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Potential implications of a NSFR on German banks' credit supply and profitability

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Non-technical summary

Research Question

The financial crisis showed that a sound capital base is a necessary, but not sufficient condition for banks to be resilient to major shocks: sound liquidity buffers to withstand short-term liquidity shocks and a sound stable funding base to withstand prolonged investors' mistrust are equally important. The Basel Committee has formalized the latter lesson into the *Net Stable Funding Ratio* (NSFR) as a part of its regulatory reform package Basel III. It will require banks to fund their long-term assets using long-term liabilities: a modern version of the 'Golden rule of Banking'. By limiting the maturity mismatch between assets and liabilities, this might reduce banks' mismatch income and profitability. Furthermore, banks might respond to this new regulatory constraint by reducing their long-term asset holdings, and hence restrict the supply of credit. Precisely the potential impact on banks' profitability and credit supply is estimated in our study setting up a microeconomic banking model and applying it to all German banks.

Contribution

Our paper makes three contributions to the existing literature. Firstly, our NSFR estimates are partially calibrated to actual NSFR figures reported by individual banks, minimizing the modeling error. Secondly, our compliance strategies are not heuristics, but result as optimal strategies from an optimization on a bank level. Thirdly, our profit decomposition into margin income, mismatch income and operations adjustment costs is more granular than in previous impact studies and more closely aligned to how banks internally measure profitability and associated risks.

Results

Using data as of 31 December 2012, we find that 9% of German banks did not comply with the NSFR as defined by the Basel Committee later in 2014. This is a significant reduction compared to the 39% that we find with its prior definition, the NSFR (2010), for the same sample. Structurally, banks that do not comply with the NSFR (2014) hold less liquid assets, rely less on retail funding, but more on short-term market funding and are more highly leveraged. A microeconomic model applied to each of the 163 non-compliant banks suggests that they would engage in 70 different strategies to become compliant. All strategies are growth strategies and none of them cuts lending. On average, banks would see their Return on Assets dropping once by moderate 10 bps. Our conclusion is that an introduction of the NSFR (2014) as minimum standard is unlikely to exhibit adverse consequences for credit supply and bank profitability.

Nichttechnische Zusammenfassung

Fragestellung

Die Finanzkrise hat gezeigt, dass eine starke Kapitalbasis eine notwendige, aber keine hinreichende Bedingung dafür ist, dass Banken großen adversen Schocks standhalten können: adäquate Liquiditätspuffer und eine langfristige Refinanzierungsbasis sind mindestens genauso wichtig, um kurz- bzw. mittelfristige Refinanzierungsengpässe zu überwinden. Der Baseler Ausschuss für Bankenaufsicht hat letztere Erkenntnis mit der Strukturellen Liquiditätsquote (Net Stable Funding Ratio, NSFR) formalisiert. Die NSFR ist Teil des Basel III - Reformpaketes. Die Einführung einer NSFR verlangt von Banken, dass langfristige Aktiva durch langfristige Passiva refinanziert werden: eine moderne Version der 'Goldenen Bankregel'. Das könnte die Fristeninkongruenz und das daraus resultierende Transformationseinkommen zwischen Aktiva und Passiva reduzieren sowie in letzter Konsequenz zu einem systematischen Gewinnrückgang der Banken führen. Darüber hinaus könnten Banken auf diese neue regulatorische Anforderung mit einer Reduzierung des Kreditgeschäftes reagieren. Basierend auf einem mikroökonomischen Modell werden diese potentiellen Auswirkungen auf Profitabilität und Kreditvergabe, für alle deutschen Banken untersucht.

Beitrag

Unsere Studie erweitert die bestehende Literatur hinsichtlich dreier Aspekte: erstens sind unsere NSFR-Schätzungen teilweise mithilfe realer NSFR-Zahlen, welche von Banken gemeldet wurden, kalibriert. Das stellt sicher, dass der Modellfehler messbar wird und von uns minimiert werden kann. Zweitens sind die Anpassungsstrategien, die Banken in unserem Modellrahmen wählen, nicht extern vorgegeben, sondern werden endogen aus einem mikroökonomischen Bankenmodell hergeleitet. Drittens ist unsere Modellierung der Erträge und Aufwendungen mit ihren Komponenten Konditionenbeitrag, Strukturbeitrag und Anpassungskosten granularer als in früheren Arbeiten und näher an der bankinternen Messung von Profitabilität und Risiken.

Ergebnisse

Angewandt auf den deutschen Bankensektor zeigt unser Modell zum Stichtag 31.12.2012, dass 9% (=163) aller Banken die NSFR (2014) nicht eingehalten hätten. Verglichen mit der NSFR (2010), welche von 39% aller Banken nicht eingehalten worden wäre, ist das eine signifikante Reduzierung. Strukturell unterscheiden sich Banken, welche die NSFR (2014) nicht einhalten von denen, die sie einhalten darin, dass sie weniger liquide Aktiva vorhalten, sich weniger durch Privatkunden- und stärker durch kurzfristige institutionelle

Einlagen refinanzieren sowie geringer kapitalisiert sind. Für die 163 Banken, welche die NSFR (2014) nicht einhalten, leitet unser Modell insgesamt 70 verschiedene Anpassungsstrategien her, um die NSFR einzuhalten. Alle Strategien sind bilanzverlängernd und keine Strategie führt zu einer Reduzierung der Kreditvergabe. Im ersten Jahr nach der NSFR-Einführung würde der Return on Assets für diejenigen Banken, welche die NSFR (2014) nicht einhalten, im Mittel um 10 Basispunkte sinken. Aus unseren Erkenntnissen ergeben sich keine Hinweise darauf, dass die Einführung der NSFR (2014) als Mindeststandard die Profitabilität der deutschen Banken drastisch reduzieren bzw. die Kreditversorgung gefährden würde.

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Potential implications of a NSFR on German banks' credit supply and profitability*

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Abstract

We study how a Net Stable Funding Ratio as defined by the Basel Committee in 2014 (NSFR (2014)) would affect the profitability of German banks and their capacity to lend. With a NSFR-model that is partially calibrated against reported NSFRs, we find that 9% of German banks do not comply with the NSFR (2014). This is a significant reduction compared to the 39% that we find for its prior definition, the NSFR (2010), for the same sample. Structurally, banks that do not comply with the NSFR (2014) hold less liquid assets, rely less on retail funding, but more on short-term market funding and are more highly leveraged. A microeconomic model applied to each of the 163 non-compliant banks suggests that they would engage in 70 different strategies to become compliant. All strategies are growth strategies and none of them cuts lending. On average, banks would see their Return on Assets dropping once by moderate 10 bps. Our conclusion is that an introduction of the NSFR (2014) as minimum standard is unlikely to exhibit adverse consequences for credit supply and bank profitability.

Keywords: NSFR, Credit supply, Profitability

JEL classification: G21, G28.

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1 Introduction

Motivation

The financial crisis showed that a sound capital base is a necessary, but not sufficient condition for banks to be resilient to major shocks: sound liquidity buffers to withstand short-term liquidity shocks and a sound stable funding base to withstand prolonged investors' mistrust are equally important. The Basel Committee has formalized the latter lesson into the *Net Stable Funding Ratio* (NSFR) as a part of its regulatory reform package Basel III. It will require banks to fund their long-term assets using long-term liabilities: a modern version of the 'Golden rule of Banking'. By limiting the maturity mismatch between assets and liabilities, this might reduce banks' mismatch income and profitability. Furthermore, banks might respond to this new regulatory constraint by reducing their long-term asset holdings, and hence restrict the supply of credit. Precisely the potential impact on banks' profitability and credit supply is estimated in our study setting up a microeconomic banking model and applying it to all German banks.

The German banking sector with its more than 1,800 banks is an interesting sample as it accounts for a large portion of the European sector and contains banks of very different business models and sizes. Two versions of the NSFR exist: the original NSFR definition as of 2010 (cf. BCBS (2011), subsequently abbreviated as NSFR (2010)) and the re-calibrated version as of 2014 (cf. BCBS (2014), subsequently abbreviated as NSFR (2014)). The focus of this paper is on the NSFR (2014). We only refer to the NSFR (2010) by two instances: for calibration purposes and for assessing the impact of the recalibration in 2014.

In contrast to existing impact assessments such as King (2013), we use a microeconomic model in which banks seek compliance at the lowest possible cost. Paying attention to the fact that the NSFR affects mismatch income, we separate mismatch- and margin income and trade them off with operations adjustment costs that banks bear if they restructure their balance sheet.

We find that NSFR compliance is unlikely to be achieved by reducing credit supply and that the associated reduction of mismatch income is of very limited size. Going beyond previous NSFR impact assessments such as King (2013), our paper includes a leverage constraint, but does not formally incorporate all regulatory minimum standards like the risk-weighted capital ratio and the liquidity coverage ratio (LCR). However, we qualitatively argue in our result section that optimal strategies are LCR-neutral or even improving and thus would remain optimal with an additional LCR-constraint. Furthermore, the incorporation of the leverage ratio partially mitigates the omission of the risk-weighted capital ratios. A simultaneous analysis of all Basel III - ratios with their interaction is beyond the scope of this paper, but studied e.g. by Heidorn, Schmaltz, and Torchiani (2015).

NSFR - a primer

The NSFR can be seen as a more sophisticated implementation of the 'Golden Banking Rule' that stipulates that stable assets need to be funded by stable liabilities. 'Stable' refers to the proportion of assets, liabilities and off-balance sheet items that are assumed

to remain on the balance sheet for more than a year. The stable portion of an asset or an off-balance position (subsequently abbreviated OBS) p is subsequently denoted by α_p (cf. (1)). The stable portion of a liability position p is subsequently denoted by ρ_p. The volume of balance sheet position p is denoted X_p. α_p and ρ_p may be understood as the rollover probability at maturity of an asset or a liability respectively. α_p and ρ_p for the different balance sheet positions have been published in BCBS (2014) for the NSFR (2014).[1] The stability-weighted sum across all assets and off-balance sheet items represents the amount of *required stable funding* denoted RSF. The stability-weighted sum across all liabilities represents the amount of *available stable funding* denoted ASF. The NSFR ('Net Stable Funding Ratio') is defined as the ratio between ASF and RSF and thus measures how much of the required stable funding is actually covered by available stable funding:

$$\text{RSF} = \sum_{p \in \text{Assets,OBS}} \alpha_p X_p, \quad \text{ASF} = \sum_{p \in \text{Liabilities}} \rho_p X_p \quad \text{and NSFR} = \frac{\text{ASF}}{\text{RSF}} \tag{1}$$

The NSFR (2014) of a bank with a funding base of 90 mio EUR retail funding ($\rho_p = 90\%$) and 10 mio EUR capital ($\rho_p = 100\%$) which is invested in 80 mio EUR retail lending, $\geq 1Y$ ($\alpha_p = 85\%$), 15 mio EUR retail lending, $< 1Y (\alpha_p = 50\%)$, and 5 mio EUR cash reserve ($\alpha_p = 0\%$) is obtained as follows:

$$\begin{aligned} NSFR =& \frac{90\% \cdot 90 + 100\% \cdot 10}{85\% \cdot 80 + 50\% \cdot 15 + 0\% \cdot 5} \\ =& 120.5\% \end{aligned}$$

It is planned to implement the NSFR (2014) as a minimum standard of 100% from 2018 onwards. In summary the NSFR measures whether banks' long-term assets will be sufficiently funded during the next 12 months with the existing funding mix and thus without depending on additional external funding. If the NSFR-assumptions are correct and if the weights for ASF and RSF are correctly calibrated, banks with a NSFR of 100% will be resilient against funding shocks.

Literature

We structure our literature review into three parts: the rationale for a NSFR, econometric properties of structural funding ratios and – most closely related to our paper – other impact studies on the NSFR. Overall, literature on liquidity regulation and its empirical effects is still very scarce compared to the literature on capital regulation (cf. Allen (2014)).

Perotti and Suarez (2011) and Segura and Suarez (2012) show that banks ignoring negative externalities from maturity mismatches choose mismatch levels that are too high compared to the social optimum. Imposing limits like a NSFR on short-term funding is a mechanism to recover the socially optimal level. Bouwman (2013) surveys the literature on how banks create liquidity and derives potential implications for liquidity regulation. The authors highlight the introduction of the LCR and NSFR as means to limit the risks resulting from banks' liquidity creation. Analogously to Segura and Suarez (2012), but

[1] For NSFR (2010), the calibration can be found in BCBS (2011).

with a different argument, Diamond and Rajan (2001) find that short-term funding is the optimal maturity for the individual bank with an opaque asset holdings, since the necessary debt roll-overs provide a viable threat and protect banks' investors against excessive risk taking by bank management.

Vázquez and Federico (2015) find that high NSFRs are related to a lower default probability for European and U.S. banks. In the same vein, Yan, Hall, and Turner (2012) report that the introduction of the NSFR would reduce expected crisis cost. Kapan and Minoiu (2013) report that banks with a higher NSFR have been able to maintain (syndicated) lending better in times of a funding shock than banks with lower NSFRs. The predictive power of the NSFR for defaults has recently been challenged by Aikman, Galesic, Gigerenzer, Kapadia, Katsikopoulos, Kothiyal, Murphy, and Neumann (2014). They study whether simple key ratios (heuristics) have higher discriminative power than sophisticated ratios. On a sample of the largest 116 global banks[2] they report higher discriminative power for the loan-to-deposit ratio and the wholesale funding ratio than for the NSFR. Jobst (2014) measures the funding vulnerability based on bank-level NSFRs and computes the expected loss that might result from a collective failure to withstand a funding shock and hence to breach the NSFR. Dietrich, Hess, and Wanzenried (2014) report that the NSFR decreased before and increased during the financial crisis for 921 Western European banks. Addressing the question 'Who are the non-compliant banks', they report that banks with higher capital ratios, lower loan growth, more interest-bearing business and banks operating in their home country have higher NSFRs. Surprisingly, all banks tend to have lower NSFRs if the yield curve is steep, and GDP growth is high. Asking whether the NSFR would impact performance, they report that higher NSFRs come along with higher funding cost[3] and that a higher NSFR helps to stabilize overall profit. Banks with low NSFRs however are not more profitable than banks with high NSFRs – implying that the advantage in funding costs might be offset by less profitable business activities.

The impact study closest to ours is King (2013). The author estimates the shortfall in stable funding for 15 countries based on Bankscope accounting data, assumes strategies to achieve NSFR compliance and estimates the associated costs that reduce net interest income. For a subset of the German banking industry[4], he finds an average ASF [% of total assets] of 49.5% and RSF of 63.6%, leading to an NSFR of 78% and a shortfall in stable funding of 14.1% of total assets. This shortfall is eliminated through a heuristically derived reduction of the balance sheet category *other investments*, retail loans and *other assets*. The positions *govt. bonds*, *cash* and *corporate loans* increase. On the funding side, the strategy is to increase wholesale funding with maturity $\geq$ 1yr. The impact on the net interest margin is driven by assumptions on the steepness of the interest rate curve. King (2013) assumes that the cost of funding maturity lengthening is about 100bps for maturities between $<$ 1yr and $\geq$ 1yr, the opportunity cost between high-rated, liquid and low rated, illiquid investments to be about 200bps and the excess return between investments over government securities to be 100bps.

[2]More than 100 m USD total assets at the end of 2006

[3]Interest expenses/ average deposits

[4]The sample comprises 47 banks, 40% Commercial and bank holding companies, 2% investment banks, 34% Cooperative and savings banks, 23% Mortgage banks

Other impact studies not exclusively dedicated to the NSFR, that also consider capital ratios and/or the liquidity coverage ratio, include the paper by the Macroeconomic Assessment Group (2010), BCBS (2010), Angelini, Clerc, Curdia, Gambacorta, Gerali, Locarno, Motto, Roeger, den Heuvel, and Vlcek (2011), Elliott, Salloy, and Santos (2012), Kopp, Ragacs, and Schmitz (2010) and IIF (2011).

Our approach and contribution

Our paper makes three contributions to the existing literature. Firstly, our NSFR estimates are partially calibrated to NSFR figures reported by individual banks, minimizing the modeling error. Secondly, our compliance strategies are not heuristics, but result as optimal strategies from an optimization on bank level. Thirdly, our profit decomposition into margin income, mismatch income and operations adjustment costs is more granular than in previous impact studies and more closely aligned to how banks internally measure profitability and associated risks. The impact of the NSFR on credit supply is driven by two factors: how strongly banks are non-compliant (estimation of shortfall size) and how non-compliant banks might respond to achieve compliance (derivation of adjustment strategies).

Consequently, our impact assessment follows two steps: we first estimate the shortfall based on balance sheet information. Unlike previous studies that used publicly available accounting information we use more granular balance sheet information from Bundesbanks' regulatory reporting. This reduces the number of assumptions we need to make about the composition of assets and liabilities. While this reduces our model error, our approach is not free of assumptions either. However, since we have access to reported NSFRs (2010) for a subsample, we can both calibrate our main assumptions as well as quantify model risk[5]. Previous studies were all based on estimates without any link to actual NSFRs. For the NSFR (2014), we find that 9% of German banks (corresponding to 163 banks) are non-compliant with an average stable funding shortfall of 6.68% of total assets. If the NSFR had not been revised in 2014, the non-compliance rate would have amounted to 39% with an average shortfall of 8.75% of total assets under NSFR (2010).

Thus, the 2014 - revision significantly reduced both the number of non-compliant banks and the magnitude of shortfall. Studying the balance sheet structure, we find that NSFR (2014) - non - compliant banks hold less liquid assets, rely less on retail funding, but more on short-term market funding, and are higher leveraged. In a second step, we quantify the impact of the NSFR on credit supply and profitability by asking how non-compliant banks are likely to respond to achieve compliance. In contrast to previous studies that use ad hoc strategies and heuristics, our strategies are optimal in the sense that they are endogenously determined by a structural, microeconomic banking model. The model describes individual banks that seek to comply with the NSFR at the lowest possible cost. Each balance sheet position can be increased or reduced to achieve compliance - but changes do not come for free: they affect net interest income (separately modeled as margin- and maturity mismatch income) and cause operations adjustment costs. The separate modeling of margin- and maturity mismatch income is standard in the bank profitability literature and especially important in the context of the NSFR, because the NSFR potentially limits the maturity mismatch. The operations

[5]The subsample we use accounts for roughly 50% of total assets of the entire sector.

adjustment cost capture additional cost that are due when extending or cutting back certain business activities (cf. Andrae, Heidorn, Pokutta, and Schmaltz (2014)). As a novelty compared to Andrae et al. (2014), we incorporate the idea that adjustment costs for small positions are higher than for large positions because large (small) positions mean that the bank is (not) specialized in that business and hence has (in-)efficient processes in place and is perceived as an active (passive) counterparty in that market. As a second novelty, we introduce bank-specific funding cost where large and/ or highly capitalized banks benefit from lower funding cost compared to small and/ or low capitalized banks. Margins are modeled in the spirit of Andrae et al. (2014) where margins decrease when positions increase. It is noteworthy that margins, mismatch income and adjustment costs are bank-specific. Applying our model to the 163 NSFR (2014) non-compliant banks leads to 70 different compliance strategies. The heterogeneity of the strategy universe is a direct consequence from the bank-specific P&L-parameters. Although heterogenous in nature, there are several elements that these strategies have in common: they are all growth strategies where none of them cuts lending. Furthermore, raising long-term market funding and investing it in short-term market assets and short-term corporate lending is a recurring scheme among the 70 strategies. The average balance sheet changes amount to 9% although the shortfall is only 6.7%. This confirms that not all changes are changes that are enforced by the NSFR-constraint. Thus, our optimal strategies combine both a regulatory and a business rationale. Profitability-wise banks see their Return on Assets dropping on average by moderate 10 bps. Thus, our model suggests that it is very unlikely that banks respond to an introduction of a NSFR by reducing credit supply. Instead, there are much more NSFR (2014) - efficient and less costly strategies to pursue.

The remainder of this paper is organized as follows: Section 2 introduces and motivates our analytical framework. Section 3 provides a qualitative and quantitative description of our sample. Section 4 presents our findings. In Section 5 we study the sensitivity of our findings against changes in key assumptions. Section 6 concludes.

2 A microeconomic bank model

2.1 Optimization framework

We assume that banks are at their self-determined optimum under current regulation. Furthermore, we assume that banks face operations adjustment costs a_p if position p is expanded or cut-back. Adjustment costs model the difficulties banks face when they move away from their current optimum.[6] An additional NSFR-constraint divides our sample into compliant- and non-compliant banks. Compliant banks don't move because their current optimal business model is still within the eligible set. However, non-compliant banks have to move, even if their P&L might be negatively impacted. Our model assists non-compliant banks to determine the strategy that ensures NSFR compliance with minimal P&L impact.

Our banking model consists of the objective function (maximizing P&L-changes[7]) and a set of constraints (the NSFR-constraint, a leverage constraint, and two technical constraints). We first describe the objective function and subsequently the constraints. The objective function decomposes the P&L impact into three components: changes in margin income (cf. (2)), changes in maturity mismatch income (cf. (3)) and changes in operations adjustment costs (cf. (4)):

$$\max_{\{\Delta X_{i,1},\ldots,\Delta X_{i,N}\}} \quad \Bigg(\sum_{p=1}^{N} m_{i,p}(X_{i,p}) \cdot \Delta X_{i,p} \tag{2}$$

$$+ \sum_{p\in\text{Assets}}^{N} s_{i,p} \cdot \Delta X_{i,p} - \sum_{p\in\text{Liabilities}}^{N} s_{i,p} \cdot \Delta X_{i,p} \tag{3}$$

$$- \sum_{p=1}^{N} a_{i,p} \cdot \|\Delta X_{i,p}\| \Bigg) \tag{4}$$

Here $\Delta X_{i,p}$ denotes changes in balance sheet position p of bank i. Like all other position variables, it is normalized to total assets, i.e. it usually lies between -1 and +1. $m_{i,p}$ denotes the margin of bank i for position p, $a_{i,p}$ adjustment costs for p at bank i, and $s_{i,p}$ the mismatch income of position p derived from bank i's funding curve. The margin $m_{i,p}$ measures the profit contribution of product p after covering all financial periodic cost[8]. All three profit components are bank-specific and modeled with sub-models that are introduced below.

Since we use a stylized single-period model, all quantities $m_{i,p}$, $s_{i,p}$ and $a_{i,p}$ are understood as comparative present values[9]. The objective function is subject to four constraints

[6] In a more general sense, adjustment cost summarizes all factors that make banks sticking to their current optimum and that are not formally incorporated in the model.

[7] Which is identical to minimize compliance cost.

[8] Financial costs are funding cost, credit risk cost, and operating cost.

[9] Adjustment costs are usually once-off cost, i.e. by definition present-valued. Margins and mismatch income are periodic concepts. To make them comparable and mathematically combinable with adjustment cost, their values must be present valued.

(cf. (5) - (8)): the bank has to comply with the NSFR (5), a leverage constraint of 4%[10] (6), the changes of assets have to equal the changes of liabilities for the new balance sheet to balance (7), and final positions need to be non-negative (8). Let RSF_0 and ASF_0 be banks' initial ASF and RSF positions, and ρ_p and α_p the stable portion of an asset or a liability as defined in (1), then

$$\text{RSF}_0 + \sum_{p \in \text{Assets}}^{N} \rho_p \cdot \Delta X_{i,p} = \text{ASF}_0 + \sum_{p \in \text{Liabilities}}^{N} \alpha_p \cdot \Delta X_{i,p} \tag{5}$$

$$X_{i,Equity,0} + \Delta X_{i,Equity} \geq 4\% \cdot \sum_{p \in \text{Assets}}^{N} (X_{i,p,0} + \Delta X_{i,p}) \tag{6}$$

$$\sum_{p \in \text{Assets}}^{N} \Delta X_{i,p} = \sum_{p \in \text{Liabilities}}^{N} \Delta X_{i,p} \tag{7}$$

$$\Delta X_{i,p} \geq - X_{i,p,0} \quad \forall p \in P \tag{8}$$

Note that in its current version, the model does not include other regulatory constraints like risk-weighted capital ratios (CET1-, T1-, or Total capital ratios) or liquidity constraint (LCR). This is mainly due to the difficulties to source reliable initial estimates for these Basel III - ratios for the main sample[11]. We discuss the robustness of our results with respect to this omission in Section 4.3. The model is risk-neutral in its valuations for the parameters $s_{i,p}$, $m_{i,p}$ and $a_{i,p}$, and optimizes for expected profit under going concern. We aim at describing the optimal compliance path that the bank should take given its expectations. The incorporation of unexpected gains or losses (which lead to additional buffers) are beyond the scope of this paper and left for future research. Risk and (regulatory) risk aversion enters as the NSFR- and leverage constraints.[12] Specifically, any compliance strategy will affect the default risk of the bank, and hence change the bank's funding spread: a better alignment of maturities lowers the mismatch volume, but it also lowers the bank's default risk and thus its funding cost. If data on institutions' internal risk aversion with respect to mismatch risk would be available, it could be incorporated as an additional constraint to endogenously determine an optimal maturity mismatch.

Our current setup with only a regulatory risk aversion can be seen as a case where the regulator is more risk averse than the bank such that the regulatory constraint becomes always binding before the internal constraint. Summarizing, we run bank-level optimizations where every bank maximizes its expected P&L subject to the NSFR-, leverage- and some technical constraints. The decision variables are changes in the balance sheet positions ($\Delta X_{i,p}$). The P&L consists of bank-specific margin- and maturity mismatch income ($m_{i,p}$ and $s_{i,p}$ respectively) as well as operations adjustment cost ($a_{i,p}$) induced by changes in position volumes.

[10] 4% is obtained as the regulatory minimum of 3% plus a buffer of 1%

[11] Note that their Basel II - counterparts are known, but that they are not useful as all banks comply with them. Challenges and thus pressure to adjust balance sheets result from Basel III - ratios.

[12] The NSFR reflects the regulatory risk aversion for maturity mismatch risk. The leverage ratio reflects the regulatory risk aversion for leverage risk.

2.2 Sub-models for P&L-components

We set up sub-models for adjustment costs $a_{i,p}$ (cf. (9)) and maturity mismatch income $s_{i,p}$ (cf. (10)) in order to capture important characteristics for these P&L-components. In order to facilitate the reading, we summarized all formal definitions in one block. Subsequently, we motivate and explain the structure of the sub-models.

0. Notation:

$$\begin{aligned}
X_{i,p,0}: &\quad \text{Initial \% of position p on total assets at bank i}\\
T_p^{max}: &\quad \text{Initial maturity of position p}\\
\{f_i, i=1,\dots,T\}: &\quad \text{Sector funding curve}\\
t_i: &\quad \text{Support point of funding curve}\\
x_{50\%,p,0}^{sector}: &\quad \text{Sector median of } X_{i,p,0}\\
a_p^{sector}: &\quad \text{Sector adjustment cost of position p}\\
m_p^{sector}: &\quad \text{Sector margin of position p}\\
\epsilon_p: &\quad \text{Demand elasticity of position p}\\
CR: &\quad \text{Basel II - Total Capital ratio}
\end{aligned}$$

1. Bank-specific adjustment cost:

$$a_{i,p} := \frac{1 - X_{i,p,0}}{1 - x_{50\%,p,0}^{sector}} \cdot a_p^{sector} \tag{9}$$

2. Bank-specific mismatch income:

$$s_{i,p} := \left(\sum_{n=0}^{N} \frac{t_{n+1} - t_n}{T_p^{max}} \cdot f_{n+1} \right) \cdot f_p^{\text{behav.}} \cdot f_i^{\text{Size, Capital}} \tag{10}$$

$$f_p^{behav.} \equiv \begin{cases} \alpha_p & p \in \text{assets}, < 1Y \\ \rho_p & p \in \text{liabilities}, < 1Y \end{cases}$$

$$f_i^{\text{Size, Capital}} := 1 + 0.5 \cdot (1 - c_i^{\text{Size}}) + 0.5 \cdot (1 - c_i^{\text{CR}}) \tag{11}$$

$$c_i^{\text{Size}} := 1 - \frac{\text{Total assets}_i}{\text{Total assets of largest bank of sector}} \tag{12}$$

$$c_i^{\text{CR}} := \begin{cases} 1; & CR \geq q_{75\%} = 19.98\%) \\ 2/3; & 16.25\% = q_{50\%} \leq CR < q_{75\%} \\ 1/3; & 13.68\% = q_{25\%} \leq CR < q_{50\%} \\ 0; & \text{otherwise} \end{cases} \tag{13}$$

3. Bank-specific margin income:

$$m_{i,p} := m_p^{sector} \cdot \begin{cases} (1 - \epsilon_p \cdot \Delta X_{i,p}), & \Delta X_{i,p} > 0 \\ 1, & \text{otherwise} \end{cases} \tag{14}$$

2.2.1 Adjustment cost

Definition (9) introduces bank-specific adjustment cost as a bank without a material volume in a certain position might find it difficult to substantially increase this volume (e.g. extensive marketing campaigns might be necessary). The opposite holds for banks with already large volumes in a certain position: the bank is likely to be perceived as a specialist in this product and it is easy (= cheap) for the bank to adjust this volume. Furthermore, banks with large volumes in a position are likely to have more efficient processes in place (economies of scope and scale) than banks where the same position is rather an exotic product that is infrequently used. Whether a position is 'large' or 'small' is measured by the distance of the individual position to the sector median $x^{sector}_{50\%,p,0}$ of that position across all banks. The higher the deviation, the more the average adjustment cost a^{sector}_{p} is scaled up (smaller than sector median) or down (larger than sector median). Figure 1 illustrates the adjustment model for the segment retail lending. The sector median of retail lending is 44.80%. The assumed adjustment cost amount to 2%. Many firms are assigned adjustment cost between 1% and 2.5%. Those (very few) firms that currently do not perform retail lending services have high starting cost which is reflected by adjustment cost of more than 3%.

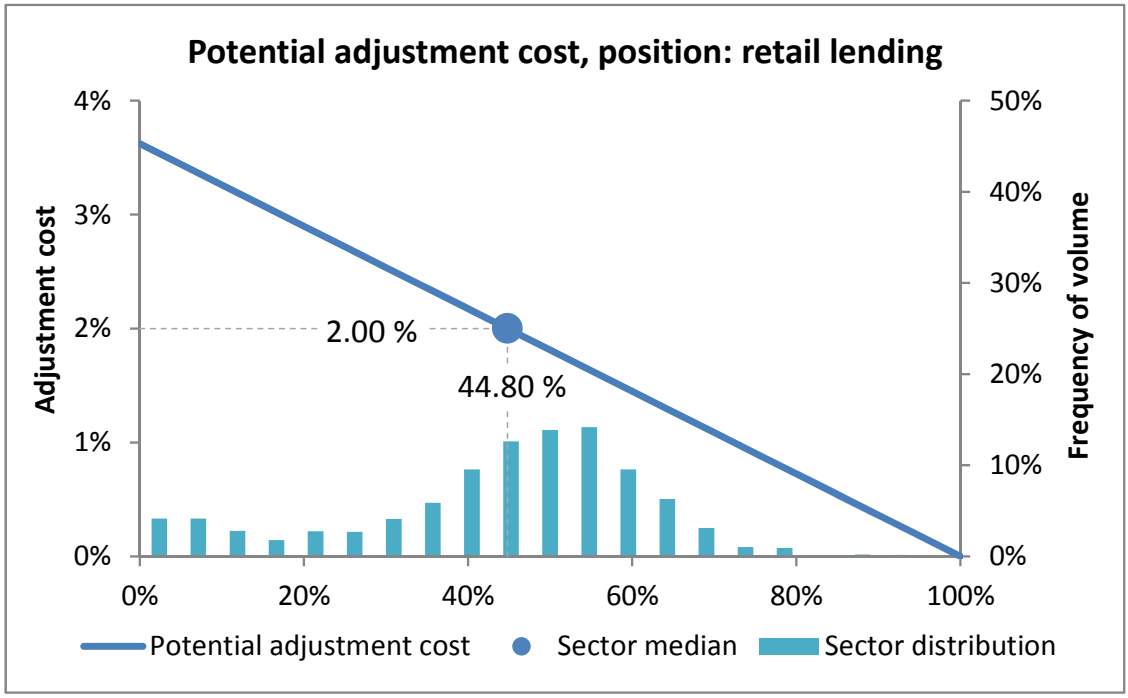


Figure 1: Adjustment cost are higher (lower) for positions smaller (larger) than the sector median.

2.2.2 Mismatch income

Mismatch income measures the contribution of maturity mismatches between assets and liabilities to the overall P&L. The mismatch income is determined on a margin-neutral curve f_t, the interbank- and capital market funding curve, where the bank is price-taker, in order to clearly separate margin and mismatch income[13]. The mismatch income results as the difference between funding spreads s_p received from assets and funding spread s_p paid to liabilities as (3) suggests. The spread for each position, i.e. the aggregate mismatch contribution, consists of three elements: the maturity-weighted average of the sector funding curve formed by $\{f_n; n = 0, ..., N\}$ (cf. (10)) multiplied with a scaling factor for the position stickiness ($f_p^{\text{behav.}}$) and a factor for bank size and bank capitalization ($f_i^{\text{Size, Capital}}$). Like this we derive bank- and position-specific marginal mismatch income. Subsequently, we describe each of the three terms.

Maturity-weighted funding curve as core of position income

The linearized annual mismatch income contribution of a balance sheet position p of volume X_p and maturity T_p would be obtained as follows:

$$MM_{p,j} = T_p \cdot X_p \cdot f_{0,T_j} \qquad \text{(Mismatch income of single item)}$$

with f_{0,T_j} denoting a banks' market funding rate for maturity [0,T_j]. However, a position p, such as retail lending, is composed of thousands of loans j with different maturities. The mismatch income of a position p for bank i would be obtained as the sum across all different maturities j:

$$MM_{i,p} = \sum_{j=1}^{J} T_{p,j} \cdot X_{p,j} \cdot f_{0,T_{p,j}} \qquad \text{(Position mismatch income)}$$

To employ this approach however we would need the maturity distribution $\{T_{p,j}\}$ for each position which is not available in regulatory databases. Hence, we have to make an assumption on the maturity distribution for each product p. An analysis of the Bundesbank's statistical publications on banking shows that the long-term evolution of lending volumes was very stable[14]. This supports our assumption that maturing loans are usually replaced by new loans with the same initial maturity, which implies uniformly distributed maturities in each position p. For instance, if the dominating retail loan is a 5yr loan, this means that the position *retail lending* is composed of 20% 5yr loans, 20% 4yr loans (which were originated 1 year ago), down to 20% 1yr loans (that were originated 4 years ago). Using the assumption of stable portfolios, we only need to know the maximum maturity for new loans T_p^{max}: the aggregate mismatch contribution of position p, s_p, is then obtained as the maturity-weighted average of the funding curve formed by $\{f_i; i = 0, ..., I\}$ (cf. 10). This is the final position income for positions where clients withdraw (funding) or repay (lending) at their legal tenors. However, there are many sticky products where the behavioral maturity is longer than the legal maturity. We account for this with a behavioral override explained in the next section.

[13] See Schierenbeck (2003), Grant (2011) and Dermine (2012) as well as references therein.
[14] See Deutsche Bundesbank (2015), p8.

Behavioral override

The mismatch income without override is based on contractual maturities. However, for sticky products, the economic maturity which is relevant here is much longer than their legal maturity (which we use for the mapping to the funding curve); hence we have to correct the mismatch income by accounting for its stickiness. Without the correction, legally short-term but economically long-term retail deposits would receive a very low mismatch income although in reality they are available long-term. For simplicity, we use the stickiness assumptions of the NSFR, which is reflected by the RSF- and ASF-weights for positions of less than a year remaining legal (!) maturity.

Size and capital adjustments

Until this point, our funding terms are position-, but not bank-specific. However, this sharply contrasts with reality where small banks and banks with lower capital ratios exhibit higher funding cost.[15] We have incorporated this via a correction factor (cf.(13)). The correction factor has two additive add-ons for size (between 0 and 0.5) and for capitalization (between 0 and 0.5). Thus, small and weakly capitalized banks would see their funding cost doubled with respect to large and highly capitalized banks. Size is measured relative to the largest bank of the sector whereas capitalization is measured in terms of quantiles of Basel II - capital ratios. Table 2 illustrates the two-dimensional factor distribution.

TA\ TCR	<= q25%	<= q50%	<= q75%	q75% <
0%	2.00	1.84	1.67	1.50
10%	1.95	1.79	1.62	1.45
20.0%	1.90	1.74	1.57	1.40
30.0%	1.85	1.69	1.52	1.35
40.0%	1.80	1.64	1.47	1.30
50.0%	1.75	1.59	1.42	1.25
60.0%	1.70	1.54	1.37	1.20
70.0%	1.65	1.49	1.32	1.15
80.0%	1.60	1.44	1.27	1.10
90.0%	1.55	1.39	1.22	1.05
100.0%	1.50	1.34	1.17	1.00

Figure 2: Values of the bank-specific factor $f_i^{\text{Size, Capital}}$ in dependence of size (TA) and Basel II - capital ratio (TCR). Large and highly capitalized banks fund at the sector curve (scaling = 1.00, lower right corner) whereas small and low capitalized banks have up to 100% higher funding cost (factor = 2.00, upper left corner).

[15] We are thankful to an anonymous referee for pointing out this important issue. Babihuga and Spaltro (2014) report on a core sample of 25 major international banks that funding cost decrease with the credit worthiness of the bank and with the level (and type) of capital. Their sample selection criteria were that the banks are (i) systemically important in their economies by the end of 2012 and (ii) have quarterly CDS-quotes.

2.2.3 Margin income

In order to incorporate the idea of marginally decreasing product profitability and in the spirit of Andrae et al. (2014), our product margins deteriorate if a bank increases the product volumes. This is especially important if many banks chose the same NSFR-response.[16] Products with high competition (e.g. marketable instruments) have a high margin elasticity whereas products for less sophisticated clients (e.g. retail) have low margin elasticity. We incorporate decreasing margins, but not increasing margins in order to remain conservative. Note that adjustment cost and mismatch income are linked to initial position volumes and do not change during the optimization. By contrast, margin adjustments are linked to the changes in positions, i.e. our decision variables. It is this dynamic feedback element that makes our optimization model non-linear.

3 Data and parameter characteristics

This section describes our two samples (a calibration sample and the main sample) and the parameters margin, adjustment cost and funding cost.

3.1 Samples

We employ two samples: the main sample that consists of the German banking sector and a supervisory sub-sample (calibration sample) that covers around half of the sector. We use the calibration sample which contains actual NSFRs and shortfall figures to calibrate three unobservable characteristics of the full sample[17]. The calibration sample is representative for the sector (= our main sample) in terms of size, business models and ownership structure. The reported figures are the best information on actual NSFR numbers available prior to the introduction of the new European regulatory reporting.

In contrast to previous studies, the calibration of the model to actual, reported NSFRs allow us to obtain a model error estimate. Main and calibration sample contain data as of 31/12/2012 - the cut-off date of our study. No data from other time points is used. When we refer to NSFR (2010) or NSFR (2014), we refer to two different NSFR calibrations proposed by the Basel Committee in 2010 and revised in 2014. However, the bank data where we test these calibrations are always as of 31/12/2012. At the cut-off date, our main sample contains $N = 1855$ banks. We exclude banks with zero total assets ($N = 4$), banks with negative equity ($N = 33$) and banks that will be unwound by 01/01/2018, the date when the NSFR is likely to come into force as minimum standard ($N = 3$). This filter leaves us with $N = 1815$ banks. The excluded banks amount to less than 1% of sector assets. Constituting the German banking sector, our main sample does not suffer from any selection bias. Moreover, it spans the whole heterogeneity that the German sector offers in terms of size, business model and ownership structure. For each bank, we import a granular balance sheet (55 items) as reported on 31/12/2012 within

[16] We are grateful to an anonymous referee for pointing out the systemic character of the margin response.

[17] The three unobservable characteristics are: (i) RSF-weight for liquid assets, (ii) RSF-weight for corporate lending <1Y, and the RSF-weight for marketable assets, <1Y.

the German monthly balance sheet reporting framework.[18] For banking groups, we use the consolidated balance sheet. We opt for granular Bundesbank data to limit the use of assumptions on NSFR-weights to a minimum. The imported balance sheet items are aggregated into 20 positions that constitute the decision variables of our model shown in Figure 3[19]. In particular, we distinguish the four main segments retail-, corporate-, public sector- and capital markets on each side of the balance sheet. These positions are split into buckets $<$ 1yr and $\geq$ 1yr because the NSFR assigns different weights to positions below and above one year of remaining maturity. The risk buffers 'liquid assets' and 'equity' as well as 'other assets' and 'other liabilities' complete the balance sheet.

No	Assets		Liabilities		No
01	< 1Y	Retail	Retail	< 1Y	11
02	≥ 1Y			≥ 1Y	12
03	< 1Y	Corporate	Corporate	< 1Y	13
04	≥ 1Y			≥ 1Y	14
05	< 1Y	Public sector	Public sector	< 1Y	15
06	≥ 1Y			≥ 1Y	16
07	< 1Y	Markets	Markets	< 1Y	17
08	≥ 1Y			≥ 1Y	18
09	Liquid Assets		Equity		19
10	Others		Others		20

Figure 3: Balance sheet structure. The changes in volume of each position to achieve compliance constitute our decision variables $\Delta X_{i,p}$. The vector of all changes constitute a strategy.

3.2 Descriptive statistics of sample

The descriptive statistics of our sample decision variables are summarized in Tables 1 and 2. All figures are in million Euros unless indicated otherwise. We report variation defined as the difference between the 75%-quantile and the 25%-quantile. As Table 1 shows, the sector features highly skewed distributions in all characteristic figures which is a direct consequence from the sector heterogeneity. The most equally distributed business across the sector is retail, which is to be expected given that a major part of the sample consists of savings banks and credit unions. Retail credit is largely long-term, as it includes mortgages, and with 12% of total assets in the sector it is the largest credit segment by volume. The second largest credit segment with 10% of total assets is corporate business, which is far more short-term and more concentrated with fewer banks than retail credit. Larger institutions extend a disproportionate share of long-term corporate credit. Short-term corporate credit lines are relatively evenly distributed.

Liquid assets are of comparable magnitude as lending to corporates. Note that our definition of liquid assets is broader than the definition used for the LCR and the NSFR (2014). Liquid assets are slightly more concentrated than retail lending, which may be

[18] We use 31/12/2012 for the main sample as this is also the reporting date of our calibration sample.

[19] The mapping and additional assumptions are documented by Table 13 for assets and Table 14 for liabilities in the appendix (cf. Section A.2).

explained by the fact that some banks specialize in dealing with liquid assets while others only hold amounts required by regulation.

Direct access to capital markets is less concentrated than the corporate segment. Market positions are overwhelmingly short-term. Overall, 6% of sector assets are classified as market.

Table 1: Descriptive statistics on German banking sector assets as of year-end 2012 [all figures in mio. EUR]

Assets	Median	Avg.	Variation	Q-95%	Q-5%
Retail, stable	195,4	888,6	444,0	2306,5	1,5
Retail, < 1yr	11,2	141,3	24,2	128,8	0,7
Corporate, stable	33,3	660,9	119,9	952,2	0,1
Corporate, < 1yr	31,5	373,6	122,3	720,7	0,4
Public, stable	0,5	200,2	10,6	193,4	0,0
Public, < 1yr	0,0	82,5	1,2	69,1	0,0
Markets, stable	24,3	365,7	73,8	514,4	0,4
Markets, < 1yr	25,0	508,7	67,2	745,4	2,3
Liquid	94,3	964,8	237,4	1485,2	3,9
Other	19,0	253,2	45,2	311,4	1,5

On the liability side (Table 2), retail funding is quite common across the sector, and largely dominated by short-term deposits. With regard to the NSFR, it is important to note that market funding is as important as retail funding in volume terms, with larger institutions relying more on market funding. Market funding is largely available both long-term and short-term for the average bank; larger institutions tend to rely more on short-term market funding. Smaller institutions rely more on corporate funding both long- and short-term.

Table 2: Descriptive statistics on German banking sector liabilities as of year-end 2012

Liabilities	Median	Avg.	Variation	Q-95%	Q-5%
Retail, stable	96,4	379,0	237,8	1034,0	0,0
Retail, < 1yr	147,8	748,3	331,0	1664,5	3,7
Corporate, stable	42,8	377,0	119,6	787,3	0,5
Corporate, < 1yr	37,5	396,5	106,8	627,9	0,7
Public, stable	0,0	32,8	0,1	18,0	0,0
Public, < 1yr	3,6	85,8	17,9	141,8	0,0
Markets, stable	9,0	943,6	33,9	390,3	0,0
Markets, < 1yr	3,6	871,6	26,3	1198,9	0,0
Equity	45,6	296,4	108,6	604,9	5,1
Other	27,8	386,7	71,2	498,2	1,4

Table 3 shows the behavior of the interest component of the ROE (iROE), the loan-deposit ratio and the distribution of total assets. Interest income (measured here by the iROE) is quite relevant for most institutions, as average and median are very similar.

Variation in this component is likely explained by success or failure in the management of maturity transformation. Loan-deposit ratios vary considerably across the sector, with larger institutions relying less on deposits as a source of funding. That the holding of total assets within the German banking sector is highly skewed can be concluded from row 3 of Table 3 that describes the distribution of total assets of each individual bank (to sector assets): in fact, the smallest 95% of German banks hold just 0.08% of total assets.

Table 3: Descriptive statistics on German banking sector as of year-end 2012

Characteristic ratios	Median	Avg.	Variation	Q-95%	Q-5%
iROE (reported)	24,1%	23,8%	12,7%	40,2%	1,6%
Loan-deposit ratio	74,5%	82,5%	26,8%	119,4%	33,3%
Share total assets	0,01%	0,06%	0,01%	0,08%	0,00%

3.3 Funding curve

To proxy banks' funding cost, we use EURIBOR (maturities < 1yr) and the average yield of outstanding bank debt (maturities ≥ 1yr) as reported to Bundesbank. The funding curve that corresponds to f_{n+1} in (10) is displayed in Figure 4.

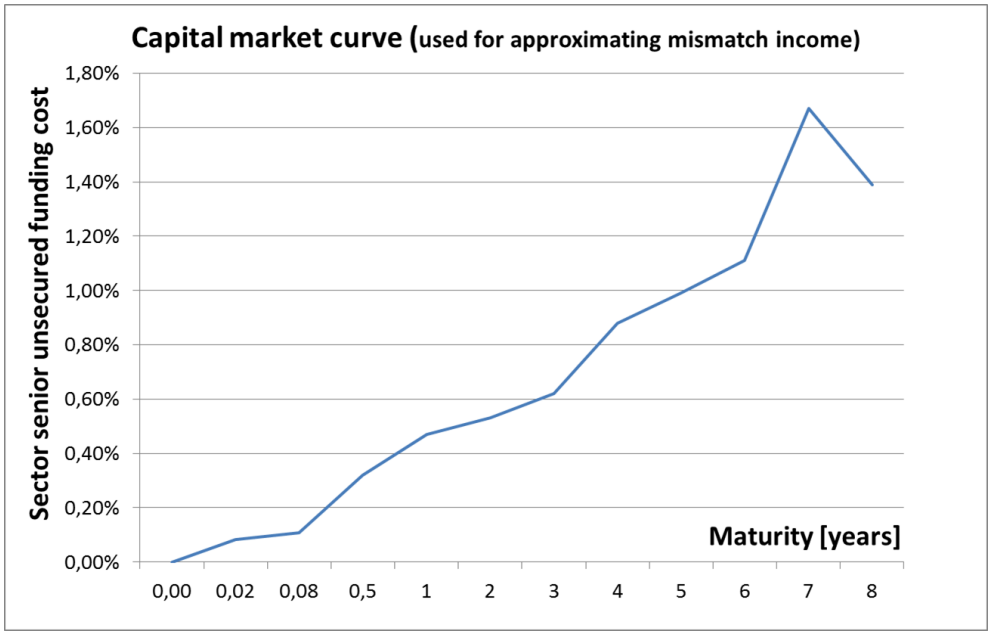


Figure 4: Funding curve to measure mismatch income

Note that this curve only constitutes the departure point for the mismatch income. The position- and bank-specific contribution is derived with the behavioral- and size/ capital - scaling factors (cf. (10). We acknowledge that CDS-spreads would be a better indicator of banks' funding spread, but since only a minority of German banks have liquid CDS-prices, we opted for using interbank funding quotes. Note that our results are invariant against levels of funding curves, since the mismatch income is based on the

slope only. To test the robustness of our results against changes in slope, we re-run our analyses with a steeper, a flat, and an inverted curve in Section 5.

3.4 Model parameters

We solve the model as described in Section 2 with the parameters summarized in Table 4. Assets are labeled as 'A-...' whereas liabilities are labeled as 'L-...'. Subsequently, we motivate each parameter choice (moving from left to right in Table 4).

Table 4: Model parametrisation.

No	Decision variables/ Position p	NSFR-weights α_p, ρ_p 2010	NSFR-weights α_p, ρ_p 2014	Margin m_p	Max T_p [Y]	Mismatch s_p	Adj. cost a_p	Volume $x^{sector}_{50\%,p,0}$ (median)	Elasticity ϵ_p
1	A-Retail, ≥1Y	1.00	0.85	2.00%	8.0	0.90%	2.00%	44.8%	4.0
2	A-Retail, < 1yr	0.80	0.50			0.72%			
3	A-Corporate, ≥1Y	1.00	0.85	1.50%	5.0	0.60%	1.00%	12.6%	6.0
4	A-Corporate, < 1yr	0.60	0.50			0.36%			
5	A-Public, ≥1Y	1.00	0.85	0.25%	8.0	0.90%	1.00%	0.25%	6.0
6	A-Public, < 1yr	0.50	0.50			0.45%			
7	A-Markets, ≥1Y	1.00	1.00	0.11%	5.0	0.60%	0.50%	10.9%	10.0
8	A-Markets, < 1yr	0.00	0.10			0.08%			
9	A-liquid	0.30	0.30	-0.50%	0.50	0.28%	0.50%	19.4%	10.0
10	A-Other	1.00	1.00	0.20%	5.0	0.00%	2.00%	3.5%	0.1
11	L-Retail, ≥1Y	1.00	1.00	0.51%	3.0	0.38%	1.60%	60.0%	1.0
12	L-Retail, < 1yr	0.90	0.95			0.35%			
13	L-Corporate, ≥1Y	1.00	1.00	0.25%	2.0	0.27%	0.80%	16.6%	2.0
14	L-Corporate, < 1yr	0.50	0.50			0.13%			
15	L-Public, ≥1Y	1.00	1.00	0.10%	3.0	0.38%	0.80%	1.0%	8.0
16	L-Public, < 1yr	0.50	0.50			0.19%			
17	L-Markets, ≥1Y	1.00	1.00	0.00%	5.0	0.60%	0.40%	3,2%	10.0
18	L-Markets, < 1yr	0.00	0.20			0.00%			
19	L-Equity	1.00	1.00	-10.00%	8.0	0.90%	5.00%	8.8%	0.1
20	L-Other	0.00	0.00	0.00%	5.0	0.60%	1.00%	5.3%	0.1

3.4.1 Product category weights α_p and ρ_p

Due to our granular database and few necessary assumptions, our decision variables are very similar to the product categories used in the definition of the NSFR. As the RSF-weights ρ_p and ASF-weights α_p are given by the BCBS for each product category p, there is no ambiguity on the weight to be assigned. The only position that needs an assumption on the weight is 'liquid assets', since the RSF-weights of liquid assets vary between 0% and 50%. We set the weight to 30% to signal that our definition of 'liquid asset' is broader than the definition used by the LCR and the NSFR (2014). The NSFR (2014) mainly differs from the NSFR (2010) in that it significantly reduces total RSF for all banks across the sample. Under the NSFR (2014), all non-financial assets ≥ 1yr would be assigned an 85% RSF factor compared to 100% under NSFR (2010).

Non-financial corporate assets and corporate funding receive symmetric treatment with $\rho = \alpha = 50\%$ below one year under both NSFR definitions. Given our data sources however we had to include some SME lending with $\rho_{SME} = 0.85$ in the corporate segment, which is why we adjust the RSF weight to $\rho_{Corp,<1\text{yr}} = 0.6$.

Above one year, the NSFR (2010) treated corporate assets and liabilities symmetrically, while the NSFR (2014) generates additional free ASF, because it assigns $\alpha = 1$

and but only $\rho = 0.85$ in the corporate segment above one year. Since the NSFR (2014) introduces a 6m-to-12m bucket for marketable assets $<$ 1yr with $\rho = 0.5$, we increase the corresponding weight for marketable assets below 1yr to $\rho_m = 0.1$, assuming that most instruments in this class have a maturity of less than 6 months. The same category 6m-to-12m has been introduced on the funding side for market-based funding. Here, we set the weight to 0.2 assuming again that most instruments in this class have a maturity of less than 6 months, but not as short as on the asset side.[20]

3.4.2 Sector margins m_p

The majority of margins are taken from Andrae et al. (2014). Additionally, we assume a negative margin for liquid assets (-0.50%), a zero margin for market funding and 0.10% margin for public sector funding. In general we set the margins of assets higher than those of liabilities to capture the idea that lending activities are usually more profitable than funding activities. Note that equity has also a negative margin. We assume retail funding to be the most profitable funding source (0.51%) followed by corporate funding (0.25%) and public sector funding (0.10%) Note that sector margins become bank-specific via a submodel (14).

3.4.3 Margin elasticities ϵ_p

Margin elasticities have been taken from Andrae et al. (2014) as well. The idea is that elasticity increases with the degree of professionalism of the customers. In this spirit, retail customers have low elasticity (i.e. margins do not substantially drop if volumes increase). By contrast, corporate and public sector clients, and even to a higher degree financial counterparties are margin sensitive, i.e. they require a higher rate (funding) or lower rate (lending) (translating into a lower margin) if the bank seeks to fund/ lend more. The positions 'Other assets', 'Other liabilities' and 'Equity' have been assigned a very low elasticity indicating that these positions need to be held, no matter the price.

3.4.4 Sector mismatch contribution s_p

The mismatch income results from the maturity-weighted funding curve. For stable portfolios, the longest maturity determines the maturity distribution. We assume mid-term to long-term lending (8yr) for retail and public sector whereas corporate, bond investments and other assets are of shorter maturity (5yr). The relevant maturity for liquid assets is the liquidation horizon, which we assume to be 6 months. The funding base is of shorter maturity than assets (retail funding 3yr against retail lending 5yr) to account for maturity mismatching.

[20] If market lending and -funding would be exclusively interbank transactions, symmetric weights would be required. However, banks also borrow (but usually don't lend) from other financial counterparties like insurance companies or funds at mid-term maturities. To account for this asymmetry, we have set the weight for market funding to 0.2 and the one for market lending to 0.1.

3.4.5 Sector adjustment cost a_p

For adjustment cost we assume the following ranking (for assets and liabilities):

$$a_{Retail} > a_{Corporate} = a_{Publicsector} > a_{Markets}$$

Together with the sector medians, we derive bank-specific adjustment cost for each position. Figure 5 shows an exemplary distribution (and values for the sector) of adjustment cost for three selected positions where the distribution of the adjustment cost results from a distribution of the volumes.

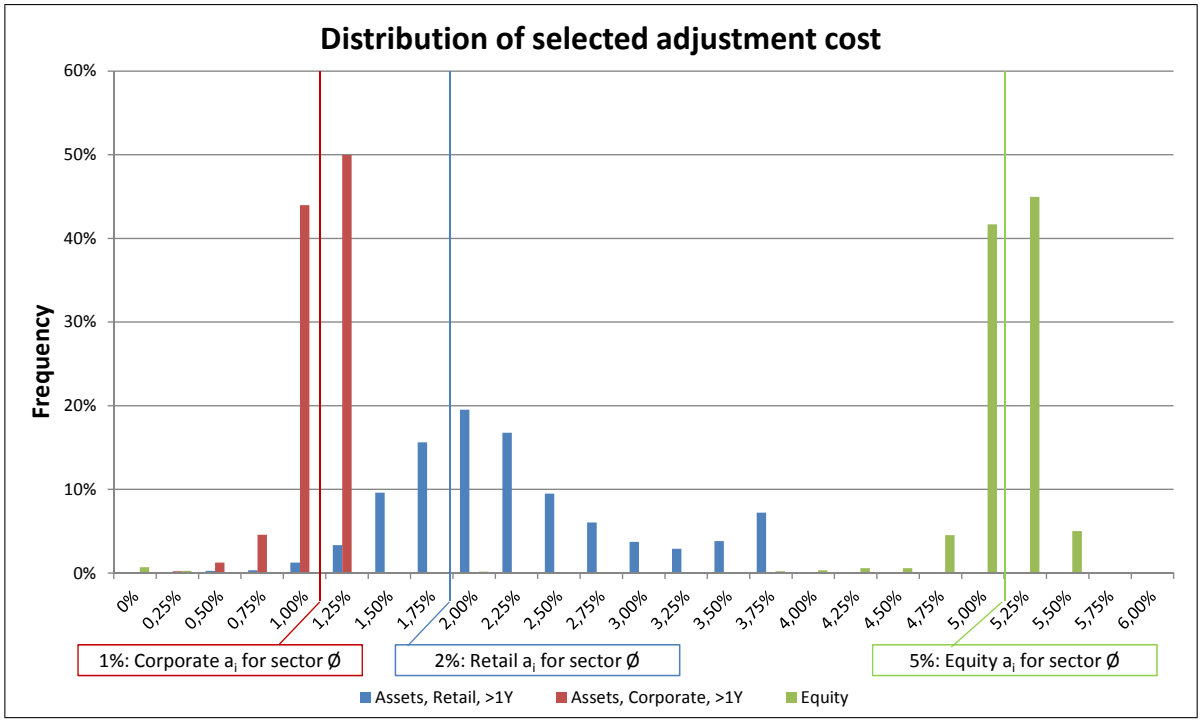


Figure 5: Distribution of Adjustment Cost depending on banks' volumes. ø denotes the median.

4 Results

The discussion of our results is organized along three sections: firstly, we discuss the shortfall on a sector level. Secondly, we look at the distribution of shortfall across banks. Thirdly, we discuss the optimal strategies to become NSFR - compliant.

4.1 Sector-level stable funding shortfall

We estimate the sector shortfall in ASF using balance sheet information that have been reported to Deutsche Bundesbank as of 31/12/2012. While very granular, this data contains three positions with ambiguous NSFR-weights ('Corporate lending, $< 1Y$', 'Liquid assets', and 'Marketable assets, <1Y') because these positions contain products with different NSFR-weights. However, from a different sample, the calibration sample, we know the reported NSFR (2010) for 37 banks of our main sample. This allows us to calibrate the three unknown NSFR-weights against the known NSFRs. The calibration is discussed in more detail in the next section.

4.1.1 Calibration quality

Since we are focused on total sector shortfall and individual bank compliance status, we calibrate using these two measures: whether the aggregated shortfall is estimated correctly and whether compliance is correctly predicted for individual banks. Absolute shortfall amounts of individual institutions do not enter into our calibration. For the 37 banks (52% of total assets of German banking sector) for which we have reported NSFR (2010), figures we are able to match our shortfall estimation to the total reported shortfall.These aggregated shortfalls are obtained as the sum of all bank level shortfalls. Only banks with a shortfall are taken into account and allocating shortfall to the wrong bank is not penalized. A regression of modeled vs. reported NSFR (2010) suggests that our approximation of the NSFR has a reasonable fit on bank level ($R^2 = 41\%$). In particular, our model correctly predicts the compliance status (compliant/non-compliant) for around 80% of our calibration sample.

Aggregate Shortfall: how representative is the calibration sample for NSFR (2010)[21]?

In order to assess how representative the calibration sample is, Table 5 summarizes the sector shortfall and compares it to the calibration sample. The calibration sample covers roughly 50% of the sectors' total assets, and 2% in terms of bank population. The shortfall size (in relation to total assets) on the non-monitored banks is slightly higher (4.4%) than on the monitored banks (3.4%), since the monitoring sample accounts for 52% of sector total assets but only for 41% of sector shortfall. Shortfall severity is also higher for the non-monitored non-compliant banks as their shortfall accounts for 8.8% of total assets, whereas the shortfall for the monitored non-compliant banks accounts for only 3.7% of their total assets.

[21] We can answer this question for NSFR (2010) only as we only have reported NSFR (2010) figures, but not NSFR (2014) figures.

Sample	banks	SF banks	TA/ Sample	SF/ Sample	SF/TA (all)	SF/TA (non-compl.)
Calibration sample	37	19	52%	41%	3.4%	3.7 %
Sector sample	1815	713	100%	100%	4.4%	8.8%

Table 5: Shortfall comparison of calibration sample vs. sector for NSFR (2010). Both overall size (TA to sample vs. SF to sample) and severity (SF/TA for non-compliant banks) of shortfall are higher for non-monitored banks.

Impact of 2014 - recalibration on sector shortfall

Table 6 compares the sector shortfalls for NSFR (2010) to those of NSFR (2014). Under the NSFR (2014), both the number of non-compliant banks and the shortfall severity drops to 163 (formerly 713) and 6.7% (formerly 8.8%) respectively. Under the NSFR (2014) non-compliant banks covered 16.1% of sector lending whereas under the NSFR (2010) non-compliant banks encompass 53.6% of sector lending.[22] The revised NSFR (2014) has lower RSF-weights for long-term retail and corporate lending and higher ASF-weights for retail funding. For the sector sample, we find an average reduction of 16% RSF and an average increase of 7% ASF. Delving into the reason, we find that 8% of the 16% overall RSF-reduction stems from the lowering of NSFR-weight (100% to 85%) for long-term lending ($> 1Y$) to non-financial counterparties. The remaining 8% are due to a lower weight for unencumbered retail and SME loans. All other key changes listed in the appendix of the NSFR (2014) paper BCBS (2014) have no significant impact for German banks on the asset side. The 7% additional ASF result mainly from the weight increase for less stable deposits from 80% to 90%.

1. Model	2. SF banks	3. SF banks [%]	4. SF/TA (all) (TA = all)	5. SF/TA (TA = non-compl.)	6. Share of sector credit supply
NSFR (2010)	713	39.3%	4.4%	8.8%	53.6%
NSFR (2014)	163	9%	1.1%	6.7%	16.1%

Table 6: Shortfall comparison of NSFR (2010) vs. NSFR (2014). Column '4.' relates the shortfall to total assets of all banks. Column '5.' relates the shortfall to total assets of non-compliant banks only.

[22] Lending is defined as the sum of retail-, corporate- and public assets.

4.2 Bank-level stable funding shortfall

Distribution of impact severity per bank

Aggregated figures usually hide how material a stable funding shortfall is for individual banks. Thus, this section is dedicated to non-compliance on bank level. Figure 6 shows that the NSFR across the sector follows approximately a normal distribution.

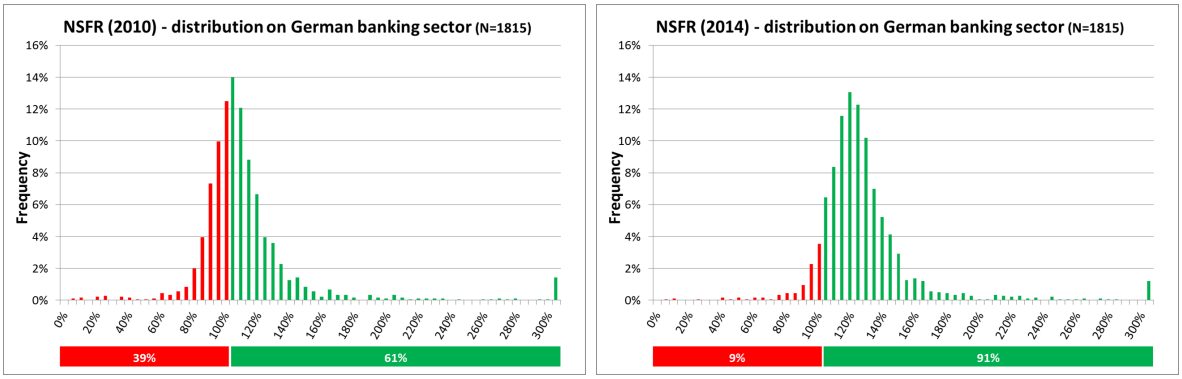


Figure 6: The proposed recalibration of the NSFR leads to a significant shift towards compliance. Left: given the (2010) calibration of the NSFR, 39.28% (= 713 banks out of 1815 banks) of the sector were not compliant by year-end 2012. Right: the recalibration proposal would reduce that share to 9% (= 163 banks).

The severity of shortfall SF_i/TA_i for bank i is roughly exponentially distributed (Figure 7). The figure suggests that for 68% of the non-compliant banks, the shortfall accounts for less than 10% of total assets under the NSFR (2010). A bank with 10% shortfall on total assets would have to lengthen its balance sheet by 10% if it funds a 100% ASF-product and invest the proceedings in 0% RSF-positions. By contrast, if the bank funds with 50% ASF- products and invests it in 0% RSF, the lengthening would be 20% of total assets. Hence, around 2/3 of banks would have to lengthen their balance sheet by 10% or less in case they followed this rule.

Under the NSFR (2014) we observe not only far fewer non-compliant institutions, but also a significant reduction in shortfall severity. Note that the seeming increase in population of the buckets with medium shortfall severity under the NSFR (2014) are due to the fact that we only plot the set of non-compliant banks, which is much smaller under the recalibrated NSFR. Of those banks remaining non-compliant under the NSFR (2014), most are concentrated in the bucket with lowest severity.

4.2.1 Common features of non-compliant banks

After having identified compliant- and non-compliant banks, we look for characteristics that are similar across non-compliant banks but as different as possible when compared to compliant banks. In particular, we study (A) Size, (B) Balance sheet structure/ decision variables and (C) Alternative funding ratios (Core funding ratio, Wholesale funding ratio, Loan-to-deposit ratio)[23] as suggested by Figure 8. For each variable we compare the mean

[23]Core funding ratio := (Equity + 'Market funding, ≥1Y' + 'Retail funding, ≥1Y' + 'Corporate funding, ≥1Y' + 'Public sector funding, ≥1Y') / Total assets, Wholesale funding ratio :=('Market funding,

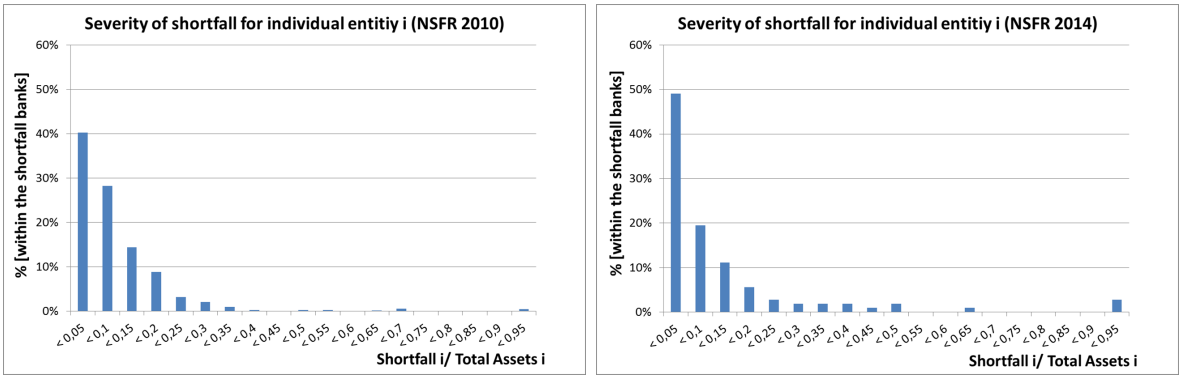


Figure 7: Severity of shortfall for individual banks. Left: NSFR (2010) with $N = 713$, right: NSFR (2014) with $N = 163$ non-compliant banks. The recalibration of the NSFR leads to a significant reduction in severity on individual bank level, except for $N = 3$ banks.

of the compliant sample with the mean of the non-compliant sample and analyze whether they significantly differ with 99%-confidence and Bonfferoni-adjustment. Variables that significantly differ between compliant (c) and non-compliant (nc) banks are grey shaded.

We find that - no matter the NSFR-version - compliant banks hold significantly more liquid assets, have significantly higher retail funding, are higher capitalized and rely significantly less on short-term market funding.[24] Furthermore, compliant banks have less long-term corporate lending than non-compliant banks. The mentioned asset positions have low RSF-weights, the mentioned funding positions have high ASF-weights which explains the compliance status of these banks. We also find that all alternative funding ratios are significantly different between NSFR-compliant and non-compliant banks. More precisely, NSFR-compliant banks have a higher core funding ratio and lower wholesale- as well as lower loan-to-deposit ratio. Since the 2014-recalibration, compliant and non-compliant banks are similar in their retail lending. The weight of this position has been lowered in NSFR (2014) such that banks with a high proportion became compliant. Now, the set of compliant banks contains banks with a low proportion (already compliant under NSFR (2010)) and banks with a high proportion of retail lending. The significant difference under NSFR (2010) is diluted under the NSFR (2014) and thus means are not significantly different anymore. Size-wise compliant banks are on average smaller than non-compliant banks. Through the re-calibration, the average size of compliant banks has not changed.

However, the average size of non-compliant banks has increased. This indicates that among the banks that became compliant through the recalibration, the majority was smaller than the (non-compliant) average size of 6.7 bn EUR total assets.

$\geq$1Y' + 'Market funding, <1Y')/ Total assets, Loan-to-deposit ratio = (Retail lending + Corporate lending + Public sector lending) / (Retail funding + Corporate funding + Public sector funding)

[24] Figure 8 also suggests that compliant banks hold less 'Other liabilities'. However this position is a 'residual' position that is likely to be very heterogenous. Thus, we prefer not to draw economic conclusions although statistically we would be entitled to do so.

Category	Statistic	Position	NSFR (2014)			NSFR (2010)		
			Compliant (c)	Non-compliant (nc)	Δ (nc - c)	Compliant	Non-compliant	Δ (nc - c)
(A) Size	Mean	TA per bank	4.814.721.214	9.262.336.589	4.447.615.375	4.234.435.303	6.728.376.727	2.493.941.423
	Mean	TA/ sector	0,05%	0,10%	0,05%	0,04%	0,07%	0,03%
(B) Decision variables	Mean	Assets, Retail, stable	39,4%	38,7%	-0,7%	35,8%	44,8%	9,1%
	Mean	Assets, Retail, < 1yr	2,7%	2,6%	-0,1%	2,6%	2,8%	0,3%
	Mean	Assets, Corporate, stable	7,4%	10,7%	3,2%	6,2%	10,1%	3,8%
	Mean	Assets, Corporate, < 1yr	7,5%	8,5%	1,0%	7,3%	8,0%	0,7%
	Mean	Assets, Public, stable	1,3%	1,6%	0,4%	1,2%	1,4%	0,2%
	Mean	Assets, Public, < 1yr	0,5%	1,8%	1,3%	0,6%	0,7%	0,1%
	Mean	Assets, Markets, stable	6,1%	5,6%	-0,5%	6,5%	5,2%	-1,3%
	Mean	Assets, Markets, < 1yr	8,9%	8,6%	-0,4%	10,7%	6,1%	-4,6%
	Mean	Assets, liquid	21,8%	13,1%	-8,6%	24,6%	15,5%	-9,1%
	Mean	Assets, other	4,3%	8,7%	4,4%	4,4%	5,2%	0,8%
	Mean	Liabilities, Retail, stable	21,8%	13,7%	-8,1%	22,7%	18,5%	-4,3%
	Mean	Liabilities, Retail, < 1yr	30,8%	19,1%	-11,7%	31,6%	26,9%	-4,7%
	Mean	Liabilities, Corporate, stable	10,0%	7,4%	-2,6%	10,1%	9,2%	-1,0%
	Mean	Liabilities, Corporate, < 1yr	8,0%	6,9%	-1,1%	8,0%	7,9%	-0,1%
	Mean	Liabilities, Public, stable	0,2%	0,2%	-0,1%	0,2%	0,2%	0,0%
	Mean	Liabilities, Public, < 1yr	1,5%	1,4%	-0,1%	1,4%	1,6%	0,2%
	Mean	Liabilities, Markets, stable	3,5%	4,3%	0,8%	3,1%	4,3%	1,2%
	Mean	Liabilities, Markets, < 1yr	3,2%	16,0%	12,8%	2,8%	6,8%	4,0%
	Mean	Liabilities, Equity	11,3%	8,3%	-3,0%	12,8%	8,4%	-4,4%
	Mean	Liabilities, other	5,9%	10,6%	4,7%	5,5%	7,5%	2,0%
(C) Alternative structural funding ratios	Mean	Core Funding ratio	46,8%	33,9%	-12,9%	49,0%	40,6%	-8,4%
	Mean	Wholesale Funding ratio	6,7%	20,3%	13,6%	5,9%	11,1%	5,2%
	Mean	Loan-Deposit Ratio	86,1%	166,1%	79,9%	76,2%	119,1%	43,0%

Figure 8: Characteristics of compliant- and non-compliant banks under NSFR (2014) and NSFR (2010). In the greyed positions, the means of both samples are significantly different (t-test with Bonfferoni-correction at 99% confidence level).

4.3 Eliminating NSFR shortfall: Compliance strategies

4.3.1 Pure asset strategies to eliminate shortfall

The simplest strategy a bank may choose to eliminate its shortfall is to reduce its asset holdings without changing the relative composition of the liability side. Such strategies would be the worst-case scenario for loan supply and might have a major impact on the real economy. While banks could in principle start shedding positions with high RSF weights without paying attention to the maturity structure of their portfolios, this would lead to unstable portfolios and potentially to a non-compliant balance sheet in the future. Hence banks can only shed assets that are maturing in a given period by not replacing maturing loans (we are excluding the possibility of securitizing exposures at this point). We therefore assume that banks start with stable portfolios, and want to keep their portfolios stable by evergreening them. Adaptation to compliance then translates into steps of annual portfolio volume reductions. The size of the shortfall reduction per year is bank-specific and depends on the banks' portfolio set and the maximum maturity of each portfolio.

For our empirical results we defined credit volume as the sum over all assets except other assets. Figure 9 shows the reduction in volume in percent of the volume in year one, when the NSFR would be introduced. While under the NSFR (2010) regime the maximum loss of credit to the real economy would over time accumulate to 5.5% of total credit supply in the year preceding the introduction of the NSFR, this figure drops to only 1.3% for the NSFR (2014). Given that this scenario is worst-case, overall impact on credit supply can be assumed to be limited under either definition.

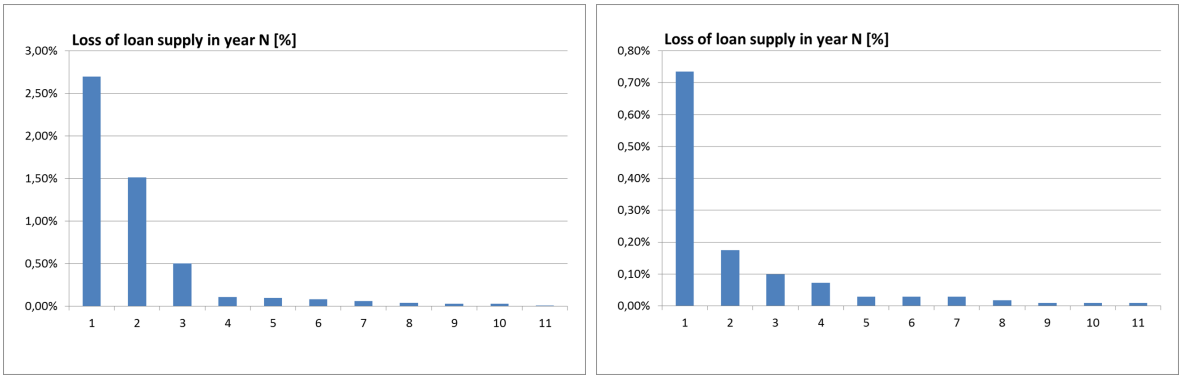


Figure 9: Maximum reduction of loan supply per year assuming stable portfolios for the NSFR (2010) calibration (left) and the NSFR (2014) calibration (right). Loan supply is equal to lending minus interbank assets and central bank assets.

4.3.2 Strategies minimizing P&L-impact

According to our model (cf. (2)) - (8)), the 163 banks that don't comply with NSFR (2014) would chose 70 different strategies. The 16 most important of them (covering banks that constitute 93% of total assets of the non-compliant sample) are summarized in Figure 10. The remaining strategies 17, ..., 70 are summarized in Figures 15 and 16 in the appendix. For confidentiality reasons we have merged the total asset information when a row only contained one or two banks. It is noteworthy that all banks chose growth strategies, i.e. they overcome the NSFR-shortfall by funding ASF-intensive positions and investing them in RSF-light positions. Growth strategies are more attractive than reduction strategies because reduction strategies imply the same adjustment cost as growth strategies, but on top also suffer from a loss in margin, whereas growth strategies generate additional margins. The common strategy element across almost all banks is the raise in long-term market funding and its investment in short-term market assets and short-term corporate lending. Additionally, some banks would choose to increase public lending (e.g. strategy 2, 3, and 15) or retail lending (strategies 4 and 13). Thus, banks do not chose pure compliance strategies, but strategies that combine the compliance- with a business objective[25]. The column 'EQ' shows the consequence of the leverage constraint: some banks increase their equity position because they do not fulfill the 4% leverage constraint (initially or as consequence of their balance sheet growth). As equity is expensive to raise, these banks see their RoA dropping more significantly than banks with other strategies. Below the table in Figure 10, we compiled a summary statistic of the (volume-weighted) changes across all non-compliant banks. On average, banks increase their balance sheet by 9%. Table 6 in Section 4.1.1 suggested that non-compliant banks have a stable funding shortfall of 6.7% (of total assets) to overcome. Thus, with pure compliance strategies (i.e., funding 1.0 ASF- and investing in 0.1 RSF-positions) the average growth would have been 7.4% (=6.7/(1.0 - 0.1)). The 9% growth indicates that banks also invest (for margin and mismatch income reasons) in positions with higher RSF (e.g. corporate lending with RSF = 0.5). The average bank raises 6.4% long-term market funding, 2.0% long-term corporate funding, 0.3% equity, 0.2% long-term retail funding and 0.1% short-

[25]This is not surprising as by design our model seeks to maximize business success whereas compliance is 'just' a constraint.

term market funding[26] and invests the proceeds in 5.2% short-term market assets, 2.6% short-term corporate lending, 0.8% long-term corporate lending (because it yields considerable margin income), and 0.1% each in liquid assets, retail lending and public lending. Profitability-wise, banks see their RoA dropping once by moderate 10 bps.

Comparing the 2014 - summary statistics with the 2010 - summary statistics at the bottom of Figure 10 confirms that banks would have responded with larger changes of 11.2% to a NSFR (2010). The number of strategies has also grown from 70 for NSFR (2014) to 102 for NSFR (2010) (see Figures 17, 18, and 19 in the appendix). The comparison sheds some light on the background mechanics of our model: for NSFR (2010) banks would had to grow more (4.8% vs. 2.0%) in long-term corporate funding and invested more in short-term market assets. Market funding provides a slight income advantage over corporate funding[27] but at around 6% new market funding the advantage vanishes because of the deteriorating margins. Now, corporate funding kicks in and fills up the rest. As the NSFR (2010) requires more stable funding, the incremental 2% are funded by corporate funding (which again would loose its advantage at a certain stage compared to retail funding which would kick in third). On the asset side, corporate lending yields an income advantage (per unit RSF) up to a certain point (around 2.6%). Afterwards, short-term market assets kick in. Therefore, the additional funding for NSFR (2010) is invested in short-term market assets.

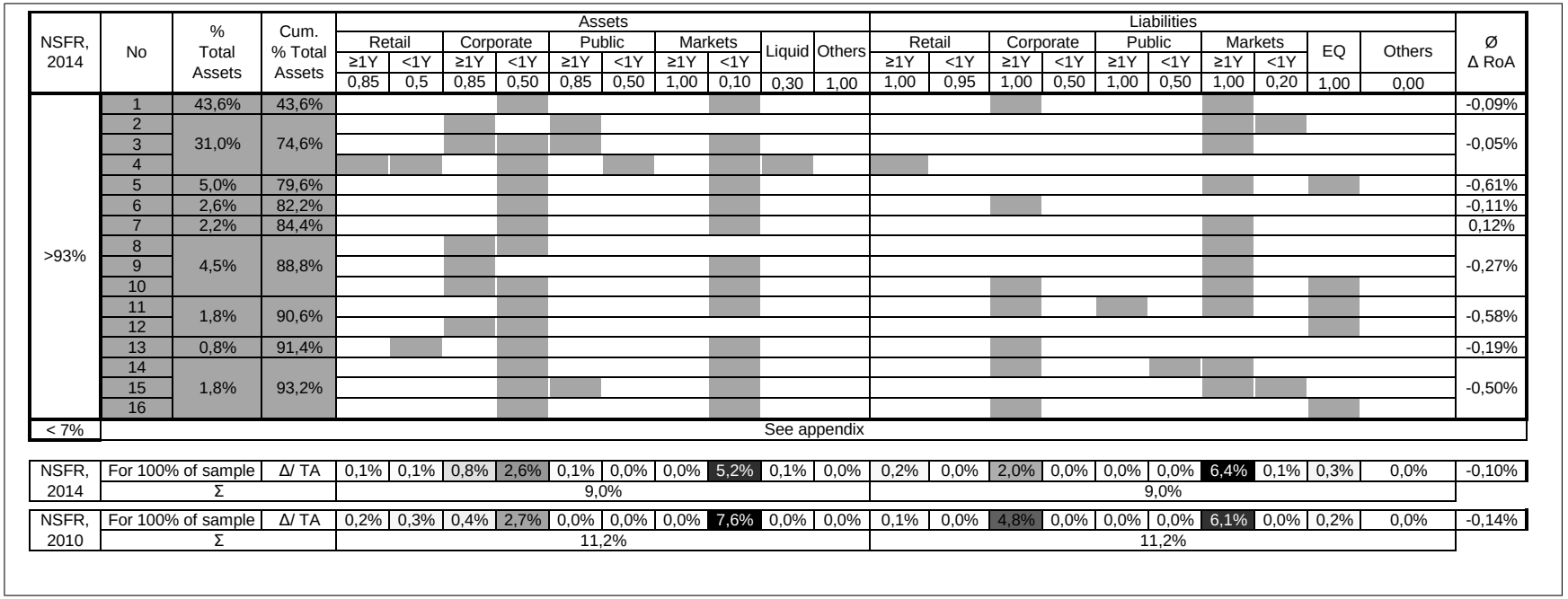
We conclude that our model does not reveal any adverse implication for credit supply nor for profitability of banks as a consequence of a NSFR-implementation. All strategies are growth strategies and especially short-term corporate lending is likely to increase. With respect to profitability, we only find small deviations from current RoAs. The highest deviations we find for banks that must increase their equity base. However, this is not a consequence of NSFR, but of the leverage constraint.

5 Robustness tests

As our model relies on a number of assumptions, we run extensive robustness tests in order to study the generality of our results and confirm the intuition behind the model mechanics. Figure 12 summarizes our findings. The tests study the robustness of our results w.r.t. (2a) the shape of the funding curve, (2b) margins and adjustment costs, and (2c) the design of the P&L/ objective function. The results of (2a) and (2b) are expressed as Δ to the base case (1). The results of (2c) are not Δ, but the solutions and thus directly comparable to (1). The column 'No' enumerates the tests. The columns 'NSFR-model', 'Margin', 'AdjC', and 'MMI' describe the change of the setup w.r.t. the base case (1). The column Δ Total Assets describes the magnitude of changes expressed as change in total assets. In order to focus on significant effects, numbers $|x| \leq 0.05\%$ are omitted.

[26] Although not providing lots of stable funding, it has small mismatch cost.

[27] Income advantage measured as (margin - adjustment cost - mismatch cost).



NSFR, 2014	No	% Total Assets	Cum. % Total Assets	Assets										Liabilities										Ø Δ RoA
				Retail		Corporate		Public		Markets		Liquid	Others	Retail		Corporate		Public		Markets		EQ	Others	
				≥1Y	<1Y	≥1Y	<1Y	≥1Y	<1Y	≥1Y	<1Y			≥1Y	<1Y	≥1Y	<1Y	≥1Y	<1Y	≥1Y	<1Y			
				0,85	0,5	0,85	0,50	0,85	0,50	1,00	0,10	0,30	1,00	1,00	0,95	1,00	0,50	1,00	0,50	1,00	0,20	1,00	0,00	
>93%	1	43,6%	43,6%																					-0,09%
	2	31,0%	74,6%																					-0,05%
	3																							
	4																							
	5	5,0%	79,6%																					-0,61%
	6	2,6%	82,2%																					-0,11%
	7	2,2%	84,4%																					0,12%
	8	4,5%	88,8%																					-0,27%
	9																							
	10																							
	11	1,8%	90,6%																					-0,58%
	12																							
	13	0,8%	91,4%																					-0,19%
	14	1,8%	93,2%																					-0,50%
	15																							
	16																							
< 7%	See appendix																							
NSFR, 2014	For 100% of sample		Δ/ TA	0,1%	0,1%	0,8%	2,6%	0,1%	0,0%	0,0%	5,2%	0,1%	0,0%	0,2%	0,0%	2,0%	0,0%	0,0%	0,0%	6,4%	0,1%	0,3%	0,0%	-0,10%
	Σ			9,0%										9,0%										
NSFR, 2010	For 100% of sample		Δ/ TA	0,2%	0,3%	0,4%	2,7%	0,0%	0,0%	0,0%	7,6%	0,0%	0,0%	0,1%	0,0%	4,8%	0,0%	0,0%	0,0%	6,1%	0,0%	0,2%	0,0%	-0,14%
	Σ			11,2%										11,2%										

Figure 10: Strategies (1-16) to achieve NSFR(2014)-compliance and sector summary statistics for NSFR (2014) and NSFR (2010). Grey-shaded cells mean that the bank(s) increase that position. White means no changes in that position.

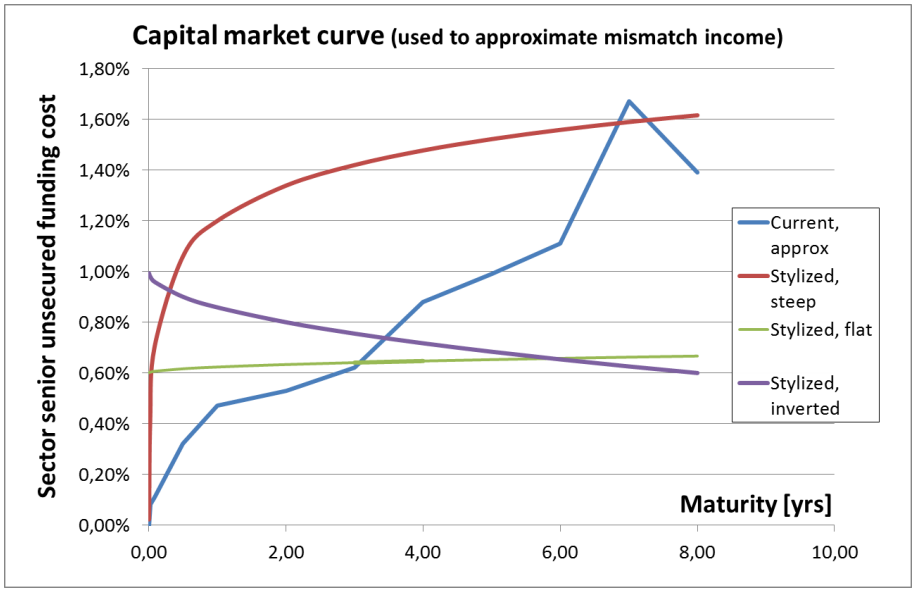


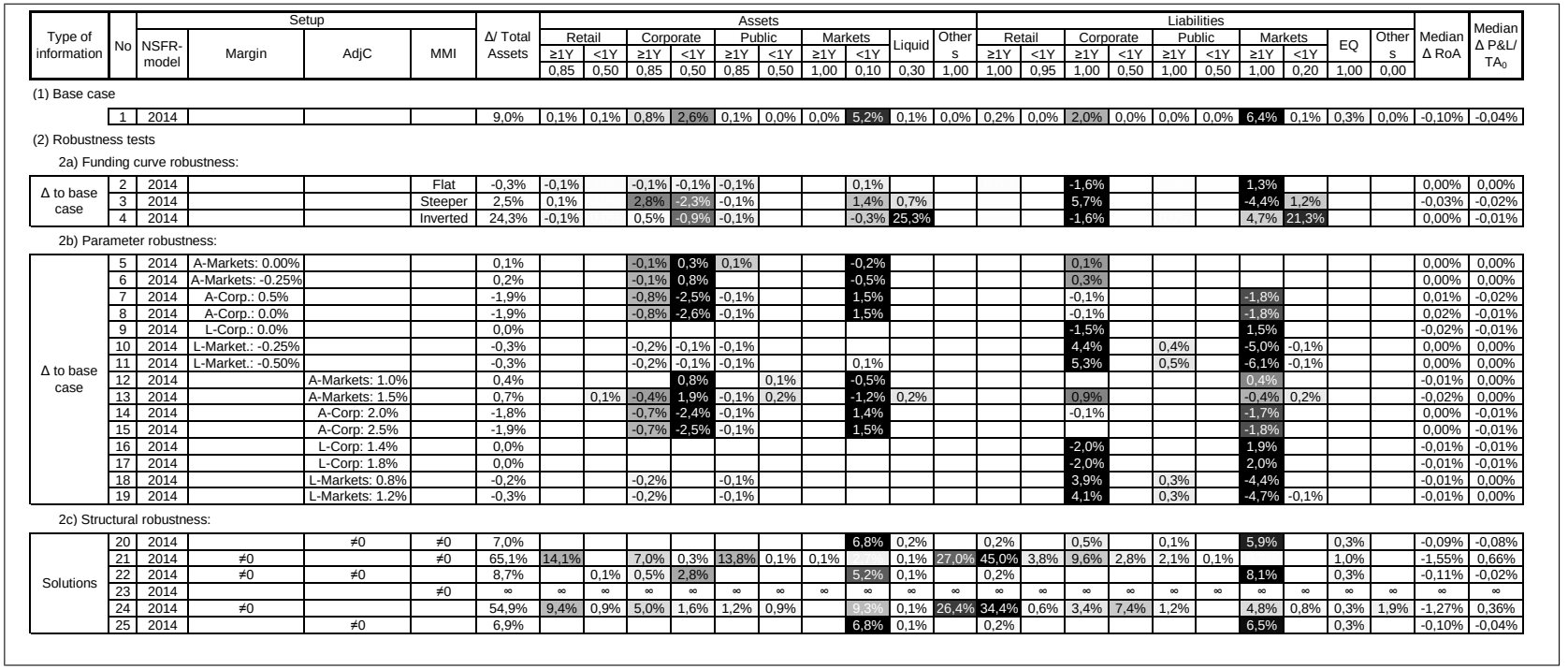
Figure 11: Funding scenarios to check the model response to funding rate shocks. We applied a steeper, a flat and an inverted bank funding curve.

5.1 Funding curve

Assuming that it is likely that the current low-interest environment in Europe will persist for some time, or that it is turned through tightening of monetary policy, we focused on these two developments. We used the stylized curves shown in Figure 11: a further slight flattening of the yield curve, a steeper curve and an inverted curve. The results are displayed in subsection (2a) in Figure 12. A flat curve (Test No 2) would slightly reduce the amplitude of strategies lowering the balance sheet growth by -0.3%. On the funding side, some 1.3% corporate funding would be replaced by market funding. A steeper curve (Test No 3) would increase the mismatch income and thus incentive for higher balance sheet growth. In the case of an inverted curve (Test No 4), we have the phenomenon that an improvement in mismatch income can be achieved in an almost NSFR-neutral way: funding short-term in capital markets and investing in short-term liquid assets. This provides an incentive to ride this strategy until the margin deterioration kicks in. Thus, with an inverted yield curve, banks would engage in more capital market activities according to our model.

5.2 Margin and adjustment cost

The robustness tests with respect to margins and adjustment cost confirm our intuition: whenever we lower a margin or increase an adjustment cost, the model shifts volume from this position to the position with the next higher margin or lower adjustment cost. Across the tests 5 - 19, balance sheet growth varies by maximal 2% (tests 7,8, 14, 15). For test 5 and 6, we gradually reduced the margin of short-term market assets. As a response, the model lowers the position growth by 0.2% (test 5) and by 0.5% (test 6). Analogously, if we reduce the margin of corporate lending to 0.5% and 0.0% (run 7 and 8), less funds are invested in these positions. Although the relative importance of the



Type of information	No	Setup				Δ/ Total Assets	Assets										Liabilities										Median Δ RoA	Median Δ P&L/ TA_0
		NSFR-model	Margin	AdjC	MMI		Retail		Corporate		Public		Markets		Liquid	Others	Retail		Corporate		Public		Markets		EQ	Others		
							≥1Y	<1Y	≥1Y	<1Y	≥1Y	<1Y	≥1Y	<1Y			≥1Y	<1Y	≥1Y	<1Y	≥1Y	<1Y	≥1Y	<1Y				
							0,85	0,50	0,85	0,50	0,85	0,50	1,00	0,10	0,30	1,00	1,00	0,95	1,00	0,50	1,00	0,50	1,00	0,20	1,00	0,00		
(1) Base case																												
	1	2014				9,0%	0,1%	0,1%	0,8%	2,6%	0,1%	0,0%	0,0%	5,2%	0,1%	0,0%	0,2%	0,0%	2,0%	0,0%	0,0%	0,0%	6,4%	0,1%	0,3%	0,0%	-0,10%	-0,04%
(2) Robustness tests																												
2a) Funding curve robustness:																												
Δ to base case	2	2014			Flat	-0,3%	-0,1%		-0,1%	-0,1%	-0,1%			0,1%					-1,6%				1,3%				0,00%	0,00%
	3	2014			Steeper	2,5%	0,1%		2,8%	-2,3%	-0,1%			1,4%	0,7%				5,7%				-4,4%	1,2%			-0,03%	-0,02%
	4	2014			Inverted	24,3%	-0,1%		0,5%	-0,9%	-0,1%			-0,3%	25,3%				-1,6%				4,7%	21,3%			0,00%	-0,01%
2b) Parameter robustness:																												
Δ to base case	5	2014	A-Markets: 0.00%			0,1%			-0,1%	0,3%	0,1%			-0,2%					0,1%								0,00%	0,00%
	6	2014	A-Markets: -0.25%			0,2%			-0,1%	0,8%				-0,5%					0,3%								0,00%	0,00%
	7	2014	A-Corp.: 0.5%			-1,9%			-0,8%	-2,5%	-0,1%			1,5%					-0,1%				-1,8%				0,01%	-0,02%
	8	2014	A-Corp.: 0.0%			-1,9%			-0,8%	-2,6%	-0,1%			1,5%					-0,1%				-1,8%				0,02%	-0,01%
	9	2014	L-Corp.: 0.0%			0,0%													-1,5%				1,5%				-0,02%	-0,01%
	10	2014	L-Market.: -0.25%			-0,3%			-0,2%	-0,1%	-0,1%								4,4%		0,4%		-5,0%	-0,1%			0,00%	0,00%
	11	2014	L-Market.: -0.50%			-0,3%			-0,2%	-0,1%	-0,1%			0,1%					5,3%		0,5%		-6,1%	-0,1%			0,00%	0,00%
	12	2014		A-Markets: 1.0%		0,4%				0,8%		0,1%		-0,5%									0,4%				-0,01%	0,00%
	13	2014		A-Markets: 1.5%		0,7%		0,1%	-0,4%	1,9%	-0,1%	0,2%		-1,2%	0,2%				0,9%				-0,4%	0,2%			-0,02%	0,00%
	14	2014		A-Corp: 2.0%		-1,8%			-0,7%	-2,4%	-0,1%			1,4%					-0,1%				-1,7%				0,00%	-0,01%
	15	2014		A-Corp: 2.5%		-1,9%			-0,7%	-2,5%	-0,1%			1,5%									-1,8%				0,00%	-0,01%
	16	2014		L-Corp: 1.4%		0,0%													-2,0%				1,9%				-0,01%	-0,01%
	17	2014		L-Corp: 1.8%		0,0%													-2,0%				2,0%				-0,01%	-0,01%
	18	2014		L-Markets: 0.8%		-0,2%			-0,2%		-0,1%								3,9%		0,3%		-4,4%				-0,01%	0,00%
	19	2014		L-Markets: 1.2%		-0,3%			-0,2%		-0,1%								4,1%		0,3%		-4,7%	-0,1%			-0,01%	0,00%
2c) Structural robustness:																												
Solutions	20	2014		≠0	≠0	7,0%								6,8%	0,2%		0,2%		0,5%		0,1%		5,9%		0,3%		-0,09%	-0,08%
	21	2014	≠0		≠0	65,1%	14,1%		7,0%	0,3%	13,8%	0,1%	0,1%		0,1%	27,0%	45,0%	3,8%	9,6%	2,8%	2,1%	0,1%			1,0%		-1,55%	0,66%
	22	2014	≠0	≠0		8,7%		0,1%	0,5%	2,8%				5,2%	0,1%		0,2%						8,1%		0,3%		-0,11%	-0,02%
	23	2014			≠0	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞
	24	2014	≠0			54,9%	9,4%	0,9%	5,0%	1,6%	1,2%	0,9%		0,8%	0,1%	26,4%	34,4%	0,6%	3,4%	7,4%	1,2%		4,8%	0,8%	0,3%	1,9%	-1,27%	0,36%
	25	2014		≠0		6,9%								6,8%	0,1%		0,2%						6,5%		0,3%		-0,10%	-0,04%

Figure 12: Results of studying robustness against changes in funding curve (2a), margins and adjustment costs (2b) and P&L-design (2c). All results are expressed as Δ w.r.t. the base case (1) except for 2c. Figures $|x| \leq 0.05\%$ are omitted to improve readability.

changes slightly change, the common strategic elements across banks (raising long-term capital market- and corporate funding and investing the proceeds in short-term market assets and corporate lending) still persist.

5.3 P&L - design

In the last round of robustness tests, we challenge the overall design of our model by sequentially switching off certain P&L-components. None of these configurations represent a realistic bank, but the tests help us to identify which P&L-component is the most important one for the robustness of our results. The tests 20-22 switch off margin income (test 20), adjustment cost (test 21) and mismatch income (test 22). We can see that switching off margin income or mismatch income does not have a major consequence: optimal strategies are very similar to the base case. However, switching off adjustment cost induces high balance sheet growth. This effect is more pronounced if we look at the runs 23-25 where two P&L-components are switched off (and only one P&L-component remains active). Here, only run 25 (AdjC are switched on) leads to similar strategies as in the base case. Run 24 (margin income is switched on) still leads to converging solutions/ strategies because of the margin elasticity effect, but such an effect is missing in the mismatch income which leads to a non-converging setup (indicated by ∞). This also points out that the NSFR does not completely limit the mismatch income as the mismatch income is generated across the whole funding curve and not only in two buckets ($< 1Y$, $\geq 1Y$). If the NSFR would perfectly correlate with the mismatch income, a NSFR-limitation would in our setup also imply a limitation in mismatch income and thus a converging model. This imperfect correlation is an important aspect that regulators address by complementing the NSFR-information with interest shock information under Pillar 2.

Omission of other regulatory constraints Apart from NSFR and leverage ratio, banks must also fulfill risk-weighted capital ratios, and a liquidity coverage ratio. Unlike the NSFR, the weighting scheme for capital ratios (risk weights) and liquidity coverage ratio ($\leq$ 30d, $>$ 30d) cannot be deducted from accounting information. Thus, following the same approach as for NSFR (using the known quantities on the subsample to calibrate the model for the complete sample) wouldn't work for risk-based capital ratios and the LCR. In general we expect our optimal strategies to be invariant against additional risk-based capital- or LCR-constraints. The reasons are as follows: the optimal strategies for NSFR(2014) as reported in Section 4.3.2 are not only NSFR-improving, but also improve LCR. They are LCR-improving because the new funding does not increase outflows, but might increase inflows (via the investment in 'Marketable assets, <1Y'). With this respect, an additional LCR-constraint is unlikely to change our optimal NSFR-solution. With respect to capital ratios, we expect changes, but they would be fairly small. Our NSFR-strategies consist of building up additional assets. As soon as the risk-weight of these assets is not zero, our NSFR-strategies reduce risk-weighted capital ratios. The bulk of assets is generated as "Marketable assets, <1Y'. It is fair to assume that their risk weight is rather small. The other large portion concerns short-term corporate lending. Here, it is almost certain that the risk weight differs from zero. Banks that are (risk-weighted) capital- and NSFR-constraint would have to substitute a small portion of long-term market funding

by equity funding (in a similar fashion how our leverage constraint currently works). However, we expect this substituted portion to be rather small as equity shortfalls are usually much smaller than NSFR-shortfalls.[28] Volume-wise, the equity strategy would be rather an appendix to the NSFR-strategy. Thus, one would expect the same strategies for NSFR alone, but instead of having 100% debt stable funding, a small portion of the stable funding might be equity to overcome the capital shortfall. Summarizing, we believe that the interaction terms with LCR and risk-weighted capital ratios would be rather small and that our NSFR-strategies are still optimal when these constraints would be added.[29]

6 Conclusion

The financial crisis has shown that a Net Stable Funding Ratio (NSFR) that limits banks' maturity mismatch risk might be needed in order to increase the resilience of banks with respect to funding shocks. As a consequence of this regulatory instrument, however, banks might see their mismatch income vanish and respond by cutting back credit in order to achieve compliance with it. Precisely for these considerations, our study analyzes the potential impact of a NSFR requirement on credit supply in Germany and the profitability of German banks. Our framework consists of two steps: in a first step, we estimate the initial NSFR and the shortfall in stable funding for each bank. Subsequently, we derive optimal compliance strategies for those banks that do not fulfill the NSFR. Unlike previous NSFR studies, we have actual NSFRs for a subset of our sample that enables us to partially calibrate our model against actual NSFRs. We apply the calibrated model to estimate the shortfall for each bank. In a second step, we derive strategies to overcome the shortfall.

Unlike previous NSFR studies, the compliance strategies that we derive are not heuristics. Instead, they result from a microeconomic bank model without a-priori restrictions on the strategy set[30]. The model determines the strategy that achieves compliance and yields the highest P&L-contribution. We decompose the P&L-contribution into margin- and mismatch income as well as non-financial adjustment cost. All three parameters are bank-specific in order to account for the heterogeneity of the sector. The optimal strategy is described as a vector of changes of banks' balance sheet positions. In order to partially capture capital constraints, our optimization also includes a leverage constraint of 4%[31].

Estimating the overall shortfall, we find that 163 German banks (out of 1815 banks) or 9% of the sector population does not yet comply with the NSFR (2014). On average, the shortfall in stable funding amounts to 6.7% of total assets of non-compliant banks. Without the revision of the NSFR in 2014, these figures would have been significantly higher. Under the initially proposed NSFR (2010), 713 banks or 39% of the sector population would not be compliant with an average shortfall of 8.8% of total assets.
Subsequently, we asked whether NSFR (2014)-non-compliant banks share common char-

[28] cf. BCBS (2013): the reported capital shortfall amounts to around 80 bn EUR whereas the NSFR-shortfall amounts to around 2.000 bn EUR.

[29] A paper that exclusively focuses on interaction terms between Basel III - ratios is Heidorn et al. (2015). They found that interaction is on average small. The largest synergies stem from capital- and NSF-ratio as capital serves as risk buffer in both ratios.

[30] Andrae et al. (2014) only allow for strategies that leaves the balance sheet size constant.

[31] We assume a buffer of 1% above the regulatory requirement of 3%.

acteristics that - at the same time - differentiate them from compliant banks. With 99% confidence, we find that non-compliant banks hold less liquid assets, rely less on retail funding, but more on short-term market funding and are less capitalized. Furthermore, they have more corporate lending. With respect to alternative funding ratios, non-compliant banks do not only have lower (non-compliant) NSFRs, but they also have lower core funding ratios, a higher wholesale funding ratio and a lower loan-to-deposit ratio.

In the second step, we apply our microeconomic model to each non-compliant bank to derive an optimal way to overcome the shortfall. For the 163 non-compliant NSFR (2014) banks, we find 70 different strategies. Such a heterogenous outcome does not come as a surprise as our model preserves heterogeneity by bank-specific margins, mismatch income and adjustment cost. Although heterogeneous in detail, strategies have some elements in common: all banks increase their balance sheets. The large majority increases their stable funding by raising long-term market funding and investing it in short-term market assets and short-term corporate lending. None of the strategies implies a reduction in lending. We also find that only banks that are constraint by the leverage ratio, raise equity. None of the banks raises equity to fulfill the NSFR as our model accommodates cheaper sources of stable funding. The average growth rate is 9% and thus higher than the average stable funding shortfall. This suggests that banks are combining compliance with business objectives. Profitability-wise we find that banks see their Return on Assets dropping once by moderate 10 bps. Under the NSFR (2010), the strategy universe is naturally more dispersed (102 strategies, but with 6 times more non-compliant banks), but the strategies feature the same common elements as under NSFR (2014). In this regard, the NSFR (2014) strategies are the same, but simply of smaller magnitude than the NSFR (2010) - strategies.

We run several robustness tests with respect to funding curve developments, model parameters (margin and adjustment cost) and P&L-design and find that only in the case of inverted yield curves, strategies would need to be re-adjusted.
We conclude that it is very unlikely that banks respond to an introduction of a NSFR by reducing credit supply. Instead, there are much more NSFR (2014) - efficient and less costly strategies to pursue. Furthermore, the reduction in profitability is very moderate. These findings are robust against changes in margins, adjustment costs, and funding curves.

Our framework could be extended in several ways: Firstly, Basel III - risk-weighted capital ratios could be incorporated as additional constraints as soon as reliable estimates are available. Secondly, we believe that a dynamic link between the riskiness of the firm and its funding cost would add an interesting angle. Currently, this link is static as the funding cost only depends on the initial riskiness but not on the riskiness after optimization. Thirdly, exogenous funding shocks could be incorporated which would incentivise risk-averse banks to hold an (endogenously optimal) buffer beyond the regulatory minimum.

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A Data

A.1 Assumptions underlying necessary approximations

While our data set allows a mostly assumption-free estimation of shortfall, we had to estimate some breakdowns of aggregated figures. In particular, we had to make the following assumptions about the maturity structure of our balance sheet data:

1. the category *Foreign corporate & retail* $\geq 1yr$ existing in German regulatory databases is 80% corporate and 20% retail
2. the category *Foreign corporate & retail* $< 1yr$ is 50% corporate and 50% retail
3. *Savings deposits* are 70% retail $\geq$ 11yr, 10% retail $<$ 1yr and 20% corporate $>$ 1yr
4. 90% of *bonds* are liquid bonds, 10% are not liquid (calibrated using known NSFR figures)
5. 25% of *subordinated debt* is $\geq$ 1yr and 75% is $<$ 1yr
6. 75% of *securitized liabilities* are $\geq$1yr and 25% are $<$ 1yr (calibrated using known NSFR figures)

Assumption 4 and 6 have been calibrated against reported NSFRs to minimize the shortfall error between our model NSFR and the reported NSFR on the 37 monitored banks. We have chosen to use these two items for calibration, because their parameter values tend to have a large impact on the shortfall. In Table 4, the decision variable 'Corporate $>$ 1yr' is assigned the weight $\rho = 0.6$ instead of 0.5 as given by the Basel rules text for the NSFR (2010). This adjustment is due to the fact that we had to include SME figures in the Corporate segment due to data restrictions. The SME segment is taken to be retail under the NSFR (2010) with a weight of $\rho = 0.85$. Secondly, the retail RSF weight was adjusted from $\rho = 0.85$ down to $\rho = 0.8$ in Table 4 to account for the fact that the retail category in our model includes mortgages with weight $\rho = 0.65$. Neither adjustments had a significant impact on our results.

A.2 Mapping of imported balance sheet data to model decision variables

Figures 13 and 14 document the mapping of imported asset- and liability positions onto decision variables of our model. The imported positions are to be read row-wise (stated on the left) and the decision variables are to be read column-wise. Rows with a single '1' mean that the position can be aggregated without ambiguity to one decision variable. Rows with several weights split up imported quantities and assign them to different decision variables.

(A) Assets			Asset decision variables									
			01	02	03	04	05	06	07	08	09	10
			Retail, < 1yr	Retail, ≥1Y	Corporate, < 1yr	Corporate, ≥1Y	Public sector, <	Public sector, ≥1Y	Markets, < 1yr	Markets, ≥1Y	Liquid assets	Other assets
Reported data	01	Interbank assets, <1Y	0	0	0	0	0	0	1	0	0	0
	02	Interbank assets, ≥ 1Y	0	0	0	0	0	0	0	1	0	0
	03	Central bank assets, <1Y	0	0	0	0	1	0	0	0	0	0
	04	Corporate lending, <1Y	0	0	1	0	0	0	0	0	0	0
	05	Corporate lending, ≥ 1Y	0	0	0	1	0	0	0	0	0	0
	06	Financial corporations, <1Y	0	0	0	0	0	0	1	0	0	0
	07	Financial corporations, ≥ 1Y	0	0	0	0	0	0	0	1	0	0
	08	Retail lending, <1Y	1	0	0	0	0	0	0	0	0	0
	09	Retail lending, ≥ 1Y	0	1	0	0	0	0	0	0	0	0
	10	Public sector lending, <1Y	0	0	0	0	1	0	0	0	0	0
	11	Public sector lending, ≥ 1Y	0	0	0	0	0	1	0	0	0	0
	12	Foreign (Corp. & Retail) , <1Y	0.5	0	0.5	0	0	0	0	0	0	0
	13	Foreign (Corp. & Retail), ≥ 1Y	0	0.2	0	0.8	0	0	0	0	0	0
	14	Cash	0	0	0	0	0	0	0	0	1	0
	15	Deposits at central bank	0	0	0	0	0	0	0	0	1	0
	16	Treasury bills	0	0	0	0	0	0	0	0	1	0
	17	Bills	0	0	0	0	0	0	0	0	1	0
	18	Bonds	0	0	0	0	0	0	0	0.1	0.9	0
	19	Shares	0	0	1	0	0	0	0	0	0	0
	20	S_AND_L_INTERESTS	0	0	0	0	0	0	0	0	0	1
	21	Minority interests	0	0	0	0	0	0	0	0	0	1
	22	Trust assets	0	0	0	0	0	0	0	0	0	1
	23	Public assets	0	0	0	0	0	1	0	0	0	0
	24	Fixed assets	0	0	0	0	0	0	0	0	0	1
	25	Other assets	0	0	0	0	0	0	0	0	0	1
	26	Derivatives, Price > 0	0	0	0	0	0	0	0	0	0	1
	27	Asset Consolidation	0	0	0	0	0	0	0	0	0	1
	28	Central Bank, non-bank assets	0	0	0	0	0	0	0	0	0	1
	29	Net derivatives receivables	0	0	0	0	0	0	0	1	0	0

Figure 13: Mapping of reported asset positions to model decision variables, asset side

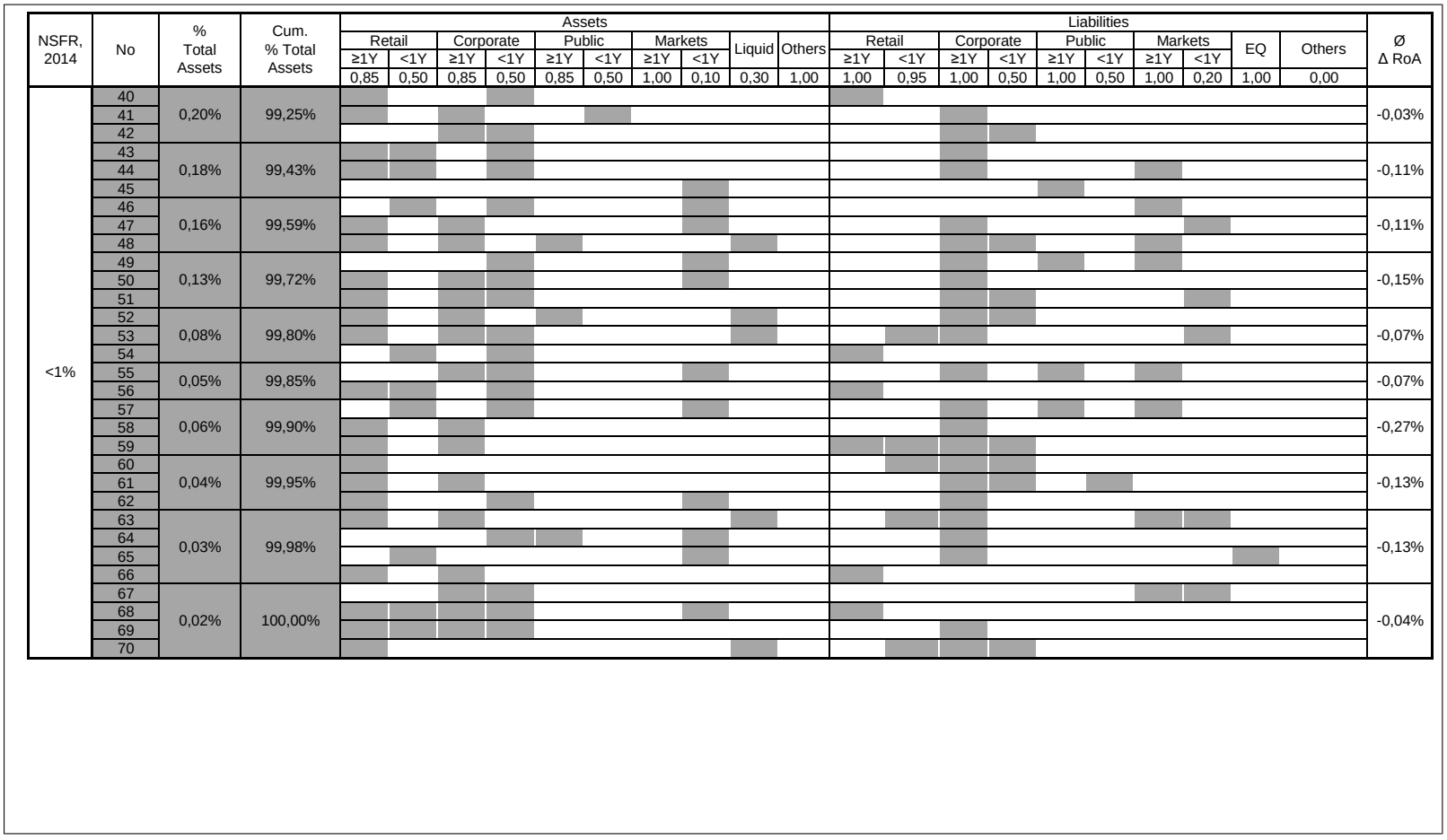
(B) Liabilities			Liability decision variables									
			11	12	13	14	15	16	17	18	19	20
			Retail, < 1yr	Retail, ≥1Y	Corporate, < 1yr	Corporate, ≥1Y	Public sector, < 1yr	Public sector, ≥1Y	Markets, < 1yr	Markets, ≥1Y	Equity	Other liabilities
Reported data	29	Interbank liabilities , <1Y	0	0	0	0	0	0	1	0	0	0
	30	Interbank liabilities, ≥ 1Y	0	0	0	1	0	0	0	0	0	0
	31	Central bank liabilities , <1Y	0	0	1	0	0	0	0	0	0	0
	32	Central bank liabilities, ≥ 1Y	0	0	0	0	0	0	0	1	0	0
	33	Saving deposits	0.1	0.7	0	0.2	0	0	0	0	0	0
	34	Non-financial corporate funding , <1Y	0	0	1	0	0	0	0	0	0	0
	35	Non-financial corporate funding, ≥ 1Y	0	0	0	1	0	0	0	0	0	0
	36	Funding from financials , <1Y	0	0	0	0	0	0	1	0	0	0
	37	Funding from financials, ≥ 1Y	0	0	0	0	0	0	0	1	0	0
	38	Retail funding (non-saving deposits) , <1Y	1	0	0	0	0	0	0	0	0	0
	39	Retail funding (non-saving deposits), ≥ 1Y	0	1	0	0	0	0	0	0	0	0
	40	Public sector funding, <1Y	0	0	0	0	1	0	0	0	0	0
	41	Public sector funding, ≥ 1Y	0	0	0	0	0	1	0	0	0	0
	42	Foreign (Corp. & Retail) , <1Y	0.5	0	0.5	0	0	0	0	0	0	0
	43	Foreign (Corp. & Retail), ≥ 1Y	0	0.5	0	0.5	0	0	0	0	0	0
	44	Conditional liabilities	0	0	0	0	0	0	0	0	0	1
	45	Securitized liabilities	0	0	0	0	0	0	0.25	0.75	0	0
	46	Trust liabilities	0	0	0	0	0	0	0	0	0	1
	47	Provisions	0	0	0	0	0	0	0	0	1	0
	48	Reserves	0	0	0	0	0	0	0	0	1	0
	49	Subordinated debt	0	0	0	0	0	0	0.75	0.25	0	0
	50	Jouissance capital	0	0	0	0	0	0	0	0	1	0
	51	General bank risk	0	0	0	0	0	0	0	0	1	0
	52	Equity	0	0	0	0	0	0	0	0	1	0
	53	Other liabilities	0	0	0	0	0	0	0	0	0	1
	54	Derivatives, price < 0	0	0	0	0	0	0	0	0	0	0

Figure 14: Mapping of reported liability positions to model decision variables, liability side

B Results

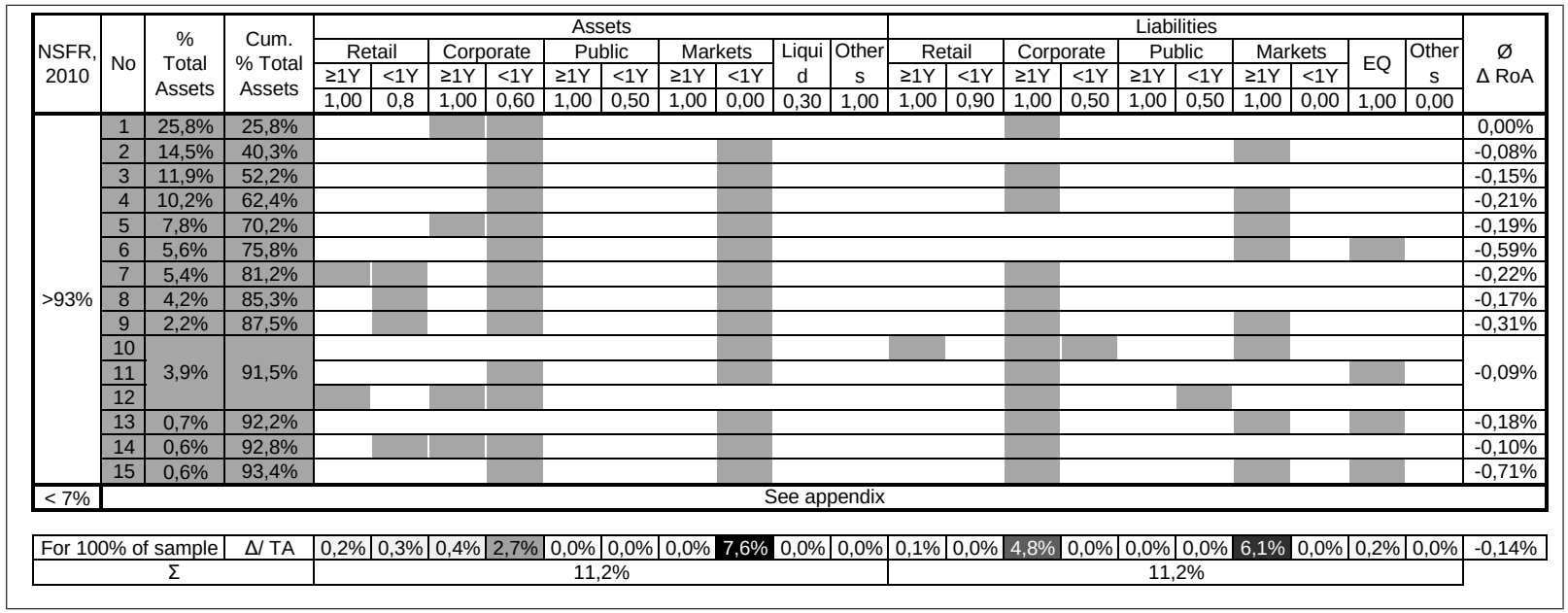
NSFR, 2014	No	% Total Assets	Cum. % Total Assets	Assets										Liabilities										Ø Δ RoA
				Retail		Corporate		Public		Markets		Liquid	Others	Retail		Corporate		Public		Markets		EQ	Others	
				≥1Y	<1Y	≥1Y	<1Y	≥1Y	<1Y	≥1Y	<1Y			≥1Y	<1Y	≥1Y	<1Y	≥1Y	<1Y	≥1Y	<1Y			
				0,85	0,5	0,85	0,50	0,85	0,50	1,00	0,10	0,30	1,00	1,00	0,95	1,00	0,50	1,00	0,50	1,00	0,20	1,00	0,00	
<6%	17	0,49%	93,7%		■		■									■								-0,12%
	18	0,43%	94,1%	■			■									■								-0,05%
	19	0,84%	95,0%		■		■	■								■				■				-0,03%
	20			■		■										■	■							
	21	0,76%	95,7%			■	■				■									■		■		-0,25%
	22						■									■	■							
	23	0,35%	96,1%		■		■				■					■				■				-0,33%
	24	0,84%	96,9%			■	■									■				■				-0,16%
	25						■	■			■									■				
	26					■	■				■					■								
	27	0,24%	97,2%	■		■	■									■								-0,07%
	28	0,45%	97,6%			■					■									■	■			-0,11%
	29			■	■		■				■					■								
	30	0,41%	98,0%								■					■		■		■		■		-0,24%
	31			■	■		■									■	■		■					
	32	0,52%	98,5%				■				■					■				■		■		-0,31%
	33						■				■	■		■								■		
	34						■									■								
	35	0,26%	98,8%		■		■				■			■										-0,17%
	36			■	■	■			■							■								
	37	0,25%	99,0%		■		■									■				■				-0,05%
	38			■	■	■		■								■			■		■			
	39				■	■										■								

Figure 15: Strategies (17-39) to achieve NSFR(2014)-compliance



NSFR, 2014	No	% Total Assets	Cum. % Total Assets	Assets										Liabilities										Ø Δ RoA
				Retail		Corporate		Public		Markets		Liquid	Others	Retail		Corporate		Public		Markets		EQ	Others	
				≥1Y	<1Y	≥1Y	<1Y	≥1Y	<1Y	≥1Y	<1Y			≥1Y	<1Y	≥1Y	<1Y	≥1Y	<1Y	≥1Y	<1Y			
				0,85	0,50	0,85	0,50	0,85	0,50	1,00	0,10	0,30	1,00	1,00	0,95	1,00	0,50	1,00	0,50	1,00	0,20	1,00	0,00	
<1%	40	0,20%	99,25%	■			■							■										-0,03%
	41			■		■			■							■								
	42					■	■									■	■							
	43	0,18%	99,43%	■	■		■									■								-0,11%
	44			■	■		■									■				■				
	45										■							■						
	46	0,16%	99,59%		■		■				■									■				-0,11%
	47			■		■					■					■					■			
	48			■		■		■				■				■	■			■				
	49	0,13%	99,72%				■				■					■		■		■				-0,15%
	50			■		■	■				■					■								
	51			■		■	■									■	■				■			
	52	0,08%	99,80%	■		■		■				■				■	■							-0,07%
	53			■		■	■					■			■	■					■			
	54				■		■							■										
	55	0,05%	99,85%			■	■				■					■		■		■				-0,07%
	56			■	■		■							■										
	57	0,06%	99,90%		■		■				■					■		■		■				-0,27%
	58			■		■										■								
	59			■		■								■	■	■	■							
	60	0,04%	99,95%	■											■	■	■							-0,13%
	61			■		■										■	■		■					
	62			■			■				■					■								
	63	0,03%	99,98%	■		■						■			■	■				■	■			-0,13%
	64						■	■			■					■								
	65				■						■					■						■		
	66			■		■								■										
	67	0,02%	100,00%			■	■													■	■			-0,04%
	68			■	■	■	■				■			■										
	69			■	■	■	■									■								
	70			■								■			■	■	■							

Figure 16: Strategies (40-70) to achieve NSFR(2014)-compliance



NSFR, 2010	No	% Total Assets	Cum. % Total Assets	Assets										Liabilities										Ø Δ RoA
				Retail		Corporate		Public		Markets		Liquid	Others	Retail		Corporate		Public		Markets		EQ	Others	
				≥1Y	<1Y	≥1Y	<1Y	≥1Y	<1Y	≥1Y	<1Y			≥1Y	<1Y	≥1Y	<1Y	≥1Y	<1Y	≥1Y	<1Y			
				1,00	0,8	1,00	0,60	1,00	0,50	1,00	0,00	0,30	1,00	1,00	0,90	1,00	0,50	1,00	0,50	1,00	0,00	1,00	0,00	
>93%	1	25,8%	25,8%																					0,00%
	2	14,5%	40,3%																					-0,08%
	3	11,9%	52,2%																					-0,15%
	4	10,2%	62,4%																					-0,21%
	5	7,8%	70,2%																					-0,19%
	6	5,6%	75,8%																					-0,59%
	7	5,4%	81,2%																					-0,22%
	8	4,2%	85,3%																					-0,17%
	9	2,2%	87,5%																					-0,31%
	10	3,9%	91,5%																					-0,09%
	11																							
	12																							
	13	0,7%	92,2%																					-0,18%
	14	0,6%	92,8%																					-0,10%
	15	0,6%	93,4%																					-0,71%
< 7%	See appendix																							
For 100% of sample	Δ/ TA	0,2%	0,3%	0,4%	2,7%	0,0%	0,0%	0,0%	7,6%	0,0%	0,0%	0,1%	0,0%	4,8%	0,0%	0,0%	0,0%	6,1%	0,0%	0,2%	0,0%	-0,14%		
Σ		11,2%										11,2%												

Figure 17: Strategies 1-15 to achieve NSFR(2010)-compliance

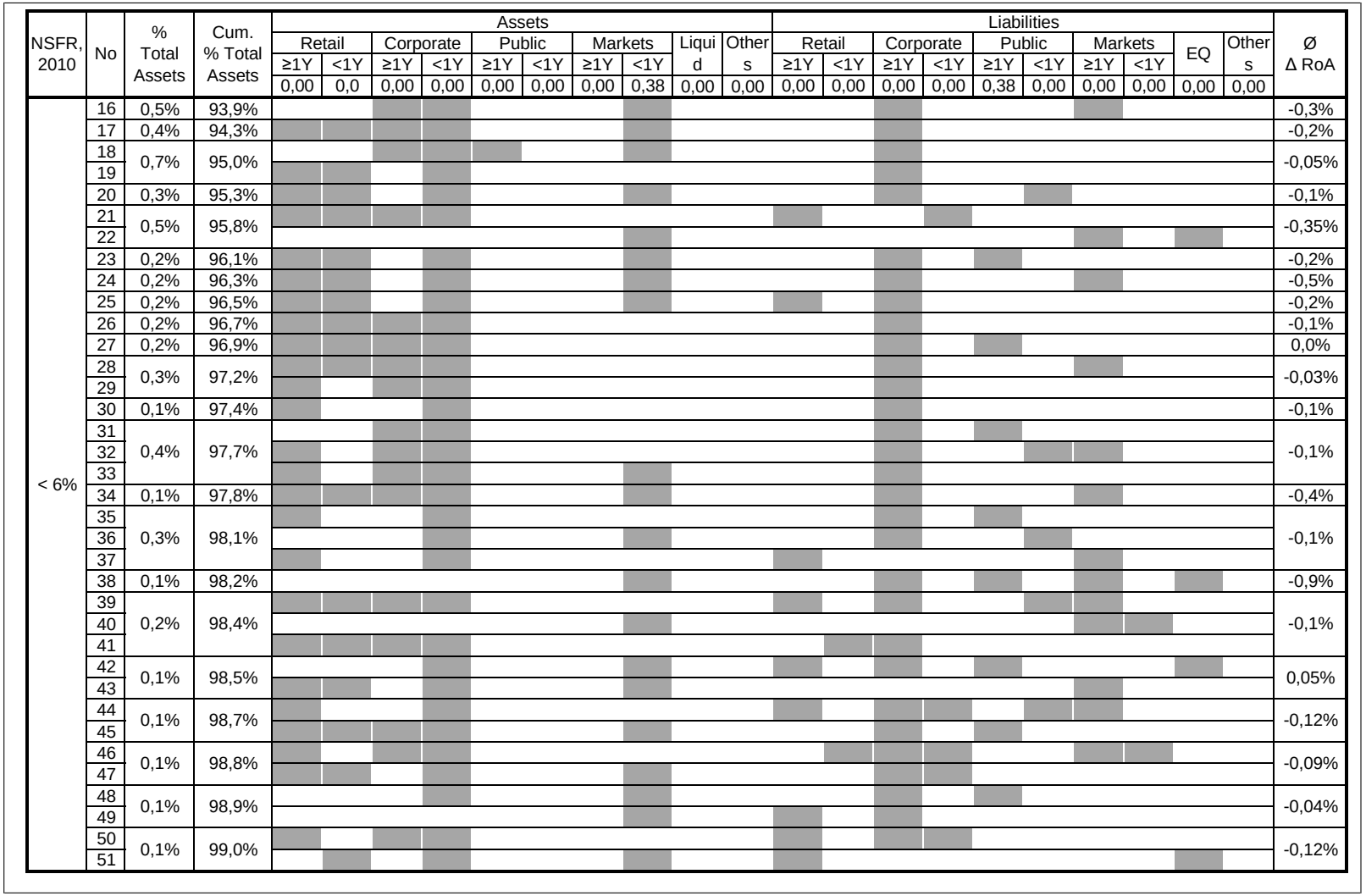


Figure 18: Strategies 16-51 to achieve NSFR(2010)-compliance

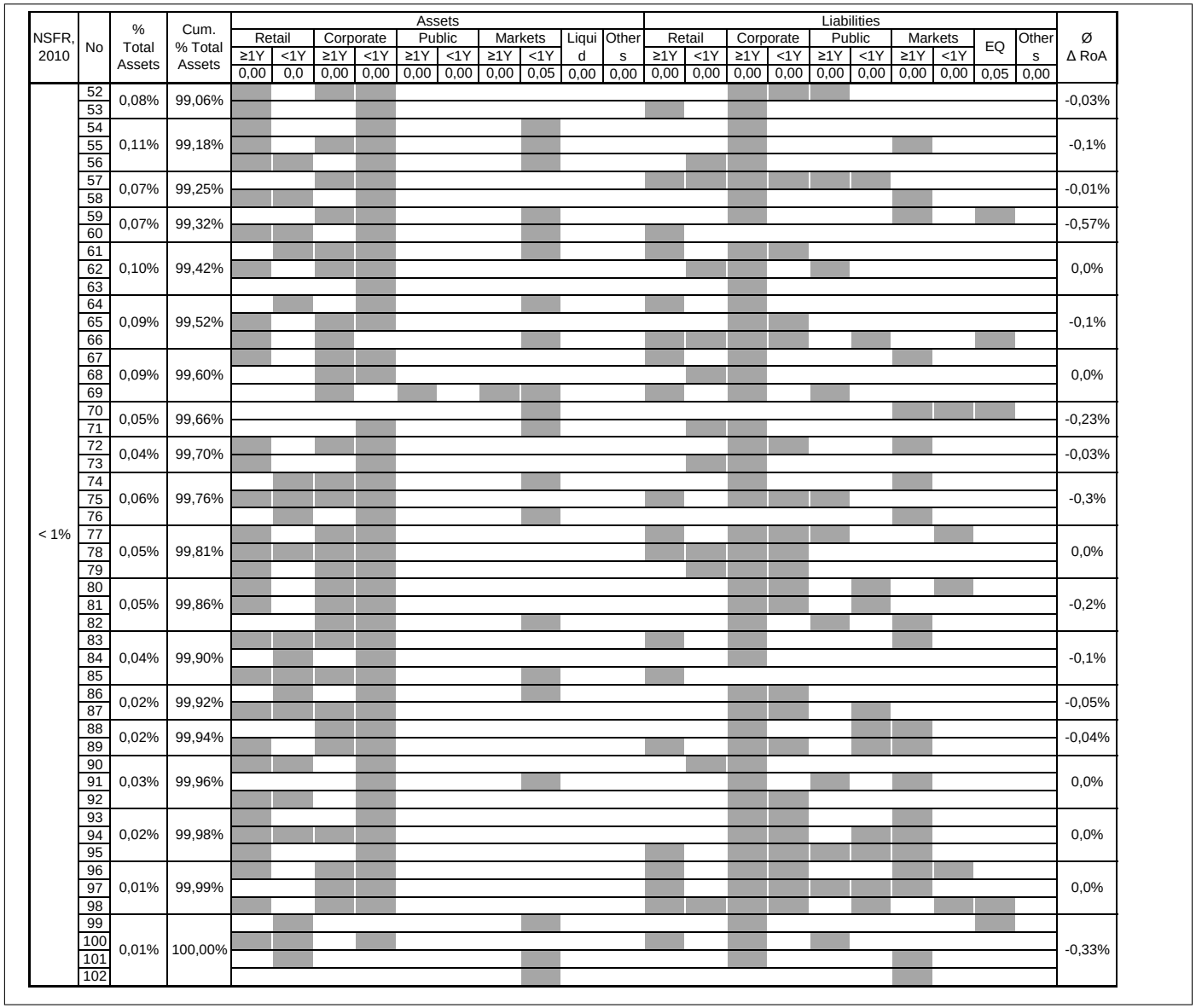


Figure 19: Strategies 52-102 to achieve NSFR(2010)-compliance