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Modelling of Non-Maturing Liabilities in Survival Period for Liquidity Risk Management Purposes

Patrik Mihalech[1]

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Abstract: *Correct assessment of banking risks is essential for a healthy banking system and the development of economy. This paper focuses on liquidity risk management, more specifically on modelling of non-maturing liabilities. Liquidity risk emerges as a consequence of uncertainty in terms of future cash inflows and outflows. Due to the fact, that result of a liquidity crisis is not only loss, but directly bankruptcy of financial institutions, liquidity risk belongs among major banking risks. This paper aims to project future cash outflows emerging from corporate deposit accounts without contractual maturity with a focus on stress outflows, in case of crisis. Bootstrap simulation techniques are introduced and performed on anonymized historical time series of cumulative corporate balances of Slovak commercial banks. Stress scenario based on analysis is proposed as entry to the calculation of broader liquidity Survival period indicator.*

1. INTRODUCTION

Bank institutions are exposed to a huge amount of different risk factors. Given their significant impact on the financial sector and economic development of the country, banks must be under the control of regulative authorities of which usually the most important is the central bank of the country. The main goal of banking regulation is to ensure, that banks have a sufficient amount of capital at their disposal, to cover risks that are undertaken to avoid bankruptcy of financial institutions (Hull, 2018). The purpose of regulation is not to eliminate all sources of risks, for in that case making business in banking would not be possible but sustaining that probability of bankruptcy is very low. Therefore, the purpose of the regulation is not the entire elimination of risk factors but to safeguard that level of risks is moderate (Skoglund & Chen, 2015). The most important international authority creating bank regulation is the *Basel Committee for Banking Supervision (BCBS)*[2] which developed a substantial number of regulative frameworks which were later implemented into the legal system of participating countries.

While in the past emphasis for given mainly on credit and market risk, currently also another type of bank risk come into focus, and liquidity risk is among them. Given the prominent role, that liquidity risk played in the financial crisis 2008-09 (such as bankruptcy of Northern Rock and Bear Stearns investment bank) it was evident that more prudent regulation is necessary. The most important papers published by BCBS regarding liquidity risk are *Principles for Sound Liquidity Risk Management and Supervision* (2008), *Basel III: International framework for liquidity risk measurement, standards and monitoring* (2010), *Monitoring tools for intraday liquidity management* (2013a) and *Basel III: The Liquidity Coverage Ratio and liquidity risk monitoring tools* (2013b).

1 University of Economics in Bratislava, Faculty of Economic Informatics, Dolnozemská cesta 1, 852 35 Bratislava, Slovakia

2 Basel Committee for Banking Supervision is main creator of international standards for banking regulation and currently consists of 45 members, of which most are central banks and another regulative institutions in 28 different jurisdictions.

Liquidity risk has its specifics that need to be treated accordingly. Among these specifics, the most prominent one is the necessity to know the maturity of financial instruments and bank products. Essentially banks have on their balance sheet a huge amount of liabilities without maturity, such as sight deposits[3]. For liquidity risk management purposes, it is essential to develop a projection of these cash outflows in the future to be able to correctly assess liquidity risk. The aim of this paper is to present the usage of bootstrap techniques for estimation of deposit outflows in one-year time horizon on a given confidence level for a stress scenario that would simulate crisis and significant withdrawal of deposits by corporate clients of the bank. The goal of the analysis is to use these estimated outflows in the calculation of liquidity survival period under stress conditions.

2. LIQUIDITY RISK

The need for liquidity in banks emerges from the uncertainty of their cash flows. Banks have to be certain that they will be able to manage increased cash outflows and also decreased cash inflows, which can be both expected and unexpected (Smolík, 1995). In literature, both terms liquidity and liquidity risk are frequent. Some authors consider these terms equal and use them interchangeably. However, for example, Farahvash (2020) states that liquidity can be defined as the ability of a bank to repay its liabilities in time of maturity and the ability to convert arbitrary assets on cash by the market price. By this definition measuring liquidity depicts a projection of expected development (expected value), while measuring liquidity risk stands for estimation of negative deviation from expected development with a given probability.

Also, it is necessary to distinguish between liquidity risk and insolvency. The theoretical concept of both risks is similar, but not the same. Liquidity stands for a bank's ability to manage its cash outflows promptly and economically, while solvency is an ability of a bank to repay its obligations on a long time horizon and is related mostly to the amount of its funds. (Scannella, 2016). Scanella also divides liquidity risk into two types: funding risk and trading risk. Of these two risks we focus on funding risk, which identifies the fact, that bank is not able to effectively manage its expected and unexpected cash outflows.

3. SURVIVAL PERIOD

In terms of internal liquidity risk management, banks use complex indicators with the aim to analyse liquidity position as precisely as possible by the usage of best assumptions. One of the most common approaches is *GAP analysis*, which is based on a comparison of expected cash inflows and outflows in the future after mapping particular balance sheet items into subsistent maturity buckets based on their maturities or another behavioural assumption (in case maturity is not available for a given item or it is not the best measure for liquidity purposes). An indicator that can be calculated from the maturity ladder is called the *Survival period*. To compute the Survival period, it is necessary to calculate cumulated net cash flows divided into time buckets and deduct them from the *Liquidity buffer* called survival GAP:

$$Survival\ GAP\ (t) = Liquidity\ buffer\ (t) - \sum_{i=1}^{t} \left(CF_{out_i} - CF_{in_i}\right) \tag{1}$$

[3] Deposits which can be withdrawn from a bank either without notice, or after a very short notice period.

Where:

Liquidity buffer (t) stands for amount of high liquid assets in time bucket *t*,

CF_{out_i} is cash outflow up to time *t*,

CF_{in_i} is cash inflow up to time *t*.

Based on (1) we calculate survival GAPs for all-time buckets. Liquidity buffer depicts "stock" of liquidity that can be used by a bank as immediate payment of its obligations. It consists mostly of cash, sight deposits in the central bank (mandatory cash reserves) and high liquid assets such as government bonds and covered bonds issued by financial institutions with sufficient credit ratings. While liquidity buffer and cash inflows exceed cash outflows banks possess a sufficient amount of liquidity to timely cover their obligations. Survival period stands for the period since the beginning of the projection until survival GAP falls below 0:

$$Survival\ period = first\ time\ t, when\ Survival\ GAP(t+1)\ become\ negative \quad (2)$$

If we tried to calculate Survival GAP based only on contractual maturities, for most the banks it would reach a value of 0. The main reason for this is liabilities without maturity, such as sight deposits. Clients can withdraw any amount from their accounts at any time, meaning clients possess options based on which they can decide about the time structure of their cash flows (Castagna & Scaravaggi, 2017). Survival GAP based on contractual maturities tells us that banks would not be able to handle liquidity needs in case all of their clients would withdraw all of their deposits on the first day of projection. However, this situation is not very likely and in practice never occurs. For this reason, banks are developing statistical models which account for this option and based on historical data they model expected cash outflows on current accounts. These expected outflows are then distributed among time buckets based on statical models and the survival period is calculated anew with these behavioural assumptions instead of contractual ones. Usually, more scenarios of the Survival period are created. One scenario is base and is trying to forecast expected cash flows the most precise on past development. Other scenarios are stress scenarios and they are the most important for liquidity risk management, for they depict the situation of market-wide or firm-specific stress and are trying to quantify negative deviation from expected development. In this paper, estimation of sight deposits outflows based on the bootstrap process will be introduced.

4. METHODOLOGY

Bootstrap is a computing-intensive method that can be used for the estimation of a huge amount of different statistic metrics. Unlike in classic approaches of statistical inference, where inference about population is made based on the sample, the bootstrap estimate is based on repetitive random sampling with replacement. Bootstrapping falls under the class of resampling methods and allows us to estimate distribution functions of almost any statistic. The term "bootstrap" was first used by Bradley Efron in his paper about jackknife samples (Efron, 1979). Importance of bootstrapping increased with the development of computers, given their very high calculation demands. For the calculation of bootstrap estimates, the usage of statistical software is necessary. The calculation presented in this paper were made in the statistical programming language R.

Concept-based on repetitive random resampling can be applied in liquidity risk management for projection of expected development of deposit accounts. In this case, we do not want to estimate one parameter as is, but we want to make a projection for a longer time horizon. Usage of simulating methods in modelling of non-maturing liabilities (such as deposit products) was the subject of research of Kalkenbrener and Willing (2005) and Castanga and Fede (2013). In this paper we use the following advance:

1. Determine time horizon T and period [0, T] divide into M parts,
2. Simulate N trajectories of deposits development, where each trajectory can be considered one bootstrap sample.
3. Calculate expected level of deposits $V(0,T_i)$ for each step of projection i ϵ{0,1,…,M} by averaging of N scenarios.
4. Calculation of stressed levels of deposit volumes on confidence level p, $V^p\ (0,T_i)$ for each projection step. For liquidity risk purposes it is relevant to analyse minimal amounts of deposits in given time horizon.

Given the fact, that projections can be also increasing (which is undesirable for stress scenarios), we introduced the minima process for deposit amounts. Stochastic process V(u) defines the amount of deposits M(t) as a minimum from projected trajectories up to the given time horizon:

$$M(t) := \min_{0\le u\le t} V(u) \tag{3}$$

Due to our interest in the amount of deposits that we will possess after a given time horizon with a chosen confidence level, Value-at-risk (VaR) method is applied. VaR is often used in the calculation of financial risk and portfolio development. Iglarčíková and Pinda (2016) define VaR for a single financial asset as follows:

$$P\left(\Delta p_t \le VaR_{1-q}\right) = 1 - q \tag{4}$$

This concept is often used for financial assets and can be used in the same way for deposit modelling, only asset price (p_t) is changed for deposit amount (M(t)).

5. DATASET

For the analysis, anonymized data from Slovak commercial banks were used. These data consist of daily cumulative balances of corporate deposit accounts from 1.1.2013 to 31.12.2020 (in mln. €).

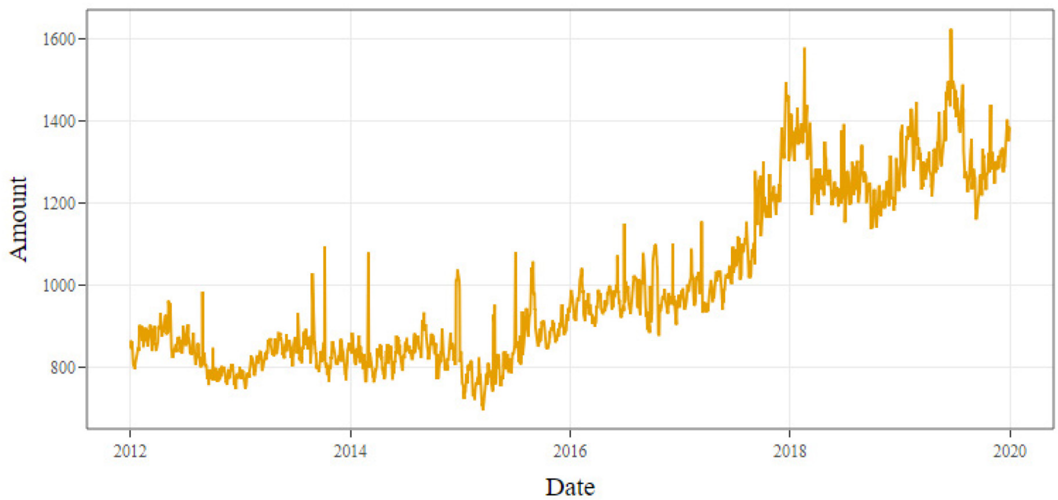

Figure 1. Dataset of corporate sight deposit volumes used for bootstrap simulation (mln. €)
Source: own creation

From these data, log differences were calculated as follows, where stands for the daily amount of deposits in time *t* and are log differences:

Log differences were randomly chosen into bootstrap samples at any time of bootstrap simulation and were able to repeat any number of times. Future development is created from the last known value (1 385,73 mln. €) as of 31.12.2020 and randomly chosen differences are added to the calculation to cover 1 year projected period horizon.

6. RESULTS

For calculation of future development of corporate deposit accounts, 10 000 bootstrap simulations were performed. Figure 2 shows the independent path of simulations (10 randomly chosen paths are highlighted). From these paths, quantiles were calculated in each projected period.

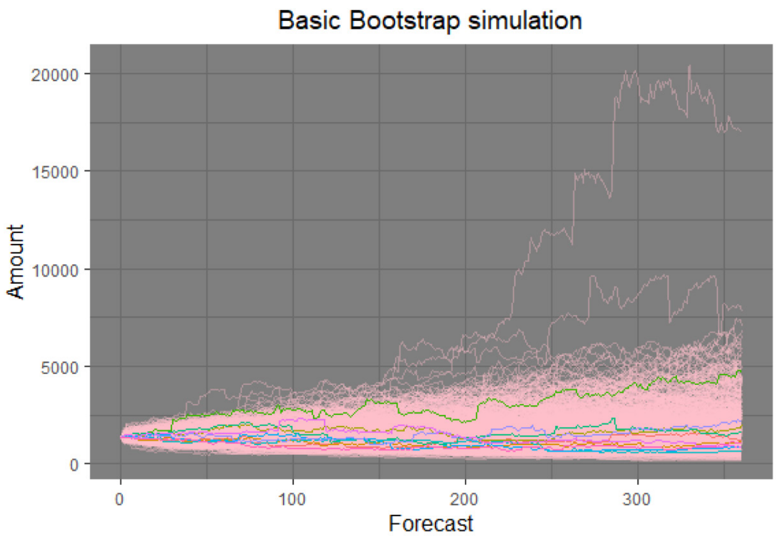

Figure 2. Bootstrap sample path, 10 000 simulations

Source: own creation

These quantiles serve us as Value-at-Risk estimators. Given this terminology, VaR(0,5) stand for median development, as far as half simulations show higher amounts, while another half is lower. This could be used for a base scenario, however, in this dataset VaR(0,5) is increasing what contradicts (3). This confirms the general trend, that deposit volumes are increasing in standard market conditions (this is also supported by expansive monetary policy in the past years). Therefore, for a base scenario in the survival period, we suggest taking the following outflows - . This means, that in the base scenario there are no outflows (what is confirmed by the generally increasing trend of underlying data) and more important is the stress scenario. Stress scenario is supposed to imitate crisis, when clients tend to withdraw their deposits at a much faster rate, than in standard operating conditions. This can be caused by a market-wide crisis or directly by some reputational problem of concrete financial institutions. In our terms, the crisis will be represented by VaR(0,95) over a one-year time horizon, which shows the amount of deposits that would bank still hold at the end of the year with 95% confidence. Results are shown in Figure 3 and depict strong stress – 95% of simulations are better each day for a 360-day time horizon. From these results, we calculate the percentual change of deposit amount (current amount to starting amount) and these percentages determine cash outflow in given time buckets.

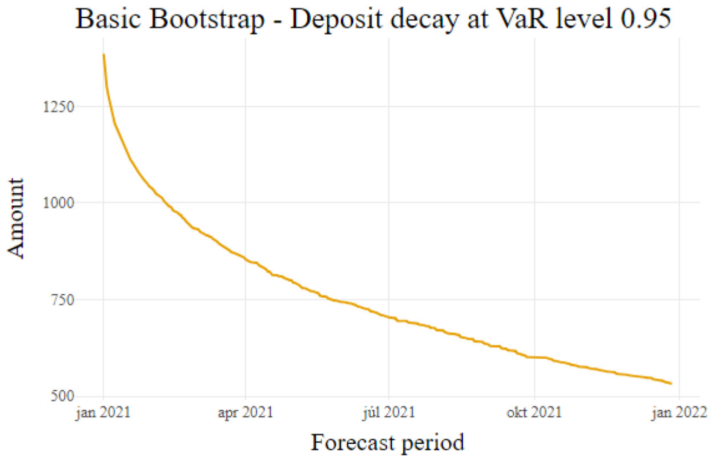

Figure 2. VaR(0,95) of corporate deposit development in one year time horizon
Source: own creation

7. FUTURE RESEARCH DIRECTIONS

Simulation methods are becoming increasingly popular in different fields of risk management. In this paper, the usage of the simple bootstrap technique to randomly draw past differences to project future stressed cash inflows that emerged from corporate deposits is shown. The only basic technique was used, where all differences have the same probability of being picked to bootstrap samples. This might not always be the desired behaviour. For example, more recent differences might be a better benchmark for current development. We suggest the introduction of exponentially weighted bootstrap simulation (EWMA bootstrap), where current differences might possess higher weight and therefore be picked during simulation more often. This might be beneficial, especially in the case of recent stress period recording in historical data. In this case maxima of basic and EWMA bootstrap outflow might be used for survival period calculation. EWMA is to be implemented in the further research of this topic.

8. CONCLUSION

In this paper, the focus was on liquidity risk management. From the theoretical point of view, banking regulation with a focus on liquidity risk is introduced. The main part of the paper was aimed at the calculation of liquidity survival period indicator and especially how to cope with the biggest problem that emerges in calculation and that are non-maturing liabilities. From these liabilities of highest importance are deposit products without contractual maturity.

Possibilities of usage of simulation methods based on bootstrap techniques with an attempt to assess future outflows of the institution have been shown. Bootstrap techniques introduce an alternative approach to standard means of statistical inference and their biggest advantage is relative straightforwardness and easy reproducibility. This is the key aspect because it is not necessary to create a new model every time a recalculation is done on new data as far as no parameters were estimated during calculation, just the whole calculation process has to be rerun again.

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