - Credit risk

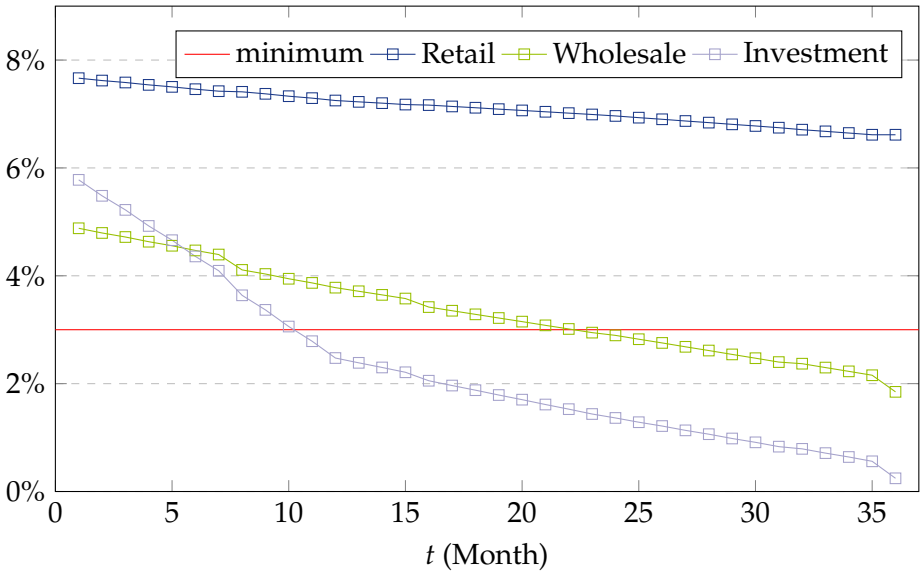


FIGURE 5.5: Results - monthly Leverage Ratio position

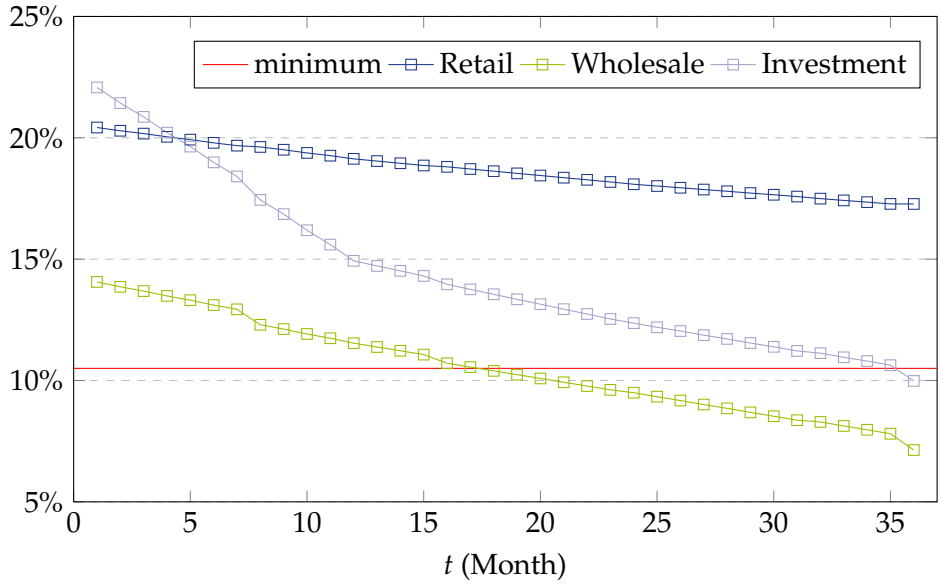


FIGURE 5.6: Results - monthly Total Capital Ratio position

In Figure 5.5 and Figure 5.6 the development of the Leverage Ratio and the Total Capital Ratio over time for all business models is shown. The retail business model is compliant with both capital ratios and the levels can be seen as risk-averse. Additionally, the retail business model is least impacted by the stressed conditions since the relative difference in credit risk performance between *t=0* and *t=36* is the smallest compared to the other business models.

The investment business model is mostly impacted when looking at the relative difference between the credit risk performance at *t=0* and *t=36*, while it has a relatively good performance on both ratios at *t=0*. This impact is mainly caused by a significant decrease in equity as a result of the severe losses that the investment model suffers (as explained in Section 5.1.3). For the Leverage Ratio, the regulatory requirement is failed in month 11 and for the Total Capital Ratio in month 36 by the investment business model.

The wholesale business model fails to meet the leverage ratio from month 23 onwards and the Total Capital Ratio is failed from month 18 onwards. This is mainly caused by a relatively low initial level of equity (which is not a business model indicator). When looking at the relative difference in credit risk performance between *t=0* and *t=36*, the wholesale business model is ranked between the other two business models in terms of impact of the stressed conditions.

5.1.5 Risk - Value

In Figure 5.7 the ΔEVE, capturing the difference between the EVE of the stressed scenario and the EVE after a parallel +200 bp interest rate shock, is shown. It measures the sensitivity of the future earnings capacity of the bank to interest rate shocks. A lower ΔEVE indicates that the bank's future earnings capacity is more sensitive to interest rate shocks.

The retail business model has the lowest ΔEVE, which indicates that their future earnings capacity is most sensitive to interest rate shocks. This is according to expectations since this business model is mostly reliant on products that yield interest and therefore is most impacted by interest rate shocks. The investment business model comes in second and the

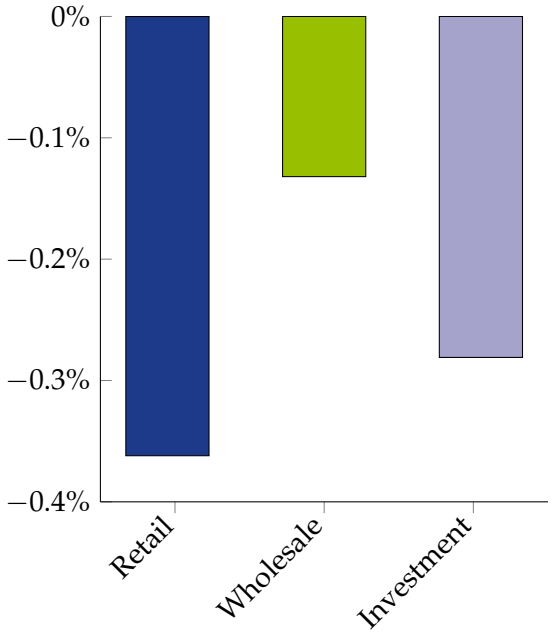


FIGURE 5.7: Results - ΔEVE with a parallel +200 bp interest rate shock

wholesale business model has the highest ΔEVE. These results are in line with the expectations on the trade-off between the EVE and the NII as explained in Section 2.3.2.

However, the ΔEVE results of all business models are within reasonable limits. This indicates that the interest rate shock only has a limited impact on the future earnings capacity.

5.2 Migration analysis

The results of the migration analysis are shown in Table 5.2. The migration analysis in this research only takes migration impact on the stressed scenario into account. This is no issue for the assessment of the risk performance since financial risks can best be investigated in periods of distress. However, for return performance also a business model's ability to generate profit during non-distressed periods should be taken into account. Even though the latter is out of scope for our research, it should be taken into account when interpreting the results.

The retail business model has a very risk-averse profile and therefore can move towards any business model without much trouble from a risk perspective. From a return perspective, the best direction for the retail business model under stressed conditions is to move toward more retail activities. However, since the retail business model has a risk-averse profile there is also limited upside potential in non-distressed periods. Therefore, moving towards more wholesale and investment activities is also an option to consider if a bank is willing to bear a bit more risk in return for the possible upside potential. When only looking at the period of distress, a movement towards wholesale activities is preferred over a movement towards investment activities since it results in higher profit.

For the wholesale business model, it is most beneficial from both a risk and return perspective to move towards more wholesale activities. This is an interesting result since the original performance of the wholesale business model in both the base and stressed scenario is rather

TABLE 5.2: Results - migration analysis

Panel A: Retail business model							
	Total NII	Total Profit	Min LCR	Min NSFR	Min LR	Min TCR	Delta EVE
Original	0,0384	-0,0140	145,73%	132,97%	6,61%	17,27%	-0,362%
More retail activities	0,0385	-0,0139	146,02%	133,03%	6,62%	17,27%	-0,364%
Delta	6,36E-05	8,14E-05	0,00292	0,00059	5,02E-05	-1,9E-05	-2,2E-05
More wholesale activities	0,0385	-0,0139	145,54%	132,83%	6,62%	17,28%	-0,361%
Delta	4,85E-05	4,98E-05	-0,00187	-0,00134	4,72E-05	9,31E-05	1,2E-05
More investment activities	0,0383	-0,0141	145,65%	133,05%	6,61%	17,27%	-0,361%
Delta	-9,9E-05	-0,00011	-0,00079	0,00081	-8,6E-05	-7,5E-05	5,3E-06
Panel B: Wholesale business model							
	Total NII	Total Profit	Min LCR	Min NSFR	Min LR	Min TCR	Delta EVE
Original	0,0162	-0,0334	72,97%	107,08%	1,85%	7,13%	-0,132%
More retail activities	0,0163	-0,0333	73,03%	107,12%	1,86%	7,16%	-0,132%
Delta	0,00012	0,00012	0,00065	0,00036	0,00012	0,000226	-5E-06
More wholesale activities	0,0163	-0,0332	73,38%	106,93%	1,87%	7,16%	-0,131%
Delta	0,00014	0,00020	0,00408	-0,00147	0,00018	0,00029	9,6E-06
More investment activities	0,0159	-0,0337	72,56%	107,08%	1,82%	7,07%	-0,132%
Delta	-0,00029	-0,00032	-0,00413	-4,0E-05	-0,00031	-0,00060	1,4E-06
Panel C: Investment business model							
	Total NII	Total Profit	Min LCR	Min NSFR	Min LR	Min TCR	Delta EVE
Original	0,0164	-0,0588	84,89%	122,82%	0,24%	9,98%	-0,281%
More retail activities	0,0167	-0,0584	85,24%	122,81%	0,28%	10,06%	-0,284%
Delta	0,00032	0,00039	0,00351	-0,00012	0,00039	0,00074	-2,7E-05
More wholesale activities	0,0167	-0,0584	84,93%	122,58%	0,29%	10,05%	-0,282%
Delta	0,00034	0,00040	0,00041	-0,00248	0,00041	0,00066	-1,0E-05
More investment activities	0,0162	-0,0591	84,98%	123,01%	0,22%	9,94%	-0,280%
Delta	-0,00021	-0,00027	0,00085	0,00189	-0,00028	-0,00046	1,0E-05

This table shows the results of the migration analysis. Panel A, panel B, and panel C represent the retail, wholesale and investment business models, respectively. The detailed explanation of the migration scenarios that are applied to each business model can be found in Section 4.3.5. The table only shows the results of the stressed scenario and does not include the base scenario. The coloured rows indicate the difference between the original scenario and the migration scenario.

weak. This might indicate that the poor performance of the wholesale business model in the stress test is not caused by the business-model-typical activities but by other factors like the initial level of cash and equity. Additionally, a movement towards retail activities is also an option to consider. Regarding the weak performance of the migration towards investment activities, this is not a feasible option from a risk perspective.

For the investment business model, it is not beneficial to move towards more investment activities during a period of distress from both a risk and return perspective. Since risk performance worsens after migrating towards more investment activities it is best for the investment business model to move to retail or wholesale activities to increase risk performance. The risk metric that needs the most attention is the Leverage Ratio. For that metric, it is most profitable to move towards more wholesale activities. Also, from a return perspective, it is most profitable in distressed periods to move towards wholesale activities.

The impact of the migrations on the ΔEVE is only very limited. This indicates that the height of the ΔEVE is not related to the business-model-typical activities, but to other factors like maturity profile. This according to expectation.

5.3 Results EBA 2018 EU-wide stress test

The EBA stress test is carried out among 48 banks in the EU. Of these 48 banks, 9 are also included in the samples of our research[7]. The EBA has published the results of the EBA stress test (EBA, 2018b) and in this section, these results are discussed briefly. However, it should be taken into account that there are many banks included in the EBA stress test that are not included in the samples of this research and vice versa and that the exact methodologies differ, therefore the results are not comparable 1 on 1.

Return

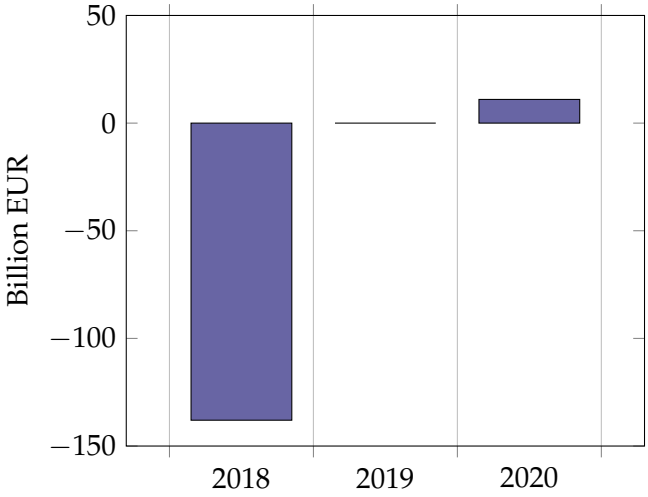


FIGURE 5.8: Results EBA stress test - average profit

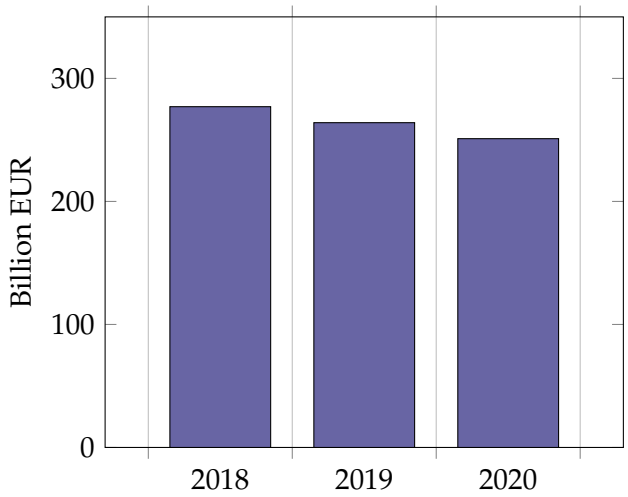


FIGURE 5.9: Results EBA stress test - average Net Interest Income

Figure 5.8 and Figure 5.9 show the average profit and average NII from the EBA stress test. It is hard to compare the height of the profit and the NII with the profit and NII generated by our model since the input of the model is controlled for asset size and several sources of income are left out in our model, however, the developments over time can be compared. The NII in the EBA stress test seems to be less volatile than the NII generated by our model.

[7] Which banks are both in the EBA stress test and our samples can be seen in Appendix E

The development of the profit of the EBA stress test shows most similarity with the investment business model in our study, with a large loss in year 1.

Additionally, these results support the findings of Ayadi, Arbak, and De Groen (2011) that non-interest income is more volatile than interest income in times of stress, since in this stress test the profit is more volatile than the NII.

Risk

In Figure 5.10 and Figure 5.11, the average Leverage Ratio and Total Capital Ratio reported by the EBA are included. The average Leverage Ratio lies above the regulatory minimum over the entire study period, whereas where the average Total Capital Ratio fails to meet its minimum requirement.

The development of the risk metrics of the EBA stress test show most similarities with the average of the three business models in our study combined instead of a specific similarity with a business model, as was the case for the profit in the EBA stress test.

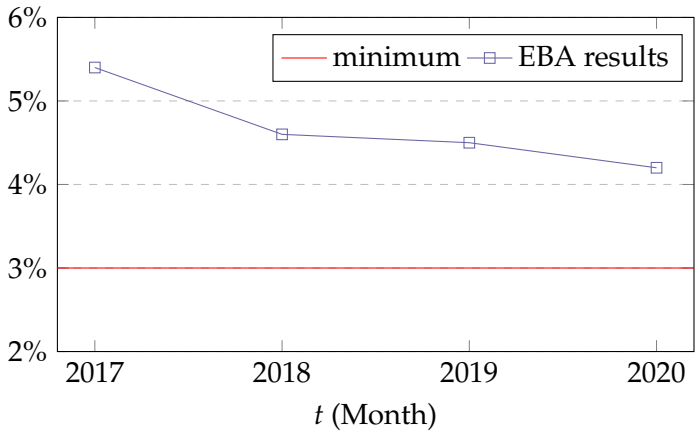


FIGURE 5.10: Results EBA stress test - average Leverage Ratio position

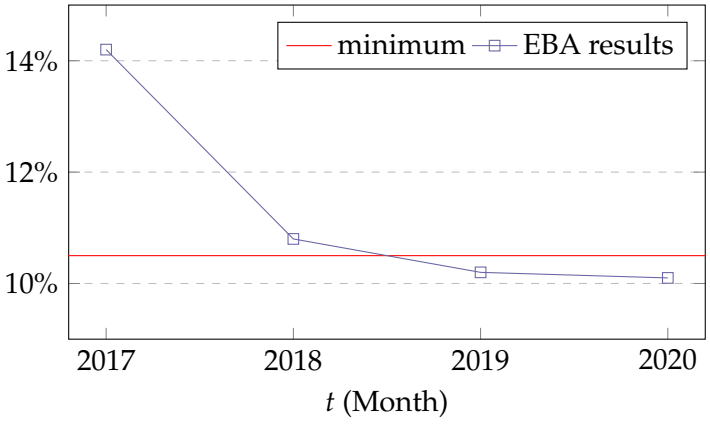


FIGURE 5.11: Results EBA stress test - average Total Capital Ratio position

Chapter 6

Conclusions

Within the context of this research, three business model have been distinguished and investigated. The last sub-question that is left to answer is:

How can the results of the model be used to get a deeper understanding of the performance of different banking business models under the Basel III framework and how should the regulator adapt?

This chapter gives an overview of the conclusion and discussion points regarding the results from an individual bank's perspective (how can banks adapt and enhance their business model), from the markets perspective (what does this mean for the financial system), and from the regulator's perspective (how can the regulator adapt to banking diversity). Additionally, some research limitations and recommendations for future research are addressed.

6.1 Conclusions, discussion & recommendations

6.1.1 Business model perspective

Bankss hould be more aware of their position in the risk-return plane and about their business model. Therefore, this section describes the conclusions that can be made regarding banking business models as a result of our research.

The retail business model is a business model with a very risk-averse profile. Therefore, it is compliant with Basel III during our stress test and reports the lowest loss compared to the other business models. However, this business model also may have limited upside potential in terms of return in non-distressed periods. Therefore, moving towards more wholesale and investment activities is also an option to consider if a bank is willing to bear more risk in return for the possible upside potential.

The wholesale business model has performed rather weakly during the stress test. However, this can be attributed mainly to relatively low initial cash and equity levels and not to risk inherent in the business-model-typical activities. This is backed up by the migration analysis, which shows that it is profitable from both a risk and return perspective to increase wholesale activities for a wholesale bank in this stress scenario. In literature, wholesale business models are seen as relatively unstable and unsafe, but our results show that the average wholesale bank in our sample has found a way to create a more resilient business model by taking safer positions in counterparty credit ratings. If this observed change can be succeeded with higher positions in cash and equity, the wholesale business model has good potential to be feasible from both a risk and return perspective. Additionally, a movement towards retail activities is also an option to consider for wholesale banks.

The investment business model is most impacted by the stress test and reports the highest loss compared to the other business models. Therefore, we mark this business model as most risky. It is not advised for an average investment bank to move towards more investment activities since there is too much risk inherent in the business-model-typical activities. An investment bank can move towards more wholesale or retail activities to improve its risk profile under stressed conditions, dependent on the expected upside potential and desired level of risk.

Combining the findings of our research leads to confirmation of conclusions of other studies (as described in Chapter 2) that including more retail products on the balance sheet will make individual banks more resilient in times of stress. However, that is not the only option that is worth considering since for some business models, migrations towards activities other than retail activities can be (even more) feasible from both a risk and return perspective. The optimal migration direction is different for every bank and is dependent on a bank's maturity profile, counterparty credit rating profile and its business-typical-activities.

6.1.2 Market perspective

The financial market is constantly changing; the BCBS has already announced new regulations (often referred to as Basel 3,5 or Basel IV), and FinTechs and other entrants are claiming their share of the market. Therefore, it is important that banks carefully and strategically choose their business model and possible migration directions. This can be realized when there is sufficient knowledge of the decision space in the risk-return plane. This section describes the conclusions that can be made regarding observed and desired patterns in the market.

The non-retail banks in our samples have reported a higher average share of retail activities compared to similar benchmarks a few years earlier. This confirms the continuation of the earlier observed collective shift towards more retail activities. Additionally, on average the banks in our sample have moved towards a more stable funding profile since Basel III's stable funding requirement is met by all business models in the stress test.

Given the flaws that became visible during the crisis, the collective shift towards retail activities might be an improvement, however, it should not go too far. If all banks move towards the risk-averse retail business model, systemic diversity decreases, which causes systemic risk to increase.

Our research shows that there are alternative ways to enhance business models while increasing resilience and that the optimal migration direction is different for every bank. This shows that there are still possibilities and potential for the banking sector to create sustainable profits with acceptable levels of risk in different business models. This opposes the neoclassical assumption that firms can optimize uniformly across a sector and might be a reason why one size might not fit all.

6.1.3 Regulatory perspective

The insights in the differences between banking business models increases regulators' ability to perform more accurate and fair risk monitoring towards banks. The next step for regulators is to adapt to these new insights. This section provides conclusions and recommendations regarding this adaption.

Before Basel III, banks were allowed create internal risk models because it would better fit the increasing complexity of the financial system. This led to a situation where banks who performed the same activities could have different risk treatments. To overcome this weakness, the BCBS has made a radical change towards a one-size-fits-all approach in Basel III. However, the complexity of the financial system did not decrease.

Therefore, we recommend regulators to further investigate the inclusion and acknowledgement of systemic diversity and banking business models in banking regulation. Including and acknowledging banking business models in the regulatory context will allow more systemic diversity and at the same time assures that banks that perform similar activities are treated equally by the regulator.

As a concrete first step to realize this, we recommend to make banking business models a regulatory concept. This does not have to be in discrete groups, as done in this research, but can be expressed in different ways. If banks are guided in how they should report and communicate their business model, it is clearer what the underlying risk and return incentives for that bank are. That way, regulators and other stakeholders can better perform their risk monitoring function towards banks.

6.2 Limitations & future research

The most important recommendation we make for future research, is to further investigate the inclusion of banking business models as a regulatory concept. For example, some of the things that should be dealt with is the exact definition of banking business models and the way banking business models should be classified and quantified.

Additionally, we only looked at systemic diversity from the perspective of business models. However, systemic diversity also can be driven by other factors like governmental aid, ownership structure, country of residence and local demographics. Therefore, a recommendation for future research is to broaden the scope on systemic diversity to further improve the knowledge of underlying patterns regarding systemic diversity.

One of the limitations of the business model classification approach used in this research is that it assumes that separable business models exist and that all banks fit one of the three business models. Therefore, intermediate strategies are not taken into account and some nuance that might be important with regard to real-world banking business models is lost. This should be taken into account when interpreting the results of this research and should also be tackled before the banking business model can become a regulatory concept.

Like every financial risk model, our model is a simplified version of reality. Several aspects have been left out, the most important being; the behavioural aspect (e.g. prepayment), the inclusion of more stress scenarios, dynamic PDs, and the inclusion of different currencies. Therefore, the model only gives a general indication of the risk-return performance of banks and banking business models. A recommendation for future research is to enhance the model. We suggest that the first steps to enhance the model could be including dynamic PDs, including other stress scenarios or including stochastic modelling.

Appendix A

Risk formulas

A.1 Total Capital Ratio

The Total Capital Ratio requirement is formulated as follows:

$$Total\ Capital\ Ratio = \frac{Tier\ 1 + Tier\ 2\ Capital}{Risk\ Weighted\ Assets\ (RWA)} \geq 10.5\% + IRP \tag{11}$$

Below the elements of the formula are described in more detail.

Common Equity Tier 1 capital consists of the sum of the following elements:

- Common shares issued by the bank that meet the criteria for classification as common shares for regulatory purposes (or the equivalent for non-joint stock companies);
- Stock surplus (share premium) resulting from the issue of instruments included Common Equity Tier 1;
- Retained earnings;
- Accumulated other comprehensive income and other disclosed reserves;
- Common shares issued by consolidated subsidiaries of the bank and held by third parties (i.e. minority interest) that meet the criteria for inclusion in Common Equity Tier 1 capital;
- Regulatory adjustments applied in the calculation of Common Equity Tier 1

Additional Tier 1 capital consists of the sum of the following elements:

- Instruments issued by the bank that meet the criteria for inclusion in Additional Tier 1 capital (and are not included in Common Equity Tier 1);
- Stock surplus (share premium) resulting from the issue of instruments included in Additional Tier 1 capital;
- Instruments issued by consolidated subsidiaries of the bank and held by third parties that meet the criteria for inclusion in Additional Tier 1 capital and are not included in Common Equity Tier 1;
- Regulatory adjustments applied in the calculation of Additional Tier 1 Capital

Tier 2 Capital consists of the sum of the following elements:

- Instruments issued by the bank that meet the criteria for inclusion in Tier 2 capital (and are not included in Tier 1 capital);

- Stock surplus (share premium) resulting from the issue of instruments included in Tier 2 capital;
- Instruments issued by consolidated subsidiaries of the bank and held by third parties that meet the criteria for inclusion in Tier 2 capital and are not included in Tier 1 capital;
- Certain loan loss provisions as specified in paragraphs 60 and 61;
- Regulatory adjustments applied in the calculation of Tier 2 Capital.

Risk Weighted Assets are calculated by multiplying the exposures by the corresponding risk weight:

- Exposures to counterparties will be risk-weighted as follows:

Credit rating	**AAA to AA-**	**A+ to A-**	**BBB+ to BBB-**	**BB+ to B-**	**Below B-**
Sovereigns	0%	20%	50%	100%	150%
Banks	20%	50%	100%	100%	150%
Corporates	20%	50%	100%	100%	150%
Retail – loans	75%	75%	75%	75%	75%

- Residential real estate exposures will be risk-weighted as follows:

LTV	**<50%**	**50% - 60%**	**60% - 70%**	**70% - 80%**	**80% - 90%**	**90% - 100%**	**>100%**
Risk weights	30%	35%	45%	45%	60%	75%	105%

A.2 Leverage Ratio

The LR requirement is formulated as follows:

$$Leverage\ Ratio = \frac{Tier\ 1\ Capital}{Total\ Assets} \geq 3\% \tag{12}$$

Below the elements of the formula are described in more detail.

Common Equity Tier 1 capital consists of the sum of the following elements:

- Common shares issued by the bank that meet the criteria for classification as common shares for regulatory purposes (or the equivalent for non-joint stock companies);
- Stock surplus (share premium) resulting from the issue of instruments included Common Equity Tier 1;
- Retained earnings;
- Accumulated other comprehensive income and other disclosed reserves;
- Common shares issued by consolidated subsidiaries of the bank and held by third parties (i.e. minority interest) that meet the criteria for inclusion in Common Equity Tier 1 capital;
- Regulatory adjustments applied in the calculation of Common Equity Tier 1.

Additional Tier 1 capital consists of the sum of the following elements:

- Instruments issued by the bank that meet the criteria for inclusion in Additional Tier 1 capital (and are not included in Common Equity Tier 1);
- Stock surplus (share premium) resulting from the issue of instruments included in Additional Tier 1 capital;
- Instruments issued by consolidated subsidiaries of the bank and held by third parties that meet the criteria for inclusion in Additional Tier 1 capital and are not included in Common Equity Tier 1;
- Regulatory adjustments applied in the calculation of Additional Tier 1 Capital.

Total Assets are the sum of all exposures on the asset side of the balance sheet.

A.3 Liquidity Coverage Ratio

The LCR requirement is formulated as follows:

$$LCR = \frac{Stock\,of\ HQLA}{Cash\,Outflow - Min(Cash\,Inflow, Cash\,Outflow * 0.75} \geq 100\% \tag{13}$$

Below the elements of the formula are described in more detail.

HQLA consists of assets with characteristics outlined in Section 2.3.2 and consists of three levels:

Item	HQLA factor
Level 1 assets:	
- Coins and banknotes - Qualifying marketable securities from sovereigns, central banks, PSEs, and multilateral development banks - Qualifying central bank reserves - Domestic sovereign or central bank debt for non-0% risk-weighted sovereigns	100%
Level 2a assets: (Max 40% of HQLA)	
- Sovereign, central bank, multilateral development banks, and PSE assets qualifying for 20% risk weighting - Qualifying corporate debt securities rated AA- or higher - Qualifying covered bonds rated AA- or higher	85%
Level 2b assets: (Max 15% of HQLA)	
- Qualifying RMBS	75%
- Qualifying corporate debt securities rated between A+ and BBB-	50%
- Qualifying common equity shares	50%

Cash Outflow is the expected cash outflow in a 30 days stress period:

Item	Outflow factor
Retail deposits	
- Stable deposits (deposit insurance scheme meets additional criteria)	3%
- Stable deposits	5%
- Less stable retail deposits	10%
- Term deposits with residual maturity greater than 30 days	0%
Unsecured wholesale funding	
- Demand and term deposits (less than 30 days maturity) provided by small business customers (Stable)	5%
- Demand and term deposits (less than 30 days maturity) provided by small business customers (Less stable)	10%
- Cooperative banks in an institutional network (qualifying deposits with the centralised institution)	25%
- Non-financial corporates, sovereigns, central banks, multilateral development banks, and PSEs	40%
- Other legal entity customers	100%
Secured funding	
- Secured funding transactions with a central bank counterparty or backed by Level 1 assets with any counterparty.	0%
- Secured funding transactions backed by Level 2A assets, with any counterparty	15%
- Secured funding transactions backed by non-Level 1 or non-Level 2A assets, with domestic sovereigns, multilateral development banks, or domestic PSEs as a counterparty	25%
- Backed by RMBS eligible for inclusion in Level 2B	25%
- Backed by other Level 2B assets	50%
- All other secured funding transactions	100%

Cash Inflow is the expected cash inflow in a 30 days stress period:

Item	Inflow factor
- Level 1 Assets	0%
- Level 2a assets	15%
- Level 2b assets: RMBS	25%
- Level 2b assets: Other	50%
- Margin lending backed by other collateral	50%
- All other assets	100%

A.4 Net Stable Funding Ratio

The NSFR requirement is formulated as follows:

$$NSFR = \frac{Available\ amount\ of\ stable\ funding\ (ASF)}{Required\ amount\ of\ stable\ funding\ (RSF)} \geq 100\% \tag{14}$$

Below the elements of the formula are described in more detail. [8pt]

Available Stable Funding is calculated by multiplying liabilities with their corresponding ASF factor:

Item	ASF factor
- Total regulatory capital (excluding Tier 2 instruments with residual maturity of less than one year) - Other capital instruments and liabilities with effective residual maturity of one year or more	100%
- Stable non-maturity (demand) deposits and term deposits with residual maturity of less than one year provided by retail and small business customers	95%
- Less stable non-maturity deposits and term deposits with residual maturity of less than one year provided by retail and small business customers	90%
- Funding with residual maturity of less than one year provided by non-financial corporate customers - Operational deposits - Funding with residual maturity of less than one year from sovereigns, PSEs, and multilateral and national development banks - Other funding with residual maturity between six months and less than one year not included in the above categories, including funding provided by central banks and financial institutions	50%
- All other liabilities and equity not included in the above categories, including liabilities without a stated maturity (with a specific treatment for deferred tax liabilities and minority interests) - NSFR derivative liabilities net of NSFR derivative assets if NSFR derivative liabilities are greater than NSFR derivative assets - "Trade date" payables arising from purchases of financial instruments, foreign currencies and commodities	0%

Required Stable Funding is calculated by multiplying all assets with their corresponding RSF factor:

Item	RSF factor
- Coins and banknotes - All central bank reserves - All claims on central banks with residual maturities of less than six months - "Trade date" receivables arising from sales of financial instruments, foreign currencies and commodities.	0%
- Unencumbered Level 1 assets, excluding coins, banknotes and central bank reserves	5%
- Unencumbered loans to financial institutions with residual maturities of less than six months	10%
- All other unencumbered loans to financial institutions with residual maturities of less than six months not included in the above categories - Unencumbered Level 2A assets	15%
- Unencumbered Level 2B assets - HQLA encumbered for a period of six months or more and less than one year - Loans to financial institutions and central banks with residual maturities between six months and less than one year - Deposits held at other financial institutions for operational purposes - All other assets not included in the above categories with residual maturity of less than one year	50%
- Unencumbered residential mortgages with a residual maturity of one year or more and with a risk weight of less than or equal to 35% under the Standardised Approach - Other unencumbered loans not included in the above categories, excluding loans to financial institutions, with a residual maturity of one year or more and with a risk weight of less than or equal to 35% under the standardised approach	65%
- Cash, securities or other assets posted as initial margin for derivative contracts and cash or other assets provided to contribute to the default fund of a CCP - Other unencumbered performing loans with risk weights greater than 35% under the standardised approach and residual maturities of one year or more, excluding loans to financial institutions - Unencumbered securities that are not in default and do not qualify as HQLA with a remaining maturity of one year or more and exchange-traded equities - Physical traded commodities, including gold	85%
- All assets that are encumbered for a period of one year or more - NSFR derivative assets net of NSFR derivative liabilities if NSFR derivative assets are greater than NSFR derivative liabilities - 20% of derivative liabilities as calculated according to paragraph 19 - All other assets not included in the above categories, including non-performing loans, loans to financial institutions with a residual maturity of one year or more, non-exchange-traded equities, fixed assets, items deducted from regulatory capital, retained interest, insurance assets, subsidiary interests and defaulted securities	100%

A.5 Delta EVE

The ΔEVE is formulated as follows:

$$\Delta EVE_i = \sum_{k=1}^{k} CF_0(t_k) * DF_0(t_k) - \sum_{k=1}^{k} CF_i(t_k) * DF_i(t_k) \tag{15}$$

where *CF* is the cash flow, *DC* is the discount factor, t_k is the time bucket midpoint, scenario *0* is the base scenario and scenario *i* is the shocked interest rate scenario.

The discount factor is continuously compounding and calculated by using the interest rate and point in time:

$$DF_i(t_k) = exp(-R_i(t_k) * t_k) \tag{16}$$

A.6 Altman's Z-score

Altman's Z-score is formulated as follows:

$$Z = 1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + 0.999X_5 \tag{17}$$

Below the elements of the formula are described in more detail:

X_1= Working capital/Total assets
X_2= Retained earnings/Total assets
X_3= Earnings before interest and taxes/Total assets
X_4= Market value of equity/Book value of total liabilities
X_5= Sales/Total assets

The Z-score says the following about the distance to default:

Z-score	Distance to default
>3	Unlikely to default
>2.7 - <3	Be on alert for default
>1.8 - <2.7	Good change of default
<1.8	Very likely to default

Appendix B

Definitions asset & liability classes

Below, the exact definitions are given of the asset and liability classes used in the model. All components of the balance sheet can be assigned to one of those classes.

B.1 Assets

Residential mortgage loans
Loans to retail customers with residential property as collateral.

Other retail loans
All other loans to retail customers, with or without collateral, that are not covered by residential mortgage loans.

Corporate loans
All loans to corporate and SME customers, with or without collateral.

Bank loans
All loans to banks and other financial institutions, with or without collateral.

Bonds
All bonds owned by the bank, issued by governments or corporates.

Trading assets
All equity shares and derivatives owned by the bank.

Cash
Cash and cash equivalents, such as balances at central banks.

Other assets
All other assets that are not assigned to one of the categories above. These assets are assumed to be non-performing in the context of this research. Examples are goodwill, properties, and tax assets.

B.2 Liabilities

Current retail deposits
Transaction accounts of retail customers which can be withdrawn on demand.

Savings retail deposits
Savings accounts of retail customers.

Term retail deposits
Accounts of retail customers for which a fixed maturity date is set.'

Corporate deposits
Current, savings and term deposits of corporate and SME customers.

Bank deposits
Current, savings and term deposits of banks and other financial institutions.

Debt securities
All debt security instruments issued by the bank.

Trading liabilities
All derivatives issued by the bank.

Subordinated liabilities
Subordinated loans or securities issued by the bank.

Other liabilities
All other liabilities that are not assigned to one of the categories above. These liabilities are assumed to be non-performing in the context of this research. Examples are tax liabilities and pension provisions.

Equity
All the equity of the bank, including common shares and retained earnings. f

Appendix C

Model components

The exposure per asset and liability class at time t (t=0,...,T) is denoted as $x_{ai,t}$ and $x_{li,t}$, respectively. In this research, the difference between t and t+1 is equal to 1 month. The asset side of the balance sheet consists of 8 general asset classes (a=1,...,8) and 10 general liability classes (l=1,...,10), as shown below:

$$a = \begin{bmatrix} Cash & i = 1 \\ Residential\ mortgage\ loans & i = 2 \\ Other\ retail\ loans & i = 3 \\ Corporate\ loans & i = 4 \\ Bank\ loans & i = 5 \\ Bonds & i = 6 \\ Trading\ assets & i = 7 \\ Other\ assets & i = 8 \end{bmatrix} \tag{18}$$

$$l = \begin{bmatrix} Current\ retail\ deposits & i = 1 \\ Savings\ retail\ deposits & i = 2 \\ Term\ retail\ deposits & i = 3 \\ Corporate\ deposits & i = 4 \\ Bank\ deposits & i = 5 \\ Debt\ securities & i = 5 \\ Trading\ liabilities & i = 7 \\ Subordinated\ liabilities & i = 8 \\ Other\ liabilities & i = 9 \\ Equity & i = 10 \end{bmatrix} \tag{19}$$

The asset and liability classes both have subclasses. The asset classes are divided by initial maturity, credit rating and loan-to-value and are denoted as $x_{ai_{mi,ci,vi},t}$. The liability classes are divided by initial maturity and therefore are denoted as $x_{li_{mi},t}$. This is shown below:

$$m = \begin{bmatrix} Not\ applicable & i = 0 \\ On\ demand & i = 1 \\ < 1\ year & i = 2 \\ \geq 1 year < 5 year & i = 3 \\ > 5\ year & i = 4 \end{bmatrix} \tag{20}$$

$$c = \begin{bmatrix} Not\ applicable & i = 0 \\ < BBB- & i = 1 \\ BBB - to\ A+ & i = 2 \\ AA - to\ AAA & i = 3 \end{bmatrix} \tag{21}$$

$$c = \begin{bmatrix} Not\ applicable & i = 0 \\ < BBB- & i = 1 \\ BBB - to\ A+ & i = 2 \\ AA - to\ AAA & i = 3 \end{bmatrix} \tag{22}$$

In Table C.1 and Table C.2, the complete set of different asset and liability classes used in the model can be found. The classes are divided, if applicable, based on maturity, credit rating, and LTV.

There are some other assumptions about the model components that the model must adhere to. First, the asset side and the liability side should be equal. Therefore, the following equation must be met at all times:

$$\sum_{i=1}^{8} x_{ai,t} = \sum_{i=1}^{10} x_{li,t} \tag{23}$$

Furthermore, at time *t=0*, the sum of the assets and the sum of the liabilities should be equal to 1. After *t=0* the size can deviate from 1, showing the relative size to *t=0*. This is defined as follows:

$$\sum_{i=1}^{8} x_{ai,0} = 1\ and\ \sum_{i=1}^{10} x_{li,0} = 1 \tag{24}$$

Lastly, at all times, the different subclasses must have a value between 0 and the total size of the balance sheet. This ensures that no short-selling will take place and that the individual subclasses do not become bigger than the total bank size, as shown below:

$$0 \leq x_{ai_{mi,ci,vi},t} \leq \sum_{i=1}^{8} x_{ai,t}\ and\ 0 \leq x_{li_{mi},t} \leq \sum_{i=1}^{10} x_{li,t} \tag{25}$$

TABLE C.1: Asset (sub)classes included in the model

	Asset class	Initial maturity	Credit rating	LTV
1	Cash	-	-	
2	Residential mortgage loans	<1y	<BBB-	<80%
3	Residential mortgage loans	<1y	<BBB-	>80%
4	Residential mortgage loans	<1y	BBB- to AAA	<80%
5	Residential mortgage loans	<1y	BBB- to AAA	>80%
6	Residential mortgage loans	>1y <5y	<BBB-	<80%
7	Residential mortgage loans	>1y <5y	<BBB-	>80%
8	Residential mortgage loans	>1y <5y	BBB- to AAA	<80%
9	Residential mortgage loans	>1y <5y	BBB- to AAA	>80%
10	Residential mortgage loans	>5y	<BBB-	<80%
11	Residential mortgage loans	>5y	<BBB-	>80%
12	Residential mortgage loans	>5y	BBB- to AAA	<80%
13	Residential mortgage loans	>5y	BBB- to AAA	>80%
14	Other retail loans	<1y	<BBB-	
15	Other retail loans	<1y	BBB- to AAA	
16	Other retail loans	>1y	<BBB-	
17	Other retail loans	>1y	BBB- to AAA	
18	Corporate loans	<1y	<BBB-	
19	Corporate loans	<1y	BBB- to AAA	
20	Corporate loans	>1y	<BBB-	
21	Corporate loans	>1y	BBB- to AAA	
22	Bank loans	On-demand	<BBB-	
23	Bank loans	On-demand	BBB- to AAA	
24	Bank loans	<1y	<BBB-	
25	Bank loans	<1y	BBB- to AAA	
26	Bank loans	>1y	<BBB-	
27	Bank loans	>1y	BBB- to AAA	
30	Bonds	<5y	<BBB-	
29	Bonds	<5y	BBB- to A+	
28	Bonds	<5y	AA- to AAA	
33	Bonds	>5y	<BBB-	
32	Bonds	>5y	BBB- to A+	
31	Bonds	>5y	AA- to AAA	
34	Trading assets	On-demand	<BBB-	
35	Trading assets	On-demand	BBB- to AAA	
36	Trading assets	<1y	<BBB-	
37	Trading assets	<1y	BBB- to AAA	
38	Trading assets	>1y	<BBB-	
39	Trading assets	>1y	BBB- to AAA	
40	Other assets	-	-	

TABLE C.2: Liability (sub)classes included in the model

	Liability class	Maturity
1	Current retail deposits	-
2	Savings retail deposits	-
3	Term retail deposits	<1y
4	Term retail deposits	>1y
5	Corporate deposits	<1y
6	Corporate deposits	>1y
7	Bank deposits	<1y
8	Bank deposits	>1y
9	Debt securities	<1y
10	Debt securities	>1y <5y
11	Debt securities	>5y
12	Trading liabilities	<1y
13	Trading liabilities	>1y <5y
14	Trading liabilities	>5y
15	Subordinated liabilities	<1y
16	Subordinated liabilities	>1y <5y
17	Subordinated liabilities	>5y
18	Other liabilities	-
19	Equity	-

Appendix D

2018 EU-wide stress test

In the document "Adverse macro-financial scenario for the 2018 EU-wide banking sector stress test", the ESRB elaborates on the macro-financial scenarios that are the basis of the 2018 EU-wide stress test. First, a baseline scenario is developed based on current economic forecasts. On the baseline scenario, an adverse scenario is applied. The adverse scenario reflects the systemic risk identified by the ESRB. The scenario includes several macroeconomic variables like GDP, inflation, unemployment, asset prices, and interest rates and covers a three-year period, starting from January 1st, 2018 and ending on December 31st, 2020. Below, a summary of the adverse scenario is given.

"The scenario is triggered by a shock to bond yields and equity prices in global financial markets. This reflects change in market participants' expectations about economic policies in major economies outside the EU, which triggers a repricing of risk premia. [...] EU stock prices would also fall sharply, by about 30% in 2018 in comparison with the baseline.

At the same time, the exogenous shock to risk premia would affect valuations in bond markets, where yields on long-term US Treasuries are assumed to rise sharply [...]. The re-pricing of bond markets would spill over to the prices of European fixed-income instruments. [...]. Overall, long-term interest rates in the European Union would be higher by 83 basis points in 2018, 85 basis points in 2019 and 80 basis points in 2020. [...]. Within the European Union, monetary policy is assumed to follow the same expectations implied by the baseline scenario, which would also limit the spillover [from the US] to EU long-term interest rates.

[...]

Money market rates (three-month interbank offered rates) in all EU countries would rise by about 55 basis points compared with the baseline scenario in 2018, reflecting higher credit premiums for banks. [...]. As, under the adverse scenario, monetary policy is assumed to follow the expectations implied by the baseline scenario, this increase should not be interpreted as being driven by monetary policy decisions.

[...]. In the adverse scenario, GDP would fall between 2.5 and 7.4% below the baseline level by 2020 for the non-EU countries. [...]. This would have an impact on EU economies, as foreign demand for EU exports would be materially reduced by 9.3% in terms of deviation from baseline levels in 2019. [...].

The global shocks are also assumed to negatively affect confidence in all EU countries, resulting in country-specific reductions in private consumption and investment which take into account recent economic performance of each country. The significant decline of domestic demand, together with increased risk premia, would trigger domestic vulnerabilities in the residential and commercial real estate sectors which could results in a major slowdown in property market activity, both in the residential and commercial property segments. [...].

[. . .]

Overall, as a result of the combined foreign and domestic real and financial shocks, the scenario implies a deviation of EU GDP from its baseline level by 8.3% in 2020, resulting in the most severe scenario in terms of GDP deviation from baseline levels compared with the previous two EBA exercises. [. . .]. A large part of the impact on GDP is driven by the domestic confidence shocks triggered by global turmoil, which together reduce EU real GDP by about 3.6 percentage points compared with the baseline by 2020. [. . .]."

Appendix E

Business model samples

		Business model	Country	Cash	Customer loans	Bank loans	Trading assets	Customer deposits	Bank deposits	Debt liabilities	Derivative exposure	Equity	Total Assets (€bn)	G-SIB/ D-SIB
1	Bankia	Investment	Spain	2,1%	57,5%	1,4%	38,9%	61,0%	17,6%	11,6%	3,5%	6,4%	€ 213,93	D-SIB
2	Société Générale*	Investment	France	9,0%	33,3%	4,8%	52,4%	32,2%	6,9%	25,9%	29,9%	5,0%	€1.275,13	G-SIB
3	UniCredit*	Investment	Italy	7,7%	53,5%	8,5%	29,9%	55,3%	14,7%	15,6%	7,8%	6,5%	€ 836,79	G-SIB
4	Novo Banco	Investment	Portugal	7,3%	49,5%	1,1%	42,0%	58,0%	16,2%	15,3%	1,2%	9,3%	€ 52,05	D-SIB
5	KBC Group*	Investment	Belgium	10,2%	48,4%	8,4%	32,7%	66,3%	11,4%	12,7%	3,1%	6,4%	€ 256,32	D-SIB
6	Banque Internationale	Investment	Luxembourg	9,0%	52,0%	4,6%	33,8%	69,7%	9,6%	9,4%	5,9%	5,4%	€ 23,15	D-SIB
7	Belfius bank*	Investment	Belgium	2,9%	50,8%	12,5%	33,8%	42,0%	7,1%	24,8%	21,0%	5,1%	€ 167,96	D-SIB
8	Intesa Paolo*	Investment	Italy	1,2%	51,5%	9,1%	37,2%	12,5%	40,6%	24,9%	14,7%	7,2%	€ 796,86	D-SIB
9	Banca Monte dei Paschi di Siena	Investment	Italy	2,9%	62,1%	7,2%	27,6%	55,3%	15,2%	20,9%	3,9%	4,7%	€ 139,15	D-SIB
10	BPCE*	Investment	France	7,5%	55,0%	7,3%	29,7%	45,2%	7,3%	30,9%	10,9%	5,7%	€1.259,90	G-SIB
11	Kutxkabank	Retail	Spain	7,7%	73,1%	1,0%	17,6%	72,8%	7,8%	9,8%	0,1%	9,5%	€ 57,44	-
12	Rabobank*	Retail	Netherlands	11,1%	71,7%	4,5%	12,5%	56,5%	3,1%	31,4%	2,4%	6,6%	€ 602,99	D-SIB
13	Volksbank	Retail	Netherlands	3,6%	81,0%	4,3%	11,1%	76,9%	4,4%	10,5%	2,1%	6,1%	€ 60,89	D-SIB
14	Bankhaus Krentschker	Retail	Austria	0,6%	78,6%	6,8%	14,1%	64,2%	14,6%	14,9%	0,0%	6,3%	€ 1,10	-
15	Permanent tsb	Retail	Ireland	0,3%	80,7%	6,7%	12,2%	74,6%	8,1%	7,8%	0,2%	9,3%	€ 22,78	-
16	National Bank	Retail	Germany	16,0%	70,0%	0,8%	13,1%	80,1%	10,0%	2,7%	0,0%	7,3%	€ 4,52	-
17	Hanseatic Bank	Retail	Germany	0,6%	91,7%	0,0%	7,5%	68,3%	17,6%	3,4%	0,0%	10,7%	€ 2,86	-
18	Bankinter	Retail	Spain	7,8%	74,5%	0,5%	16,8%	62,4%	12,1%	16,6%	2,8%	6,1%	€ 71,33	-
19	Bank of Cyprus	Retail	Cyprus	14,4%	61,9%	5,1%	18,0%	75,6%	6,0%	7,0%	0,2%	11,1%	€ 23,60	D-SIB
20	Caixa Geral de Depositos	Retail	Portugal	2,0%	67,2%	4,3%	26,5%	74,5%	6,2%	12,6%	2,6%	4,2%	€ 93,25	D-SIB
21	IKB Deutsche Industriebank AG	Wholesale	Germany	0,2%	56,4%	14,6%	28,8%	37,4%	43,2%	14,6%	0,0%	4,8%	€ 17,22	-
22	Oesterreichische Kontrollbank AG	Wholesale	Austria	1,6%	5,9%	62,3%	30,2%	2,9%	1,6%	90,2%	2,1%	3,1%	€ 26,00	-
23	Landwirscheeaftliche rentenbank	Wholesale	Germany	0,0%	7,6%	66,7%	25,7%	4,2%	3,0%	91,4%	0,0%	1,4%	€ 90,79	D-SIB
24	Banque Tarneaud	Wholesale	France	0,8%	71,2%	26,5%	1,2%	63,5%	31,4%	4,4%	0,0%	0,7%	€ 4,00	-
25	Dexia Crediop	Wholesale	Italy	0,0%	73,5%	16,3%	10,2%	22,5%	50,1%	18,7%	6,5%	2,2%	€ 20,53	-
26	Raiffeisenbank Niederösterreich-Wien	Wholesale	Austria	4,1%	45,2%	21,2%	29,6%	30,2%	30,4%	29,1%	1,6%	8,7%	€ 25,71	D-SIB
27	Crédit Agricole*	Wholesale	France	3,1%	5,2%	46,2%	45,4%	41,5%	5,2%	32,9%	14,2%	6,1%	€1.763,20	G-SIB
28	Mediobanca International SA	Wholesale	Luxembourg	0,3%	58,3%	39,6%	1,9%	11,3%	31,1%	56,9%	0,4%	0,3%	€ 70,45	-
29	The Bank of New York Mellon	Wholesale	Netherlands	32,1%	0,0%	25,5%	41,2%	0,0%	88,9%	2,0%	0,3%	8,7%	€ 36,67	D-SIB
30	Bayerische Landesbank*	Wholesale	Germany	1,7%	62,8%	17,6%	17,9%	42,9%	25,4%	22,7%	4,0%	5,0%	€ 214,52	D-SIB

*These banks are also included in the EBA 2018 EU-wide stress test

Appendix F

Average balance sheet profile per business model

Based on information from the annual reports of the banks in the sample, an average distribution is made per business model amongst the general asset and liability classes (Table F.2), amongst LTV classes (Table F.1), amongst remaining maturity classes (Table F.4), and amongst credit rating classes (Table F.3). The classes of Table F.2 are based on the general business model classes as presented in Section 3.1. The classes of Table F.1, Table F.4 and Table F.3 are based on the classes as to how they are generally presented in annual reports. Table F.5 is constructed based on the remaining maturity, as explained in Section 4.3.2.

When comparing the distributions of the different business models, the most striking remark to be made is that nearly all assets classes of the wholesale business model have a substantially higher credit rating than the asset classes of the retail business model, which in turn has a substantially higher credit rating than the investment business model. Additionally, the distribution of the business models amongst the general asset and liability classes is in line with the description of the business models as in Section 2.2.2. The distribution amongst the LTV classes is more or less equal for all business models. Lastly, when comparing the distribution among maturity classes, it is found that the retail business model has a higher share of on-demand assets and liabilities, whereas the other two business models have a higher share of asset and liabilities with maturity between 1 and 3 months.

TABLE F.1: Distribution per business model - LTV classes

	<40%	40%-60%	60%-80%	80%-100%	>100%
Retail	18.1%	30.8%	27.8%	14.7%	8.5%
Wholesale	20.0%	31.1%	28.8%	11.8%	8.3%
Investment	21.9%	31.5%	29.7%	8.8%	8.1%

TABLE F.2: Distribution per business model - asset & liability classes

	Retail	Wholesale	Investment
Cash	7.4%	4.5%	6.6%
Residential mortgage loans	40.0%	0.5%	24.5%
Other retail loans	9.4%	10.6%	3.3%
Corporate loans	25.4%	31.0%	25.3%
Bank loans	3.0%	32.2%	6.5%
Bonds	8.5%	13.3%	17.1%
Trading assets	2.6%	5.2%	11.0%
Other assets	3.7%	2.6%	5.7%
Current retail deposits	15.3%	3.2%	20.0%
Savings retail deposits	16.9%	2.6%	11.5%
Term retail deposits	15.3%	2.5%	7.1%
Corporate deposits	23.2%	15.5%	15.4%
Bank deposits	8.2%	33.8%	12.2%
Debt securities	6.8%	30.0%	10.8%
Trading liabilities	0.9%	1.2%	1.3%
Subordinated liabilities	2.0%	2.4%	7.9%
Other liabilities	3.6%	3.8%	7.8%
Equity	7.9%	5.0%	6.0%

TABLE F.3: Distribution per business model - credit rating classes

Business model	Asset classes	AAA	AA+ - AA-	A+ - A-	BBB+ - BBB-	BB+ - BB-	B+ - B-	CCC/C
Retail	Residential mortgages	29.6%	23.5%	21.2%	12.1%	12.0%	1.4%	0.2%
	Other retail loans	29.6%	23.5%	21.2%	12.1%	12.0%	1.4%	0.2%
	Corporate loans	29.6%	23.5%	21.2%	12.1%	12.0%	1.4%	0.2%
	Bank loans	35.4%	15.5%	13.8%	35.0%	0.2%	0.1%	0.0%
	Bonds	43.7%	23.6%	9.0%	21.7%	1.3%	0.7%	0.0%
	Trading assets	25.4%	15.0%	32.4%	19.9%	2.6%	4.6%	0.0%
Wholesale	Residential mortgages	49.3%	29.0%	15.6%	4.1%	1.2%	0.7%	0.0%
	Other retail loans	49.3%	29.0%	15.6%	4.1%	1.2%	0.7%	0.0%
	Corporate loans	49.3%	29.0%	15.6%	4.1%	1.2%	0.7%	0.0%
	Bank loans	34.7%	31.0%	27.1%	5.3%	1.2%	0.7%	0.0%
	Bonds	62.0%	22.3%	9.4%	5.6%	0.7%	0.0%	0.0%
	Trading assets	44.7%	23.8%	28.2%	2.5%	0.5%	0.5%	0.0%
Investment	Residential mortgages	9.9%	18.1%	26.8%	20.1%	16.2%	6.8%	2.0%
	Other retail loans	9.9%	18.1%	26.8%	20.1%	16.2%	6.8%	2.0%
	Corporate loans	8.4%	10.0%	21.9%	25.3%	22.8%	9.5%	2.1%
	Bank loans	7.1%	8.7%	25.5%	23.7%	24.9%	8.1%	2.1%
	Bonds	25.5%	25.0%	8.6%	37.8%	2.0%	1.3%	0.0%
	Trading assets	6.2%	6.3%	36.6%	37.4%	4.7%	8.7%	0.1%

TABLE F.4: Distribution per business model - remaining maturity classes

		On demand / no maturity	<3m	3m - 1y	1y - 5y	>5y
Retail	Residential mortgages	0.0%	3.8%	5.2%	17.30%	73.70%
	Other retail loans	15.5%	9.5%	16.9%	31.5%	26.6%
	Corporate loans	15.5%	9.5%	16.9%	31.5%	26.6%
	Bank loans	59.2%	23.3%	11.9%	2.7%	2.9%
	Bonds	0.0%	1.6%	7.4%	46.8%	44.2%
	Trading assets	43.8%	5.1%	14.3%	10.8%	26.1%
	Term deposits	0.0%	21.0%	41.0%	25.3%	12.7%
	Corporate deposits	31.1%	14.5%	28.2%	17.5%	8.8%
	Bank deposits	31.0%	3.8%	7.8%	46.0%	11.5%
	Debt securities	7.3%	7.1%	9.6%	38.7%	37.2%
	Trading liabilities	0.8%	0.1%	39.2%	33.9%	26.1%
	Subordinated liabilities	13.1%	3.4%	11.6%	33.7%	38.3%
Wholesale	Residential mortgages	0.0%	1.4%	2.0%	24.00%	72.60%
	Other retail loans	5.5%	7.9%	11.4%	40.4%	34.8%
	Corporate loans	2.3%	20.4%	19.9%	23.4%	33.9%
	Bank loans	32.6%	24.1%	11.8%	13.6%	17.9%
	Bonds	0.0%	21.9%	9.0%	34.4%	34.7%
	Trading assets	12.3%	4.8%	17.2%	34.4%	31.2%
	Term deposits	0.0%	61.4%	6.9%	14.6%	17.2%
	Corporate deposits	27.0%	44.8%	5.0%	10.6%	12.5%
	Bank deposits	36.6%	17.7%	8.2%	18.7%	18.8%
	Debt securities	0.2%	25.6%	23.0%	30.4%	20.8%
	Trading liabilities	0.5%	3.6%	3.7%	42.4%	49.9%
	Subordinated liabilities	0.1%	13.8%	39.4%	19.0%	27.8%
Investment	Residential mortgages	0.0%	2.4%	6.8%	14.65%	76.15%
	Other retail loans	11.5%	19.3%	8.7%	25.7%	34.9%
	Corporate loans	11.5%	19.3%	8.7%	25.7%	34.8%
	Bank loans	38.1%	23.7%	17.5%	11.4%	9.3%
	Bonds	0.0%	10.1%	14.3%	36.3%	39.3%
	Trading assets	66.0%	6.0%	6.1%	11.4%	10.4%
	Term deposits	0.0%	49.1%	23.4%	17.7%	9.8%
	Corporate deposits	43.5%	27.7%	13.2%	10.0%	5.6%
	Bank deposits	21.7%	23.8%	9.5%	39.8%	5.1%
	Debt securities	0.3%	18.2%	12.8%	33.9%	34.8%
	Trading liabilities	10.9%	2.6%	3.0%	6.7%	76.8%
	Subordinated liabilities	1.2%	43.8%	8.4%	21.1%	25.5%

TABLE F.5: Distribution per business model - initial maturity classes

Business model	Classes	On demand / no maturity	<3m	3m - 1y	1y - 5y	>5y
Retail	Residential mortgages	0.0%	0.1%	0.5%	4.88%	94.50%
	Other retail loans	15.5%	1.1%	5.7%	27.7%	50.0%
	Corporate loans	15.5%	1.1%	5.7%	27.7%	50.0%
	Bank loans	59.2%	13.3%	14.8%	4.6%	8.0%
	Bonds	0.0%	0.0%	0.7%	28.3%	70.9%
	Trading assets	43.8%	0.5%	5.3%	7.1%	43.4%
	Term deposits	0.0%	4.4%	29.9%	35.3%	30.4%
	Corporate deposits	31.1%	3.0%	20.6%	24.3%	21.0%
	Bank deposits	31.0%	0.2%	1.4%	44.8%	22.6%
	Debt securities	7.3%	0.5%	1.8%	27.1%	63.2%
	Trading liabilities	0.8%	0.0%	15.5%	32.6%	51.2%
	Subordinated liabilities	13.1%	0.1%	2.1%	21.7%	63.0%
Wholesale	Residential mortgages	0.0%	0.0%	0.1%	6.79%	93.13%
	Other retail loans	5.5%	0.7%	2.4%	30.4%	60.9%
	Corporate loans	2.3%	4.3%	9.3%	20.5%	63.6%
	Bank loans	32.6%	8.6%	7.5%	14.5%	36.8%
	Bonds	0.0%	4.8%	3.0%	28.6%	63.6%
	Trading assets	12.3%	0.3%	4.5%	27.1%	55.8%
	Term deposits	0.0%	37.7%	5.5%	18.3%	38.6%
	Corporate deposits	27.0%	27.5%	4.0%	13.3%	28.2%
	Bank deposits	36.6%	5.0%	3.7%	17.9%	36.8%
	Debt securities	0.2%	6.6%	13.0%	35.2%	45.0%
	Trading liabilities	0.5%	0.1%	0.3%	22.6%	76.5%
	Subordinated liabilities	0.1%	1.9%	23.5%	19.0%	55.6%
Investment	Residential mortgages	0.0%	0.1%	0.6%	3.74%	95.57%
	Other retail loans	11.5%	4.2%	3.0%	19.7%	61.6%
	Corporate loans	11.5%	4.2%	3.0%	19.7%	61.6%
	Bank loans	38.1%	9.0%	14.7%	15.9%	22.3%
	Bonds	0.0%	1.0%	3.7%	26.9%	68.4%
	Trading assets	66.0%	1.1%	2.4%	10.6%	19.9%
	Term deposits	0.0%	24.1%	22.2%	28.2%	25.5%
	Corporate deposits	43.5%	13.6%	12.6%	15.9%	14.4%
	Bank deposits	21.7%	7.2%	4.6%	54.3%	12.2%
	Debt securities	0.3%	3.3%	4.3%	28.3%	63.7%
	Trading liabilities	10.9%	0.1%	0.2%	1.0%	87.9%
	Subordinated liabilities	1.2%	19.4%	5.0%	22.1%	52.3%

Appendix G

Interest rate estimations

For each asset and liability class of Appendix C, an interest rate is derived, as shown in Table G.1 and Table G.2. The table reports the minimum value, the maximum value, the average value, and the last value of the interest rates over the past 5 years. The table also presents the sources from which the interest rates are derived.

TABLE G.1: Interest rate estimations per liability class

Liability class	Interest rates				Source
	Max	Mean	Last	Last	
1	0.03%	0.26%	0.11%	0.03%	ECB – Deposits from households, overnight
2	0.24%	1.44%	0.54%	0.33%	ECB – Deposits from households, redeemable at notice
3	0.29%	1.55%	0.63%	0.32%	ECB – Deposits from households, maturity <1Y
4	0.41%	1.68%	0.78%	0.52%	ECB – Deposits from households, maturity >1Y
5	0.04%	0.57%	0.18%	0.04%	ECB – Deposits from corporations, maturity <1Y
6	0.19%	1.41%	0.55%	0.42%	ECB – Deposits from corporations, maturity <1Y
7-8	-	-	-	-	
9	1.40%	2.62%	1.92%	1.83%	Bloomberg – Average Bloomberg Barclays Global Aggregate Corporate Total Return Index EUR & USD
10	2.22%	3.49%	2.79%	2.86%	Bloomberg – Average Bloomberg Barclays Euro Aggregate Corporate Total Return Index EUR & USD
11	2.22%	3.49%	2.79%	2.86%	Bloomberg – Average Bloomberg Barclays Euro Aggregate Corporate Total Return Index EUR & USD
12-14	-	-	-	-	
15	-	-	3.27%	-	Bloomberg – Average Ostrom Global Subordinated Debt, Amundi Funds II – Global Subordinated Bond, Allianz Euro Subordinated Financials.
16	-	-	3.27%	-	Bloomberg – Average Ostrom Global Subordinated Debt, Amundi Funds II – Global Subordinated Bond, Allianz Euro Subordinated Financials.
17	-	-	3.27%	-	Bloomberg – Average Ostrom Global Subordinated Debt, Amundi Funds II – Global Subordinated Bond, Allianz Euro Subordinated Financials.
18-19	-	-	-	-	

TABLE G.2: Interest rate estimations per asset class

Asset class	Interest rates				Source
	Min	Max	Mean	Last	
1	-	-	-	-	
2	1.40%	2.49%	1.73%	1.41%	ECB – Loans to households for house purchases, maturity <1Y. Adjusted for LTV based on DNB data
3	1.77%	3.13%	2.18%	1.78%	ECB – Loans to households for house purchases, maturity <1Y. Adjusted for LTV based on DNB data
4	1.40%	2.49%	1.73%	1.41%	ECB – Loans to households for house purchases, maturity <1Y. Adjusted for LTV based on DNB data
5	1.77%	3.13%	2.18%	1.78%	ECB – Loans to households for house purchases, maturity <1Y. Adjusted for LTV based on DNB data
6	1.15%	2.70%	1.88%	1.60%	ECB – Loans to households for house purchases, maturity >1Y. <5Y Adjusted for LTV based on DNB data
7	1.44%	3.40%	2.36%	2.01%	ECB – Loans to households for house purchases, maturity >1Y. <5Y Adjusted for LTV based on DNB data
8	1.15%	2.70%	1.88%	1.60%	ECB – Loans to households for house purchases, maturity >1Y. <5Y Adjusted for LTV based on DNB data
9	1.44%	3.40%	2.36%	2.01%	ECB – Loans to households for house purchases, maturity >1Y. <5Y Adjusted for LTV based on DNB data
10	1.56%	2.90%	1.96%	1.64%	ECB – Loans to households for house purchases, maturity >5Y. Adjusted for LTV based on DNB data
11	1.96%	3.64%	2.46%	2.06%	ECB – Loans to households for house purchases, maturity >5Y. Adjusted for LTV based on DNB data
12	1.56%	2.90%	1.96%	1.64%	ECB – Loans to households for house purchases, maturity >5Y. Adjusted for LTV based on DNB data
13	1.96%	3.64%	2.46%	2.06%	ECB – Loans to households for house purchases, maturity >5Y. Adjusted for LTV based on DNB data
14	4.47%	5.78%	5.12%	5.28%	ECB – Loans to households for consumption, maturity <1Y
15	4.47%	5.78%	5.12%	5.28%	ECB – Loans to households for consumption, maturity <1Y
16	5.11%	6.61%	5.85%	6.04%	ECB – Loans to households for consumption, maturity >1Y
17	5.11%	6.61%	5.85%	6.04%	ECB – Loans to households for consumption, maturity >1Y
18	1.62%	3.01%	2.05%	1.65%	ECB – Loans to corporations, maturity <1Y
19	1.62%	3.01%	2.05%	1.65%	ECB – Loans to corporations, maturity <1Y
20	2.28%	4.59%	3.15%	2.41%	ECB – Loans to corporations, maturity >1Y
21	2.28%	4.59%	3.15%	2.41%	ECB – Loans to corporations, maturity >1Y
22 - 27	-	-	-	-	
28	2.16%	16.98%	7.47%	5.98%	Bloomberg – 5Y government bonds of Greece, Brazil & South Africa
29	-0.13%	3.79%	1.24%	0.25%	Bloomberg – 5Y government bonds of Italy, Portugal, Spain, Cyprus & Ireland
30	-0.45%	3.12%	0.41%	0.12%	Bloomberg – 5Y government bonds of France, Austria, Belgium, Germany, Netherlands, USA & Luxembourg
31	3.29%	12.64%	7.68%	7.09%	Bloomberg – 10Y government bonds of Greece, Brazil & South Africa
32	0.54%	2.93%	1.66%	1.37%	Bloomberg – 10Y government bonds of Italy, Portugal, Spain & Ireland
33	-0.08%	2.76%	0.75%	0.62%	Bloomberg – 10Y government bonds of France, Austria, Belgium, Germany, Netherlands, USA & Luxembourg
34 - 40	-	-	-	-	

Appendix H

Probability of default estimations

Based on historical data of S&P, Moody's and Fitch, an average PD per credit class and per counterparty is calculated (Table H.1). This is combined with the exposures per credit rating class for the different business models (Table F.3), to calculate the average weighted PD per asset class for the three banking business models (Table H.2).

TABLE H.1: Historical PDs per credit class and per counterparty

Panel A: Retail PDs							
	AAA	AA+ - AA-	A+ - A-	BBB+ - BBB-	BB+ - BB-	B+ - B-	CCC/C
S&P	0.03%	0.26%	0.64%	1.62%	3.22%	5.13%	15.84%
Moody's	0.03%	0.20%	0.78%	1.13%	2.30%	4.43%	21.11%
Fitch	0.01%	0.13%	0.34%	0.96%	3.05%	11.95%	33.00%
Average	0.02%	0.20%	0.59%	1.24%	2.86%	7.17%	23.32%
Panel B: Sovereign PDs							
	AAA	AA+ - AA-	A+ - A-	BBB+ - BBB-	BB+ - BB-	B+ - B-	CCC/C
S&P	0.00%	0.00%	0.00%	0.00%	0.58%	1.42%	16.13%
Moody's	0.00%	0.00%	0.00%	0.10%	0.60%	2.40%	8.10%
Fitch	0.00%	0.00%	0.00%	0.00%	1.59%	1.31%	26.09%
Average	0.00%	0.00%	0.00%	0.03%	0.92%	1.71%	16.77%
Panel C: Corporate PDs							
	AAA	AA+ - AA-	A+ - A-	BBB+ - BBB-	BB+ - BB-	B+ - B-	CCC/C
S&P	0.00%	0.02%	0.06%	0.17%	0.68%	3.59%	26.82%
Moody's	0.00%	0.03%	0.04%	0.20%	0.92%	4.50%	14.85%
Fitch	0.00%	0.03%	0.07%	0.17%	0.94%	1.93%	23.52%
Average	0.00%	0.03%	0.06%	0.18%	0.85%	3.34%	21.73%

TABLE H.2: PD estimations per business model

Asset class	Retail	Wholesale	Investment
1			
2	1.39%	2.13%	3.17%
3	1.39%	2.13%	3.17%
4	0.05%	0.02%	0.07%
5	0.05%	0.02%	0.07%
6	1.39%	2.13%	3.17%
7	1.39%	2.13%	3.17%
8	0.05%	0.02%	0.07%
9	0.05%	0.02%	0.07%
10	1.39%	2.13%	3.17%
11	1.39%	2.13%	3.17%
12	0.05%	0.02%	0.07%
13	0.05%	0.02%	0.07%
14	1.39%	2.13%	3.17%
15	0.05%	0.02%	0.07%
16	1.39%	2.13%	3.17%
17	0.05%	0.02%	0.07%
18	1.39%	2.13%	2.78%
19	0.05%	0.02%	0.09%
20	1.39%	2.13%	2.78%
21	0.05%	0.02%	0.09%
22	2.00%	1.80%	2.65%
23	0.08%	0.03%	0.09%
24	2.00%	1.80%	2.65%
25	0.08%	0.03%	0.09%
26	2.00%	1.80%	2.65%
27	0.08%	0.03%	0.09%
28	1.77%	0.93%	1.99%
29	0.03%	0.01%	0.03%
30	0.00%	0.00%	0.00%
31	1.77%	0.93%	1.99%
32	0.03%	0.01%	0.03%
33	0.00%	0.00%	0.00%
34	2.56%	2.09%	2.60%
35	0.06%	0.03%	0.10%
36	2.56%	2.09%	2.60%
37	0.06%	0.03%	0.10%
38	2.56%	2.09%	2.60%
39	0.06%	0.03%	0.10%
40			

Bibliography

Aivazian, Varouj, Laurence Booth, and Sean Cleary (2003). "Dividend policy and the organization of capital markets". In: *Journal of Multinational Financial Management* 13, pp. 101–121.

Allen, Bill et al. (2012). "Basel III: Is the cure worse than the disease?" In: *International Review of Financial Analysis* 25, pp. 159–166.

Altman, Edward (1968). "Financial ratios, discriminant analysis and the prediction of corporate bankruptcy". In: *Journal of Finance* 23, pp. 589–609.

Altunbas, Yener, Simone Manganelli, and David Marques-Ibanez (2011). "Bank risk during the financial crisis: do business models matter?" In: *ECB working paper series* 1394.

Amel, Dean F and Stephen A Rhoades (1988). "Strategic groups in banking". In: *The Review of Economics and Statistics* 70, pp. 685–689.

Ayadi, Rym, Emrah Arbak, and Willem Pieter De Groen (2011). "Business models in European banking: A pre-and post-crisis screening". In: *Center for European Policy Studies*.

– (2012). "Regulation of European banks and business models: towards a new paradigm?" In: *Centre for European Policy Studies*.

Ayadi, Rym et al. (2016). "Banking business models monitor 2015 Europe". In: *Centre for European Policy Studies*.

Barth, James R, R Dan Brumbaugh, and James A Wilcox (2000). "Policy watch: The repeal of Glass-Steagall and the advent of broad banking". In: *Journal of Economic Perspectives* 14, pp. 191–204.

BCBS (2010). *Assessing the macroeconomic impact of the transition to stronger capital and liquidity requirements*.

– (2011). *Basel III: A global regulatory framework for more resilient banks and banking systems - revised*.

– (2013). *Basel III: The Liquidity Coverage Ratio and liquidity risk monitoring tools*.

– (2014). *Basel III: the Net Stable Funding Ratio*.

– (2016). *Interest rate risk in the banking book*.

Beau, Emily et al. (2014). "Bank funding costs: what are they, what determines them and why do they matter?" In: *Bank of England Quarterly Bulletin*, Q4.

Black, Fischer (1976). "The dividend puzzle". In: *The Journal of Portfolio Management* 2, pp. 5–8.

Caruana, Jaime and Adrian Van Rixtel (2013). "International financial markets and bank funding in the euro area: dynamics and participants". In: *BIS Research paper*.

Cassola, Nuno, Ali Hortaçsu, and Jakub Kastl (2013). "The 2007 subprime market crisis through the lens of European central bank auctions for short-term funds". In: *Econometrica* 81, pp. 1309–1345.

Choudry, Moorad (2017). "Strategic ALM and integrated balance sheet management: The future of bank risk management". In: *European Finance Review*.

De Haan, Leo and Jan Willem van den End (2013). "Bank liquidity, the maturity ladder, and regulation". In: *Journal of Banking & Finance* 37, pp. 3930–3950.

Demirgüç-Kunt, Asli and Harry Huizinga (2010). "Bank activity and funding strategies: The impact on risk and returns". In: *Journal of Financial Eonomics* 98, pp. 626–650.

DeSarbo, Wayne S and Rajdeep Grewal (2008). "Hybrid strategic groups". In: *Strategic Management Journal* 29, pp. 293–317.

Diamond, Douglas W and Philip H Dybvig (1983). "Bank runs, deposit insurance, and liquidity". In: *Journal of Political Economy* 91, pp. 401–419.

Dumičić, Mirna and Tomislav Rizdak (2013). "Determinants of banks' net interest margins in Central and Eastern Europe". In: *Financial Theory and Practice* 37, pp. 1–30.

EBA (2018a). *2018 EU-wide stress test - methodological note*.

– (2018b). *2018 EU-wide stress test - results*.

– (2019). *EU-wide stress testing*. URL: https://eba.europa.eu/risk-analysis-and-data/eu-wide-stress-testing.

ESRB (2018). *Adverse marcro-financial scenario for the 2018 EU-wide banking sector stress test*.

Farnè, Matteo and Angelos Vouldis (2017). "Business models of the banks in the Euro Area". In: *ECB Working Paper series* 2070.

Giordana, Gaston and Ingmar Schumacher (2012). "An empirical study on the impact of Basel III standards on banks? Default risk: The case of Luxembourg". In: *Journal of Risk and Financial Management*.

Härle, Philipp et al. (2010). "Basel III and European banking: Its impact, how banks might respond, and the challenges of implementation". In: *EMEA Banking*, pp. 16–17.

Hillier, David et al. (2014). *Fundamentals of corporate finance*. McGraw Hill.

Hull, John (2012). *Risk management and financial institutions*. John Wiley & Sons.

Köhler, Matthias (2015). "Which banks are more risky? The impact of business models on bank stability". In: *Journal of Financial Stability* 16, pp. 195–212.

KPMG (2011). *Basel III: Issues and Implications*.

Martel, Merck, Adrian van Rixtel, and E González Mota (2012). "Business models of international banks in the wake of the 2007–2009 global financial crisis". In: *Bank of Spain, Revista de Estabilidad Financiera* 22, pp. 99–121.

Mehra, Ajay (1996). "Resource and market based determinants of performance in the US banking industry". In: *Strategic Management Journal* 17, pp. 307–322.

Mergaerts, Frederik and Rudi Vander Vennet (2016). "Business models and bank performance: A long-term perspective". In: *Journal of Financial Stability* 22, pp. 57–75.

Payant, Randy (2007). "Economic value of equity — the essentials". In: *Financial Managers Society*.

Pompe, Paul and Jan Bilderbeek (2005). "The prediction of bankruptcy of small-and medium-sized industrial firms". In: *Journal of Business Venturing* 20, pp. 847–868.

Prabha, Apanard Penny and Clas Wihlborg (2014). "Implicit guarantees, business models and banks' risk-taking through the crisis: Global and European perspectives". In: *Journal of Economics and Business* 76, pp. 10–38.

Roengpitya, Rungporn, Nikola A Tarashev, and Kostas Tsatsaronis (2014). "Bank business models". In: *BIS Quarterly Review*.

Roengpitya, Rungporn et al. (2017). "Bank business models: popularity and performance". In: *BIS Quarterly Review*.

Simiyu, A (2014). "Signalling theory of dividends". In: *Journal of Behavioral Finance* 1, pp. 1–10.