Banks rely heavily on quantitative analysis and models for many aspects of their financial decisions. The ever-rising use of models in all banking processes reflects the extent to which model can improve future business decisions. The focus in this paper will be on the non-maturity deposits that represent one of the cheapest and most stable funding sources for banks. Financial institutions have seen a surge in the deposit accounts short after the financial crisis. For banks it is crucial that they quantify the surge balances, because their run-off behaviour will be significantly different from those typical for the true stable core deposits. Effective and accurate quantification of the surge deposits is of great importance for the analysis and management of the interest rate risk and liquidity risk. The paper in overall describes the regulation framework, definition of the core, non-core and surge deposits, and the possible methods of calculating the portion of the surge deposit balances according to the historical movements and based on the projected balances under the normal conditions present on the financial markets.

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In April 2016, the Basel Committee on Banking Supervision (BCBS 2016) published the standards for Interest Rate Risk in the Banking Book (IRRBB) that revise the Principles for the management and supervision of interest rate risk from 2004.

1. Introduction

The standards the standardised framework for measuring the interest rate risk. Although it should contain the standardised components, not all of them are precisely defined and banks may use internal risk parameter estimates to determine the cash flows profile of certain banking book positions.

For the purpose of this paper, the non-maturity deposits are the positions we will focus on and deep dive into the further split between core and non-core balances. For the banks it is of great importance that they model or at least quantify their products on the liability side of the balance sheet without specific repricing or maturity dates, because of the large balances they hold in the balance sheet and consequently the funding concentrating risk that is linked to these large amounts. It is not also topic that is for some time in the focus for the regulators but also banks themselves need to be prepared for different future conditions on the financial markets. Regulators are focused on the split into core and non-core parts of structural balances, but banks should go deeper and identify the part of the core deposits that could be the surge balances.

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The latter will behave differently when the conditions on the market change (switching from low-interest rate to increasing interest rate environments), the impact and the magnitude could be significant. The repricing gap and the liquidity gap could be totally different and actions for the interest rate risk and liquidity risk management should be adapted to the changed environment.

The paper has been divided into three main parts. The first part considers the regulatory issues that are the starting point for the empirical analysis, which is the second part, inclusive interpreting the results of the possible calculating methods. The last part shortly describes the potential future challenges in the field of identifying the ‘surge’ balances and their impact on the bank’s funding base.

2. Regulatory framework for the non-maturing deposits and link to surge deposit balances

Why are regulators still focused on the liquidity risk and Interest rate risk? Since the ‘great financial crisis’ began in year 2008, the financial institutions are faced with a significant increase in the deposit base. Where this increase is mainly in the non-maturing deposit (NMD) balances and on the other hand decrease can be seen in the certificate of deposits and the term-deposits. Such kind of growth is usually labelled ‘surge’ deposit balances, for which the higher run-off factor is expected. But let us first focus on the regulatory requirements regarding the general treatment of the deposits that do not have specific maturity dates.

Standard for the Interest rate risk in the banking book published by the Basel Committee on Banking Supervision in April 2016 (BCBS 2016) divides NMDs into three different categories:

- retail and transactional deposits;
- retail and non-transactional deposits;
- wholesale deposits.

As we can see from the above categorization according to the BCBS (2016) the NMDs must be segmented into retail and wholesale categories. Retail deposits are defined as deposits placed with a bank by an individual person. Deposits made by small business customers and managed as retail exposures are considered as having similar interest rate risk characteristics to retail accounts and thus can be treated as retail deposits, where the total aggregated liabilities raised from one small business customer are less than 1 million Euros. Retail deposits should be considered as held in a transactional account when regular transactions are carried out in that account (e.g. when salaries are regularly credited) or when the deposit is non-interest bearing. Other retail deposits should be considered as held in a non-transactional account. Deposits from legal entities, sole proprietorships or partnerships are captured in wholesale deposit categories.

Furthermore, as per BCBS (2016) NMDs can be divided into a stable and a non-stable part. The stable part is the portion of the NMD that is unlikely to be withdrawn. The portion of the stable part that will remain undrawn with a high likelihood even during significant changes in interest rate environment is called core deposits, while the rest of the NMD is called non-core deposit. These portions should be determined using observed volume changes over the past 10 years. NMDs are then slotted into time (maturity) buckets, depending on estimated average maturity.

Non-core deposits are automatically considered to be overnight deposits that should be put into the shortest time bucket (e.g. O/N or up to 7D). To limit overestimation of the proportion of core deposits and the time to maturity of the core deposit, the BCBS (2016) has determined the upper limits of these measures for the different account types that are shown in Table 1.

Standards are not mandatory for the banks and the supervisors, therefore in July 2018 European Banking Authority published the Guidelines on the management of interest rate risk arising from non-trading book activities (EBA 2018). Behavioural and modelling assumptions regarding the customer accounts without specific repricing dates should enable to identify ‘core’ deposit balances and other deposits. The ‘core’ deposits are defined as stable deposits to be unlikely reprice or withdrawn even under significant interest rate environment changes. Modelling assumptions should also reflect, similar as in BCBS standards (2016), depositor characteristics (e.g. retail versus wholesale) and account characteristics (e.g. transactional versus non-transactional).

For the banks it is important that they adjust the core deposits assumptions, especially taking into account the

Table 1: Upper limits (caps) on core deposits and average maturity by category

<table>
<thead>
<tr>
<th>Category</th>
<th>Cap on proportion of core deposits</th>
<th>Cap on average maturity of core deposits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail/transactional</td>
<td>90%</td>
<td>5.0 years</td>
</tr>
<tr>
<td>Retail/non-transactional</td>
<td>70%</td>
<td>4.5 years</td>
</tr>
<tr>
<td>Wholesale</td>
<td>50%</td>
<td>4.0 years</td>
</tr>
</tbody>
</table>

future decisions regarding the overall deposit (funding) strategy and deposit pricing strategy. Thus, it is clear that the surge balances, although at the moment they seem to be parked within the core deposits base, this parking is only of temporarily nature. The reason for such treatment is of non-traditional motivation, such as principal protection, flight to safety etc. Surge balances tend to move away when the interest rates rise or the financial conditions on the market improve. Behaviour of surge balances makes a source of interest rate risk and also impacts the liquidity gaps.

3. Data preparation, collection and analysis

Due to data protection and secrecy we have decided to collect, prepare and analyse the data on macro level. We have chosen data from two countries, where first one is a member of the European Union – Slovenia and second one is not – Switzerland. At first sight these two countries seem to be characteristically totally different but from the size, economic perspectives, culture and retail banking they are not so different. These two countries have been also chosen due to professional knowledge of the author, availability of historical data and different time-lines of the financial crisis.

Data included in this paper are based on the officially published data available at data portals from central banks in Slovenia (Bank of Slovenia) and Switzerland (Swiss National Bank). We have collected data for the demand deposits (deposits with no specific maturity dates) and reference interest rates (3-month / 6-month Euribor and 3-month / 6-month Libor).

Graph 1: Changes in the reference interest rates 3-month Euribor and 6-month Euribor in the period January 2007 to December 2018

Source: Data portal BSI.

Graph 2: Changes in the Slovenian deposits in the period January 2007 to December 2018

Note: Only deposits in the domestic currency are included, because the share of the deposits in the foreign currency is only approximately 2%.
Source: Data portal BSI.

3.1. Data preparation for the analysis

The data and other information used to develop a model are of critical importance, therefore there should be rigorous assessment of data quality and relevance. The data chosen should be consistent with the theory behind approach and with the chosen methodology (FED 2011). If the data are not consistent, the model risk could arise and may lead to financial loss, poor business and strategic decision making, damage the bank’s reputation etc.

Movements on the Graphs 1, 2, 3 and 4 show the strong correlation between the levels of interest rates and the deposit balances. Especially high correlation can be seen between the demand deposits and the interest rates. We also need to emphasize that there is present strong switch between demand and term deposits, where most of the balances from term deposits have been moved to demand deposits.

The switch point between demand and term deposits from Slovenian customers is mid-year 2014. The recession time-line for Slovenia is set from the 3rd quarter 2008 until the
4th quarter of 2013, which means that the switch point happened right after the end of crisis and when the interest rate levels remain low for more than two years. We do not experience the rapid growth dynamics in demand deposits before the switch point and the financial crisis. In our opinion this could be indication that a degree of surge deposit balances may be present.

Very similar trend can be also seen from the Swiss data, shown on Graphs 3 and 4. Here the historical data go even further back until the year 2000. The time-line for financial crisis present in Switzerland is set from 4th quarter 2008 until the 1st quarter of 2009. A surge in growth took place immediately after the financial crisis (October 2008) and continued approximately until the end year 2013. Flat balances until the 3rd quarter of 2008 indicate no surge growth.

Very important observation remark is also the increase of the share of the demand deposits over the years. In Slovenia this share increased from 34% in the beginning 2007 to 64% by the end of 2018, which means it almost doubled within eleven years. In Switzerland it started at 19% in 2000, went up to 24% in 2007 and increased even more in the following years and reached 51% by the end of 2018. The Swiss percentage more than doubled within eleven years, which is comparable to the Slovenian data.

What we need to bear in mind, that each bank’s position with respect to surge deposits balances will be unique and there could be some variances in comparison the macro data. But the basic principles are equal and could be a good starting point to identify the surge growth and quantify its balances.

3.2. Time series
The main purpose of the time series, which have been also used in our research, is to observe the time evolution of economic phenomena and to establish the general findings of these movements. The latter enables the prediction of further development and the acceptance of appropriate measures. Our calculations are based on monthly available data, where for Slovenia from 1 January 2007 to 31 December 2014 and for Switzerland from 1 January 2000 until 31 December 2018. Longer time series were not available from central banks data portals and in our opinion the observation period is long enough to capture the significant changes that are important for issues analysed and presented in this paper.

4. Empirical analysis

4.1. Model estimation and implementation of regression analysis
We have used the method of ordinary least squares (OLS). The OLS method is often called the “queen” of the assessment methods of regression coefficients and on the other hand it is the BLUE (“best - linear - unbiased estimator”). Regression analysis must meet certain assump-
4.2. Regression model for Slovenian demand deposits (DDSI)

Mathematical form of the model for "DDSI" is as following:

\[
DDSI_t = \beta_1 + \beta_2 DDSI_{t-1} + \beta_3 EURIBOR3_t + \beta_4 EURIBOR6_t + \beta_5 D\_CRISIS_t + u_t,
\]

where:

- \( DDSI_t \) - demand deposits of Slovenian customers for \( t \) month (dependent variable)
- \( DDSI_{t-1} \) - demand deposits of Slovenian customers for \( t-1 \) month (explanatory variable)
- \( EURIBOR3_t \) - reference interest rate 3-month Euribor for \( t \) month (explanatory variable)
- \( EURIBOR6_t \) - reference interest rate 6-month Euribor for \( t \) month (explanatory variable)
- \( D\_CRISIS_t \) - "dummy" variable due to presence of financial crisis for \( t \) month (explanatory variable)
- \( u_t \) - stochastic disturbance (or stochastic error term) for \( t \) month

We expect following signs of regressions coefficient estimators:
- for \( DDSI(-1) \) positive sign. Since this is a lagged dependent variable, the only reasonably outcome is a positive sign;
- for \( EURIBOR3 \) and \( EURIBOR6 \) negative signs. Higher interest rates should cause the movement from demand deposits to term deposits;
- for \( D\_CRISIS \) positive sign as a consequence of low interest rates the customers start to move their funds from term deposits to demand deposits;
- for \( CONSTANT \) positive sign because of an increase or preservation DDSI demand deposit balances.

4.3. Regression model for Swiss demand deposits (DDCH)

Mathematical form of the model for "DDCH" is as following:

\[
DDCH_t = \beta_1 + \beta_2 DDCH_{t-1} + \beta_3 LIBOR3_t + \beta_4 LIBOR6_t + \beta_5 D\_CRISIS_t + u_t,
\]

where:

- \( DDCH_t \) - demand deposits of Swiss customers for \( t \) month (dependent variable)
- \( DDCH_{t-1} \) - demand deposits of Swiss customers for \( t-1 \) month (explanatory variable)
- \( LIBOR3_t \) - reference interest rate 3-month Libor for \( t \) month (explanatory variable)
- \( LIBOR6_t \) - reference interest rate 6-month Libor for \( t \) month (explanatory variable)
- \( D\_CRISIS_t \) - "dummy" variable due to presence of financial crisis for \( t \) month (explanatory variable)
- \( u_t \) - stochastic disturbance (or stochastic error term) for \( t \) month

We expect following signs of regressions coefficient estimators:
- for \( DDCH(-1) \) positive sign. Since this is a lagged dependent variable, the only reasonably outcome is a positive sign;
- for \( LIBOR3 \) and \( LIBOR6 \) negative signs. Higher interest rates should cause the movement from demand deposits to term deposits;
- for \( D\_CRISIS \) positive sign as a consequence of low interest rates the customers start to move their funds from term deposits to demand deposits;
- for \( CONSTANT \) positive sign because of an increase or preservation DDCH demand deposits balance.

4.4. Economic and statistical interpretation of the results

When interpreting the results, we should consider the main characteristics of a good model. The model should have a good fit with the historical sample. The model should be stable regarding the assumptions and depending on what historical sample is being used to calibrate the model. The model should be
able to handle a negative interest rate environment. The model should be possible to be implemented in a realistic way. If it is too simple, it may perform bad. If it is too complex, it may be never used.

4.4.1. Econometric model for Slovenian demand deposits

Table 2: Results of econometric model for Slovenian demand deposits (DDSI) for the period 1 January 2007 until 31 December 2018

<table>
<thead>
<tr>
<th>Dependent Variable: (DDSI)</th>
<th>N: 144</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>164.14</td>
</tr>
<tr>
<td>t-stats</td>
<td>(1.68)</td>
</tr>
<tr>
<td>DDSI(-1)</td>
<td>0.99</td>
</tr>
<tr>
<td>t-stats</td>
<td>(94.27)</td>
</tr>
<tr>
<td>EURIBOR6</td>
<td>-24.43</td>
</tr>
<tr>
<td>t-stats</td>
<td>(2.03)</td>
</tr>
<tr>
<td>D_CRISIS</td>
<td>162.34</td>
</tr>
<tr>
<td>t-stats</td>
<td>(2.15)</td>
</tr>
<tr>
<td>R²</td>
<td>0.9964</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.9963</td>
</tr>
</tbody>
</table>

Table 3: Diagnostic tests results of regression model for Slovenian demand deposits (DDSI) (number of observations = 144)

<table>
<thead>
<tr>
<th>Test</th>
<th>Critical value (c) *</th>
<th>Calculated value *</th>
<th>Fulfilment Yes/No &amp; Results description</th>
</tr>
</thead>
<tbody>
<tr>
<td>t-statistics</td>
<td>1.977</td>
<td>t &gt; 2.03</td>
<td>Yes. We can reject the null hypothesis that individual regression coefficients are zero.</td>
</tr>
<tr>
<td>F-statistics</td>
<td>2.881</td>
<td>9452.197</td>
<td>Yes. Regression model as an overall is statistically significant (F &gt; Fc).</td>
</tr>
<tr>
<td>R²/Adjusted R²</td>
<td>0&lt; R²&lt;1</td>
<td>0.997 / 0.996</td>
<td>Yes. 99% changes of dependent variable are explained by our regression model</td>
</tr>
<tr>
<td>Autocorrelation (t-test)</td>
<td>-1.96&lt; t &lt; 1.96</td>
<td>-1.21</td>
<td>Yes. There is no autocorrelation.</td>
</tr>
<tr>
<td>Heteroscedasticity (Breusch-Pagan-Godfrey)</td>
<td>12.833</td>
<td>5.178</td>
<td>Yes. In our regression model we do not have heteroskedasticity (X² &lt; X²c).</td>
</tr>
<tr>
<td>Multicollinearity (VIF test)</td>
<td>VIF &lt; 10</td>
<td>VIF &lt; 7.5</td>
<td>Yes. No multicollinearity is present.</td>
</tr>
<tr>
<td>Model specification (Ramsey-Reset test)</td>
<td>2.881</td>
<td>0.549</td>
<td>Yes. Since F &lt; Fc we cannot reject null hypothesis, therefore we conclude that our model is correctly specified.</td>
</tr>
</tbody>
</table>

Notes: * at significance level α = 0.05 (confidence interval 95%), except the regression constant C, which is significantly different from zero at confidence interval 90%.
** i = regression coefficients/variables. *** VIF = Variance Inflation Factor.

The estimated regression coefficients are statistically significant and their signs are in accordance with our expectations after the elimination of statistical insignificant regression coefficients. The impact of the reference interest rates 3-month Euribor and 6-month Euribor is equal; therefore, we have decided to keep the 6-month Euribor which is more often used as the reference interest rate by the Slovenian banks. The regression constant C in our model represents an increase or preservation of the demand deposits for DDSI, by taking into account the significance level α = 0.10.

The results of the diagnostic tests in Table 3 show that the regression model is very good and suitable for predicting the movement of Slovenian demand deposits and to identify the potential surge deposits balances. The results of the econometric model for Slovenian demand deposits have been used to estimate the volatility and expected movements of these deposits within the observation period taking into account the stable trend under the normal market conditions. The difference between the actual (green area) and the forecasted (red area) demand deposits could be identify as surge deposits, what can be also seen from Graph 5 and they are marked with the blue arrow on Graph 5. The next step is to quantify the share of the surge balance and a simple average calculation shows that they could represent approximately 20% of total demand deposits. The banks should this amount include into the run-off behavioural patterns by managing the interest rate and liquidity risks. The outflows of the surge balances will definitely run off faster than the outflows of traditional core or stable demand deposits. The area marked with the blue arrow on Graph 5 should be recognised as surge balances and included in the modelling assumptions for projections of the future demand deposits balances. Furthermore, it is crucial that the methods used to split between the non-stable and stable part (additional split of stable part into core and non-core), take into the consideration the different run off factors for each of the individual deposit category. The type of method used by individual bank depends on the level of conservativeness. If the bank would like to play a safe game, they could also use a higher percentage based on the shorter observation period, e.g. one-year window for the business as usual scenarios in our case calculates the amount of the possible surge balances at 25%. At the end it is bank’s decision to follow the funding and overall business strategies.
The estimated regression coefficients are statistically significant and their signs are in accordance with our expectations after the elimination of statistical insignificant regression coefficients. The impact of the reference interest rates 3-month Libor and 6-month Libor is equal; therefore, we have decided to keep the 3-month Libor which is more often used as the reference interest rate by the Swiss banks. The regression constant C in our model represents an increase or preservation of the demand deposits for DDCH. The results of diagnostic tests in Table 5 show that the regression model is very good and suitable for predicting the movement of Swiss demand deposits and to identify the potential surge deposits balances. The results of the linear regression model for Swiss demand deposits fulfil the economic, statistical and econometric criteria. The model is now ready to perform the forecast, which will show the projected balances under the normal market conditions. Surge balances for the Swiss demand deposits are shown in Graph 6 and represented by the area of actual balances that exceeds the projected balances (marked with the blue arrow).

As we have implemented very simple approach for calculating the quantity of surge balances for Slovenian demand deposits, we will use the same method also for the Swiss demand deposits. According to the method used in this paper, the share of Swiss surge deposit balances is calculated at 35%, which is higher in comparison to the Slovenian share (20%). The main reasons are stronger Swiss banking system and significantly larger deposit base. If we choose the assumption based on the changes in the last 12 months also for the Swiss banks, the share of the surge deposits would be 30% and it is five percentage points lower than the average for the whole observation period. Mainly because of the special conditions that are offered to the Swiss depositors, e.g. higher interest rates for term deposits with maturity up to 3 or 5 years, while the interest rates for the demand deposits are 0% or even negative.
Table 5: Diagnostic tests results of regression model for Swiss demand deposits (DDCH) (number of observations = 228)

<table>
<thead>
<tr>
<th>Test</th>
<th>Critical value *</th>
<th>Calculated value *</th>
<th>Fullfillment Yes/No &amp; Results description</th>
</tr>
</thead>
<tbody>
<tr>
<td>t-statistics</td>
<td>1.971</td>
<td>t1 ≥ 2.0</td>
<td>Yes. We can reject the null hypothesis that individual regression coefficients are zero.</td>
</tr>
<tr>
<td>F-statistics</td>
<td>3.175</td>
<td>40623.22</td>
<td>Yes. Regression model as an overall is statistically significant [F &gt; Fc].</td>
</tr>
<tr>
<td>R²/Adjusted R²</td>
<td>0&lt;r²&lt;1</td>
<td>0.997 / 0.996</td>
<td>Yes. 99% changes of dependent variable are explained by our regression model</td>
</tr>
<tr>
<td>Autocorrelation (t-test)</td>
<td>-1.96&lt;h&lt;+1.96</td>
<td>-1.42</td>
<td>Yes. There is no autocorrelation.</td>
</tr>
<tr>
<td>Heteroscedasticity (Breusch-Pagan-Godfrey)</td>
<td>12.833</td>
<td>1.919</td>
<td>Yes. In our regression model we do not have heteroscedasticity (X^2 &lt; X^2).</td>
</tr>
<tr>
<td>Multicollinearity (VIF test)</td>
<td>VIF&lt;10</td>
<td>VIF&lt;3</td>
<td>Yes. No multicollinearity present.</td>
</tr>
<tr>
<td>Model specification (Ramsey-Reset test)</td>
<td>3.175</td>
<td>2.811</td>
<td>Yes. Since F &gt; Fc we cannot reject null hypothesis, therefore we conclude that our model is correctly specified.</td>
</tr>
</tbody>
</table>

Notes: * at significance level α = 0.05 (confidence interval 95%). ** i = regression coefficients/variables. *** VIF = Variance Inflation Factor.

5. Conclusions and future challenges

The main purpose of this paper is to show how a retail bank can develop a simple internal model for calculating the portion of the surge deposit balances that have been accumulated over the post-financial crisis period. At the beginning of the paper we have introduced the regulatory framework in the field of managing the assets and liabilities risks. Then we have described the most important elements that need to be considered in the process of identifying and quantifying the surge balances. Afterwards the model assumptions were built and the linear regression model was developed for each observing country. Surge deposit balances need to be modelled with a great conscious since they are primarily motivated by special financial market conditions and not by business as usual bank’s activities. With our model we proved that surge growth definitely began after the financial crisis and their behavioural pattern is going to change when the interest rates start to show an increasing trend. As we can see that the calculated portions of the surge balances, based on the Slovenian and Swiss demand deposits data, are very similar to those that are mentioned in the discussion among banking experts. What will be the future challenges for the banks? Firstly, they need to be aware that sooner or later the huge demand deposit base will start to shrink. Secondly, they need to be prepared for such change by starting to identify and quantify the part of demand deposit with faster run off factors and include this assumption into their future funding and business strategies.

REFERENCES