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CONTEMPORARY CHALLENGES IN THE ASSET LIABILITY MANAGEMENT

WSPÓŁCZESNE WYZWANIA W ODPOWIEDZIALNYM ZARZĄDZANIU AKTYWAMI

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Abstract: The role of the active management of the banking book in the banking industry is constantly growing. The efficient and productive use of a bank's resources subject to consolidated risk and return appetite remains of upmost importance for banks of all sizes. Therefore, the use of optimization techniques to manage the banking book of a financial institution is becoming an imperative to remain profitable. This article states that application of the optimization techniques can provide useful information to understand the target structure for the banking book in terms of its composition of liabilities and is an important tool to decrease the overall cost of funding. Moreover, the application of the optimization techniques in this article is seen as the integration of the exposure to the financial risks into one approach.

Keywords: optimization model, interest rate risk in the banking book, liquidity risk, objective function, constraints functions.

Streszczenie: Rola aktywnego zarządzania aktywami i pasywami w sektorze bankowym stale rośnie. Wydajne i produktywne wykorzystanie zasobów banku wyrażone w postaci skonsolidowanego ryzyka i stopy zwrotu pozostaje niezwykle ważne dla banków każdej wielkości. W celu zapewnienia zyskowności, wykorzystanie technik optymalizacji do zarządzania książką bankową instytucji finansowej staje się koniecznością. W artykule stwierdzono, że zastosowanie technik optymalizacji może dostarczyć przydatnych informacji do zrozumienia docelowej struktury księgi bankowej pod względem składu pasywów i jest ważnym narzędziem do obniżenia całkowitego kosztu finansowania. Co więcej, zastosowanie technik optymalizacji jest postrzegane przez autorkę jako integracja ekspozycji na ryzyko finansowe.

Słowa kluczowe: model optymalizacji, ryzyko stopy procentowej w książce bankowej, ryzyko płynności, funkcja celu, funkcje ograniczeń.

1. Introduction

This article proposes the application of the optimization techniques to decrease the cost of funding of a financial institution. It states that there is an economic benefit for the financial institution deriving from the optimization exercise and, in addition, it ensures the overall awareness of the senior management (Treasurer or CFO) as to the direction which has to be taken in order to achieve the target profile of the banking book. The optimization output will support a bank with strategic decision making such as the Funding Plan or the New Product Policy. The Regulatory and internal policies requirements are built into the constraints functions thus it is ensured that the limits are respected over time. Finally, the article provides the reader with the overview of the optimization process put in place to achieve this goal.

Asset – liability management is one of the most important issues in bank strategic planning [Kosmidou, Zopounidis 2002]. The application of the optimization tool for the determination of the optimal balance among profitability, risk, liquidity and other uncertainties has been already studied prior to the financial crisis in 2007-2009. After the financial crisis, significant regulatory pressures have additionally forced banks to improve their risk management and capital allocation practices. The Basel Committee on Banking Supervision [2016], the European Commission [2013] and the Prudential Regulation Authority [2015] require banks to revamp their approach towards the financial risk management and practice. The recent Basel III regulation highlights the necessity of the maintenance of the balance funding structure and minimum liquidity cushions and therefore forces the banks towards new business model in order to create the right incentives and to maintain regulatory limits [Lubinska 2017].

2. ALM of the banking book

The role of the Asset Liability Management in the active management of the banking book is constantly growing. This is due to its contribution related to the tactical position banks should take on to maintain healthy balance between profitability and the exposure to the financial risks in the banking book. On the one hand, it is up to the bank's Treasurer[1] to assess the direction the bank should be positioned on the interest rate curve ensuring profits in terms of the Net Interest Income (NII). It is also up to them to put in place such funding strategies which would allow for the liquidity of the bank to be managed in a proper manner. On the other though, it is the role of the second line of defence (risk management department) to make sure that the Treasurer's decisions do not lead to the excessive

[1] This is the case when the Treasury operates as a profit centre.

exposure to financial risks. This monitoring role is performed through setting up the internal policies and limits. Thus, Treasurer keeps the NII volatility within the limits and, at the same time, tries to gain, in the most efficient way, from the movement of the interest rate curve.

From the liquidity perspective, the main task of the Treasury Department is to keep the optimal amount of the liquidity portfolio known as the Liquid Asset Buffer (LAB), maintaining its Counterbalancing Capacity at the desirable level [Basel Committee on Banking Supervision 2013]. The Counterbalancing Capacity indicates the level of immunization a bank has for the potential liquidity needs arising in the stress situation. Consequently, one of the main tasks of the Treasurer is to find the target position for a bank ensuring the balance between healthy exposure to the Interest Rate Risk (IRRBB), its robust liquidity position and, in the same time, the ALM profitability (this is under the assumption that ALM is structured within the Treasury department which is allowed to take the interest rate and liquidity positioning).

The fact that there is a strict interrelation between the interest rate risk and liquidity risk is evident while looking at the projection of outstanding stocks according to the interest commitment and liquidity commitment dates. The interest rate risk gap, its impact on the ALM profitability and consequently the NII sensitivity resulting from the interest rate risk exposures is the one side of the coin. Then, there is another risk which results from the funding risk gap, its impact on the ALM profitability and its riskiness in terms of margin sensitivity. In order to present the interrelation between the liquidity and interest rate risk in detail, the simplified case has been analysed. Let u us assume that the banking book of a bank is composed of the fixed rate loan funded by the floating rate note indexed to the 3-month reference rate (3M Euribor). Their financial characteristics are as follows:

- Cut-off date: 31/12/2016;
- Par value: 100;
- ASSET – fixed rate loan at maturity 100;
- Repayment type: bullet;
- Next capital payment date: 31/12/2017;
- Next re-pricing date: 31/12/2017;
- LIABILITIES – floating rate notes 3m reset 100;
- Repayment type: bullet;
- Next capital payment date: 30/09/2017;
- Next re-pricing date: 31/03/2017.

In this example a 12-month maturity asset is funded by a 9-month maturity liability which exposes the bank to the liquidity gap. In the same time, the fixed rate asset is funded by the liability which re-prices on the 3-month basis (therefore, the interest rate risk arises on the 3-month re-fixing basis and liquidity risk after 9-month maturity). Obviously, it creates the re-pricing gap as the liability reprices before the asset (the asset gives rise to the interest rate risk at the date of its maturity). The banking book structure from the Treasurer's perspective is presented in Figure 1.

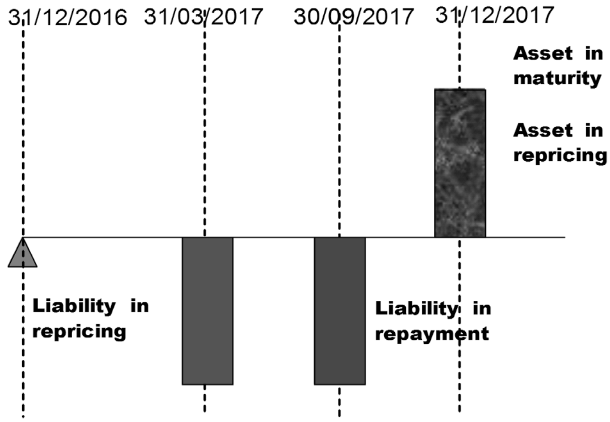

Fig. 1. Interest rate gap and funding gap in the banking book

Source: own study.

The banking book analysed here, shows the exposure to the interest rate risk on 31/03/2017 due to the re-fixing of the floating rate liability. Starting from that date the re-fixed asset will be funded by the re-fixing liability causing the interest rate gap and NII sensitivity (Figure 2). In this particular case, the Treasurer has taken

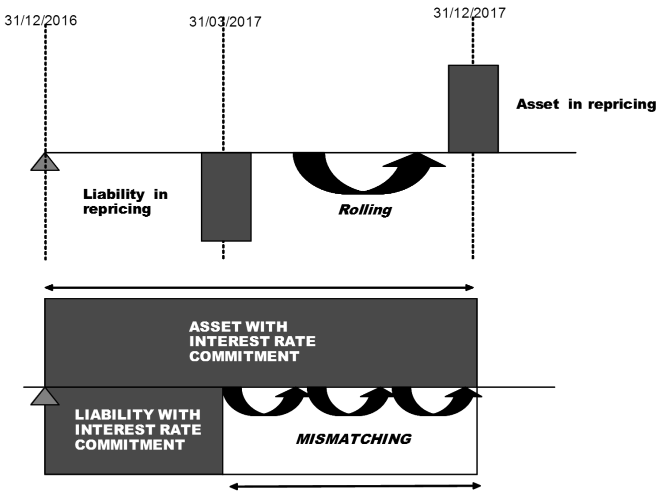

Fig. 2. Interest rate gap in the banking book and potential impact on profitability

Source: own study.

on the liability sensitive interest rate risk position as the liability re-prices before the asset exposing the bank to the interest rate risk.

The same situation analysed from the liquidity standpoint looks slightly different. The bank begins to be exposed to the liquidity risk on 30/09/2017 when the liability expires and needs to be rolled over. Starting from that date the funding risk gap creates the NII sensitivity (Figure 3).

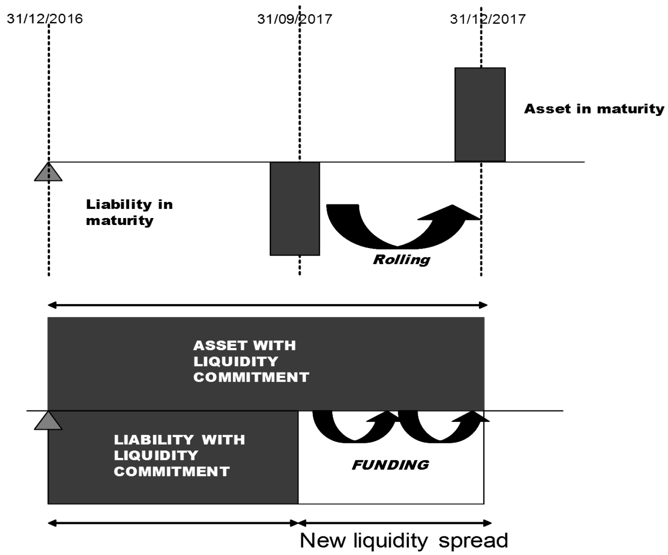

Fig. 3. Funding gap in the banking book and potential impact on profitability

Source: own study.

The realized profitability of the bank in terms of P&L impact is determined both by the past hedging strategies as to the interest rate component and the maturity transformation performed by the Treasury with reference to its liquidity component. There is clear trade-off between the expected P&L and its volatility (sensitivity). Thus, the riskiness embedded in the banking book structure is determined by the funding and hedging strategy of the bank and its risk tolerance.

Minimization of the NII sensitivity deriving from the interest rate risk and liquidity component of the banking book and what profitability needs to be provided by the ALM unit to the bank is the Treasurer's decision. The real challenge consists in understanding the trade-off between profitability and risk. This drives the funding strategies based on the choice of the appropriate composition of liabilities which represent the optimal trade off (target position) between its economical aspect (funding cost in this case) and the exposure to the financial risk the structure will impose on the bank.

Among factors such as the level of the uncertainty and the capability of the bank to predict the direction of the market there are also other factors which should be considered in the achievement of the target position, such as the unpredictable behaviour of customers of the bank both on the assets and the liabilities side, which defines the final composition of the banking book. The behavioural assumption related to the assets side are mostly defined by the *prepayment rate* of mortgages or personal loans prepaid before their contractual maturity date. This factor introduces significant uncertainty into the banking book since it can change the liquidity profile of the bank within a short-term period. Also, the hedging strategies undertaken in the past might turn out to be inefficient and might need to be adjusted.

Consequently, the main challenge of the Asset Liability Management is to find the banking book **target position** in terms of the exposure to the financial risks to minimize the cost of funding being subject to limits dictated by the internal policies and the regulator.

3. Numerical optimization – general concepts

Numerical methods are often required in finance to optimise the value of something when it depends on multiple inputs. As opposed to the analytical optimisation which involves finding the maximum and minimum of a function by finding point at which the function derivatives are zero, numerical optimisation is used when the explicitly defined function to be optimised does not lend itself to the analytical techniques, or when the function is not explicitly defined [Parramore, Watsham 2015].This section addresses the nonlinear optimization method known as the interior-point method which gets its name from the fact that the optimal solution is approached from the strict interior of the feasible region. This method is used in the Matlab optimization toolbox known as Fmincon to find a minimum of a constrained nonlinear multivariable function.

$$\min_{x \in R^n} f(x),$$

$$\text{subject to: } c_i(x) = 0,\ i \in \varepsilon,$$

$$c_i(x) \geq 0, i \in I, \tag{1}$$

where $c(x)$ is a m-vector of nonlinear constraint functions with i-th component $c_i(x)$, i=1, ..., m and $\mathcal{E}$, and I are the nonintersecting index sets. It is assumed that f and c are twice-continuously differentiable. Any point x satisfying the constraints above is called a feasible point, and the set of all such points is the feasible region. In order to solve the optimization problem, the gradient of the objective function $f(x)$ denoted by $\nabla f(x)$ or $g(x)$, has to be determined along with the Hessian matrix of second partial derivatives of $\nabla^2 f(x)$. The gradient and Hessian of *constrained functions* $c_i(x)$ are denoted by $\nabla c_i(f)$ and $\nabla^2 c_i(x)$. The $J(x)$ denotes the Jacobian matrix [Forsgren et al. 2002]:

$$B(x,\mu) = f(x) - \mu \sum_{i=1}^{m} \log c_i(x). \quad (2)$$

Here μ is a small positive scalar, often called the barrier parameter. As μ converges to zero the minimum of $B(x, \mu)$ should coverage to a solution of (1).

The barrier function gradient is:

$$g_b = g - \mu \sum_{i=1}^{m} \frac{1}{c_i(x)} \nabla c_i(x), \quad (3)$$

where g is the gradient of the objective function *f(x)* and ∇c_i is the gradient of c_i. In addition to the original, known as the "primal" variable x, the Lagrange multiplier inspired dual variable λ is introduced:

$$\lambda \in R^m \text{ and } c_i(x)\lambda_i = \mu\ , \forall i = 1, \dots, m. \quad (4)$$

In order to find the solution to the optimization problem it is necessary to satisfy the Karush-Kuhn-Tucker (KKT) optimality condition. KKT is a set of necessary conditions to be satisfied to achieve a solution in a nonlinear optimization with inequality constraints. The KKT approach to nonlinear programming generalizes the method of Lagrange multipliers, which allows only equality constraints.

This article is not meant to overview the KKT optimality conditions nor to provide the numerical solution to the inequality optimization problem. Instead, it aims to provide the reader with the general picture of the technique used to solve an actual optimization problem of minimization of cost of funds.

4. Optimization process

The first step in the optimization process is to identify the initial structure of the banking book which will act as a starting point of building the optimization problem. It defines the position, in terms of the assets and liabilities structure, existing at the analysis date. In addition, certain assumptions related to the liquidity profile in terms of the roll-over of term deposits, current and savings accounts (CASA) balance volatility and rate sensitivity, amortization profile and prepayment rate of assets have been defined as the initial conditions of the model.

Interestingly, the analysis of the initial structure of banks, based in different geographical locations, shows clear differences in the asset base and funding structure adopted by banks. For example, it appears that the commercial banks based in Italy have preferences towards floating rate items. Personal loans and commercial loans products are usually indexed to the interbank market benchmark such as Euribor. The reset frequency differs between 1M, 3M and 6M. From the funding base perspective, there is a significant reliance on current accounts provided by commercial clients and it is mostly focused on transactional current accounts. The commercial banks fund also important part of their assets through senior debt issuance and short-term wholesale funding.

Meanwhile the banks based in UK tend towards administered rate products which show high correlation to the Bank of England base rate (more than 80%). The floating rate products are predominantly linked to GBP Libor 3M. The retail banks are funded by retail current accounts and retail time deposits. The residual part of their funding structure consists of senior debt issuance. The short-term funding is mostly used for funding LAB and collateral funding.

The second step, in the optimization process, is to define the objective, constraint functions and the assumptions related to the banking book structure and behaviour such as profiling of items without deterministic maturity, roll-over of time deposits and prepayment rate. In addition, there are assumptions related to the amortization profile of assets and liabilities and their pricing (external rate to clients). The external rate to client is composed of the Funds Transfer Pricing (FTP) components (interest rate risk and liquidity risk component) and commercial spread to clients.

The objective of the optimization model for the liability side is to minimize the funding costs of the bank. The analysis needs to be performed over certain time horizon and predetermined maturity profile for the banking book items, for example, under steady Balance Sheet scenario where there is a renewal of assets and liabilities falling under maturity. The objective function is a multivariable equality function which describes the total cost of funding with variables representing the proportions of different source of funding in the total liabilities structure. The model searches for the minimum value of this function subject to certain constraints.

Let us assume that $w_A, w_B \dots w_j$ represent j-funding opportunities and w is the proportion this funding opportunity has in the total funding base. Moreover, the $v_A, v_B \dots v_j$ represent the annual cost of funds for the corresponding funding opportunity. The minimization function can be written as follows:

$$total\_cost\,(w_A, w_B, w_C, w_D) = w_A * total\_L * \sum_{i=1}^{6} v_{A_i}/12 + w_B * total\_L * \sum_{i=1}^{6} v_{B_i}/12 + w_C * total\_L * \sum_{i=1}^{6} v_{C_i}/12 + w_D * total\_L * \sum_{i=1}^{6} v_{D_i}/12. \quad (5)$$

In this particular example, the analysis is performed under the time horizon of 6 months (i=6), applied to the funding base composed of 4 (j=4) different funding opportunities (A, B, C and D) and the corresponding annual cost of funds for funding opportunity is denoted as v_A, v_B, v_C, v_D for every observation period.

The constraints functions are constructed to reflect the risk appetite of banks in different jurisdictions for liquidity and interest rate risk. In addition, there is also constraint imposed on the funding concentration to avoid over-reliance on one source of funding.

It is proposed that the bank's appetite for liquidity and funding risk are determined through:

- cumulative short-term liquidity ratio (known as Survival Horizon) which is set up over the time horizon of 30 or 60 days and determines the adequacy of the liquidity buffer of the bank;
- structural liquidity ratio which measures the extent of the maturity transformation run by the bank.

Short-term liquidity risk is quantified through the Survival Horizon (SH) metric that defines how long, during an extreme but plausible liquidity stress, the bank can survive before management actions are deployed. The goal of this metric is to ensure that the bank would have sufficient time to react and make decisions in stress which mobilise further liquidity creating actions to offset a significant stress.

The Survival Horizon analysis assesses the liquidity position under lasting 30 or 60 days stress conditions, constructed through definition of different assumptions of inflow and outflow for items on the Balance Sheet. The amount of the Liquidity buffer has to be at least equal to the net outflows calculated under stress scenarios. The worst result of the stress scenario (the highest requirement for the High-Quality Liquid Assets) is the driver of the liquidity buffer size which is held by the bank. The calculation of the cumulative short-term ratio is based on the *Maturity Mismatch Approach* which assesses the size of the liquidity gap within time buckets.

The Gap Ratio is defined as follows:

$$(\textit{Cash Inflows} + \textit{Counterbalancing Capacity}) \,/\, \textit{Cash Outflows} >= 100\%, \quad (6)$$

where 100% is the risk tolerance threshold established by the Board of Directors of the bank. *Cash Inflows* represent the incoming cash flows within the 30 or 60-days' time horizon put in place with parties outside the bank. Inflows arise from the maturity of asset, the use of irrevocable credit lines (liabilities), from the sale of marketable activities and positive components of income. Similarly, *Cash Outflows* represent the outgoing cash flows within the same 30 or 60-days' time horizon put in place with parties outside the bank. Outflows arise from maturing liabilities, from the use of irrevocable lines of credit and from negative income components. Finally, *Counterbalancing Capacity (LAB)* represents the sum of items used by the bank to meet its liquidity needs in case of stress scenario. The characteristics of Liquidity Buffer are subject to the criteria established by Basel III as high-quality level 1 and level 2 assets.

The Gap Ratio quantifies the amount of liquidity buffer which should be held by the bank to cover the proportion of the net outflows the bank experiences over the mentioned 30 or 60-days' time horizon. When the Gap Ratio is lower than the determined threshold, this means that the limit has been breached. This kind of liquidity analysis is performed via the *Maturity Ladder model* which consists in allocating the expected inflows and outflows in time buckets according to their maturity.

The structural limit shows the extent of the maturity transformation of the bank. It requires the bank to maintain a stable funding profile in relation to the composition of their balance sheet and, consequently, to reduce the funding risk over a longer time. The main objective of this metric is to ensure that the bank is funding its activities with sufficiently stable sources of funding to mitigate the risk of future funding stress. The items without deterministic maturity are allocated to their respective time buckets according to the outcome of the behavioural analysis.

The bank's exposure to the interest rate risk can be measured through the *Net Interest Income (NII) sensitivity* (impact on Earnings) under predefined interest rates shift scenario, in this example, +/– 200bps parallel shift. There is an underlying assumption, embedded in the model, related to the steady balance sheet (there is no new business assumption) and spot interest rate risk curve. The ΔNII +/–200bps is calculated using the *Maturity Gap* approach where the impact on the interest margin resulting from the movements of the interest rates is calculated as a product of the changes in the interest rates and the difference between the interest rate risk sensitive asset *(RSA)* and the liabilities *(RSL)*:

$$\Delta NII = \Delta i \times GAP = \Delta i \times (sensitive\ assets - sensitive\ liabilities). \quad (7)$$

Thus, the delta of interest margin is the function of two elements:

- interest rates movements Δi,
- difference between assets and liabilities GAP.

The total gap under the gapping period of 6 months is obtained by the summation of the subsequent gaps weighted by the time factor. This time factor represents the time between the central value of the bucket and the end of the gapping period:

$$\Delta IM = \sum GAP\ x\ (T - t) \times \Delta j, \quad (8)$$

where *T* represents the length of the gapping period, *t* – the maturity related to the i-th bucket, Δj – the shock in the interest rates curve [Lubinska 2014]. There exists the concentration limit which encourages diversification of the funding portfolio and prevents an excessive concentration of the funding sources.

5. Conclusions

The article provides an overview of the application of the optimization method to obtain the target structure of the funding base for commercial banks. It is proposed to calculate such a target structure using nonlinear optimization solver in Matlab known as fmincon. The examined problem is set up in form of multivariable objective function which minimize the cost of funds. The problem represents a nonlinear constrained optimization problem since the minimization of the objective function is subject to the banks' appetite for the exposure to the interest rate risk (delta NII sensitivity), liquidity risk (short term and structural liquidity metrics) and concentration limit. The constraint functions are both equality and inequality functions.

The article presents the hypothesis that it is possible to find the target structure of the banking book which provides the bank with the improved economic result [Lubinska 2017] and, at the same time, ensures the respect of the internal limits for risks incurred by the bank. Moreover, it improves the management of the interest rate risk and liquidity risk. In the analysis, performed by the author in her research, it was shown that the model optimizes also the short-term liquidity metrics preventing the excess liquidity to be kept in the form of a liquidity buffer, inefficient management of stable funding and NII volatility. For this reason, in the author's view, it can be seen as an integrated management tool for these risks.

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