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NII FORECASTING MODEL FOR LOCAL BALTIC BANKS IRRBB MANAGEMENT

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Abstract. This paper contributes to the existent literature and the current discussions on regulatory changes towards bank exposure to interest rate risk in the banking book (IRRBB) aiming to provide the model on the computation of earning based gap analysis under unconditional cash flow for the European Bank Authority's (EBA's) category 4 banks (i. e. small non-complex domestic financial institutions). The problem, discussed in this paper, arises because the Final Standards issued by the Basel Committee on Banking Supervision do not determine the level of sophistication of the IRRBB measurement techniques. There are different explanations of consultants, some surveys, and recommendations, but no suggestions on the particular modeling towards regulation in IRRBB have been found. Another issue addressed here is the uneven capacity of creating risk assessment models of large international and small domestic financial institutions due to the difference in human resources. We first discuss recent changes of regulation on interest rates in the banking book and the background of these changes. We then develop a methodology of the model for assessment of earning-based gap analysis under unconditional cash flows for the 4th category of banks (small, local banks). In addition, the model with one of the Baltic domestic commercial bank's simulated data is tested.

Keywords: interest rate risk in the banking book, banking supervision, unconditional cash flow, net interest income.

JEL Classification: G21, G17.

Introduction

Interest Rate Risk in the Banking Book (hereafter IRRBB) attributes the present or future risk to an institution's capital and earnings appearing from adverse variations in interest rates that affect the banking book positions. Interest rate risk ranks second in importance after credit risk when determining economic capital for the banking book and this risk, according to a Basel Committee, requires capital support (Alessandri & Drehmann, 2010; Basel Committee on Banking Supervision, 2016; Drehmann, 2007).

Banks are exposed to interest rate risk since the fixed-interest periods of their assets do not exactly correspond to the periods of their liabilities, which are usually shorter than the fixed interest periods (Angbazo, 1997; Memmel, 2018). As stated by Drehmann et al. "The maturity mismatch – or more precisely the repricing mismatch – is also the key source of interest rate risk in the banking book" (Drehmann et al., 2010).

Credit risk assessment models are widely used and successfully applied. However, there is no unified methodology or model for proper assessment of an interest rate risk in the banking book and this is the reason why this estimation is not standartised in the Basel II capital framework (Basel Committee on Banking Supervision, 2016; Kuritzkes & Schuermann, 2007). Change in interest rates implies alterations in the present value and future cash flows timing. Suchlike changes will affect the economic value of the financial institution's assets, liabilities, and/or off-balance sheet components changes. Interest rate fluctuations further influence an institution's earnings by shifting interest-rate-sensitive revenues and expenses, inducing its net interest revenues.

The IRRBB is just one of many Basel III regulatory requirements that financial institutions must meet. By properly implementing risk management requirements, institutions can streamline other elements of the regulatory architecture by adding value to the business over the long term (Doorsselaere, 2018).

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Concerns about possible interest rate volatility and its impact on bank performance are particularly relevant in the present global scenario, where interest rates are historically low in many countries and negative in some. In addition, low-interest rates and high liquidity have forced financial intermediaries to take excessive risks by raising asset prices and leveraging (Dell'Ariccia et al., 2014). If interest rates rise in the future, banks may face high-interest rate risk. A particular way to eliminate these risks is by efficient control and management of the IRRBB (Fessler, 2016).

Efficient interest rate risk supervision and control are crucial in today's volatile economic situation. Net interest rates in banks, and thus income, have been decreasing since the late 1990s by various forces that have lowered interest rates.

Finally, as global economic growth might improve, interest rate expectations are rising again. This is a good guarantee of margins, but it is not yet clear what tool will be taken for smoothing yield curves in many bond markets and for breaking up years of unconventional monetary policy.

IRRBB principles display changes in the market and supervisory practices due to the present low-interest-rate environment and accommodate methods and guidelines to be implemented by financial institutions in a broader and augmented risk management structure. Tighter standards, market changes, and increased regulatory surveillance will obligate many banks to advance their IRRBB assessment schemes improving their risk management and preparatory measures. The main directions of improvement will have to be focused on the implementation of risk management systems, institutional governance models, and preparation of human resources for appropriate qualification (Deloitte, 2017a).

The regulation is quite clear with its tasks, concerns, and guidelines. However, the problem arises because the Final Standards (FS) do not define the sophistication level of the IRRBB measurement quantitative techniques. Thus, banks have to develop various models of risk assessment using various techniques and tools. Therefore, the outcome or more specifically, the assumptions and tools for creating risk assessment models differ from bank to bank, from region to region. After the Baltic banking crises, the majority of the Baltic banks have Scandinavian capital, but there are still small local banks in the banking market. The largest market share in the Baltic States is held by Scandinavian capital banks and, with a few exceptions, these banks are usually classified as systemically important, which means that they are classified as Supervisory Review and Evaluation Process (SREP) category 1 or 2. These banks can benefit from the risk management experience of their parent banks and have much higher IRRBB management requirements. The objective of the paper is to provide the model on the computation of earning based gap analysis under unconditional cash flow for the European Bank Authority's (EBA's) category 4 banks (i. e. small non-complex domestic financial institutions). The number of banks of this type differs from one Baltic country to the other, as there are more banks of this type in Latvia and Estonia than in Lithuania, but the development of the IRRBB valuation methodology is particularly important for these banks, as they cannot use the IRRBB valuation methodology developed by parent banks. The objectives of the paper are as follows: 1) to discuss recent changes of regulation on interest rates in the banking book and the background of these changes; 2) to develop a methodology of the model for assessment of earning-based gap analysis under unconditional cash flows for the 4th category of banks (small, local banks); 3) to test the model with one of the Baltic domestic commercial bank's simulated data.

Methods used: for the development of IRRBB valuation model regression analysis was used; to test proposed model's reliability back-testing method was used.

The practical application. The model provided later in the paper could help local small banks reduce the need for human capital and save costs by applying standardised calculations.

1. The relevant literature discussion

There is a lack of scientific literature on the modeling of IRRBB and in particularly discussing various methodologies for interest rate risk assessment. Therefore, this paper would significantly contribute to the subject. The above-mentioned issue also refers to the limitation of broader scientific analysis.

After the U.S. deposits and credit crisis back in the 1980s and 1990s, the Federal Reserve Bank (FED) generated the economic value model, that allows measuring IRRBB via changes in a bank's economic value of equity (EVE) along with a duration-based assessment of interest rate sensitivity. Consequently, in 2004, the Basel Committee on Banking Supervision (BCBS) introduced an accounting-based duration model that assesses IRRBB employing a standardized shock in interest rates. However, the BCBC model has been criticized for its key assumptions by both academics (Abdymomunov & Gerlach, 2014; Cerrone et al., 2017), and financial authorities. The ability of banks to withstand significant interest rate shocks was a concern for regulators and financial institutions (Fessler, 2016; Wambold & Wieandt, 2021)

The scientific literature on a matter does not suggest any unique solution for this problem. While providing some unique models or techniques could help to move towards standardized evaluation methods. There are different explanations of consultants, some surveys, and recommendations (Deloitte, 2017a; Doorsselaere, 2018; Fessler, 2016; Financial Markets Authority, 2008; Wycisk & Blijlevens, 2018) but no suggestions on the particular modeling have been found towards regulation in IRRBB.

Recent publications have focused on banks' ability to manage their interest rate risk during the years of remarkable low-interest levels, determined by monetary policy regulations (Cerrone et al., 2017; Esposito et al., 2015).

Several authors provide different approaches to IRRBB assessment. Abdymomunov and Gerlach proposed a new method for generating yield-curve scenarios for stress testing banks' exposure to interestrate risk (IRR) based on the Nelson-Siegel's 1987 yield-curve model (Coroneo et al., 2011). The authors proposed a method with a wider variety of scenarios than were previously generated by the historical and hypothetical methods typically used in the finance industry and recommended in academic research (Abdymomunov & Gerlach, 2014).

A couple of researches has been conducted using the data of Italian banks. In 2015, Esposito et al. published the paper on how 68 Italian banks managed their exposure to interest rate risk during the 2008–2009 financial crisis (research period 2008–2012). Authors documented that on average the interest rate risk exposure – measured by duration gap approach – has been limited and lower than the signal level imposed by regulatory bodies. Second, their econometric analysis demonstrated a relation of substitutability between banks' on-balance-sheet interest rate risk and an adoption of interest "rate derivatives suggesting that banks used these two instruments to curb their overall interest rate risk exposure in case of an increase in interest rates" (Esposito et al., 2015).

A couple of years later, another research on Italian banks has been published. Cerrone et al. developed a back-testing framework to test the firmness of methodology results with actual bank risk exposure. Using a representative sample of 130 Italian banks between 2006 and 2013, their empirical analysis suggests the need to improve the standardized shock enforced by the Basel Committee on Banking Supervision (Cerrone et al., 2017).

Bloechlinger concentrates on one particular objective within interest rate management in the banking book – "analytical valuation framework for the management of fixed-income instruments traded in imperfectly competitive markets" (Blöchlinger, 2021).

The earlier literature is not being overviewed here as the problem of this paper is related to the latest regulations of the European Banking Authority on IRRBB (European Banking Authority, 2018b). Our contribution to the existent literature and the current discussions on regulatory changes towards IRRBB might be described from several angles.

First, there is no relevant literature published following European Banking Authority guidelines on IRRBB in 2018 (European Banking Authority, 2018a, 2018b). Second, recent papers do not categorize banks upon their size and national importance, whereas in our opinion it is important to stress out the regulation impact to the small local banks highlighting their problems in fulfilling the regulatory requirements due to the different capacity in human recourses compared to the big international financial institutions. Consequently, there are no models provided according to the categories of different financial institutions. Third, this paper provided the particular model for small local banks according to SREP categorization, category 4), on earning-based gap analysis and under unconditional cash flows (according to Annex II – Sophistication matrix for IRRBB measurement of European Banking Authority 2018 guidelines on IRRBB) (European Banking Authority, 2018a).

2. The IRRBB management framework

As defined by the European Banking Authority, Interest rate risk in the banking book (IRRBB) is "the current or prospective risk to both the earnings and the economic value of an institution arising from adverse movements in interest rates that affect interest rate sensitive bank's banking book positions" (European Banking Authority, 2018b). The issue of managing interest rate risk in the banking book is turning relevant recurrently, due to the tightened banking regulation and the circumstance that the financial institutions need to generate interest income in a permanently low-interest-rate frame (European Systemic Risk Board, 2016).

Perturbations of financial institutions, supervisor authorities, and governments have concentrated on the ability of banks to absorb large interest rate shocks. This amendment to managing interest rate risk is mirrored in other improvements to Basel III (Fessler, 2016). The fact that bank deposits and loans have different maturities is determining the essence of the problem. Retail banks employ maturity conversion that usually appears in maturities of loans exceeding the maturities of client deposits. This maturity transformation results in a structural period imbalance. The extent of the structural period imbalance is the result of the chosen level of interest-rate risk (mismatch risk) and the Asset and Liability Management (ALM) strategy the bank is inclined to impose on the banking book. Interest-rate risk is the current and prospective risk to both the changes in the economic value of equity (EVE) and changes in net interest income (earnings) coming from adverse fluctuations in interest rates (Wycisk & Blijlevens, 2018).

IRRBB is usually regulated by considering the adjustment amid two volatility objects: long-run EVE volatility and short-term income volatility: the arrangement between risk (of earnings and/or EVE downturn affected by negative interest rate fluctuations) and return (of net interest rate income and a probable increase in EVE due to beneficial interest rate changes) (Ozdemir & Sudarsana, 2016; Zijderveld, 2017).

In May 2015, the European Banking Authority published an amended technical document that complements the guidelines proposed by the Committee of European Banking Supervisors (European Banking Authority, 2015). A year later – 2016 Basel Committee on

Banking Supervision announced new standards revising the principles for IRRBB management and supervision set in 2004 (Cerrone et al., 2017), considerably increasing the austerity of requirements towards identification, measurement, monitoring, control, and supervision of IRRBB. The renewed principles represented a transformation in the market and regulation policy imposed by the environment of abnormally low-interest rates and provide guidelines and rules to be used by financial institutions in a broader and amended risk management framework (Deloitte, 2017b).

Poorly managed redundant interest rate risk might present a considerable hazard to a bank's current capital base and/or future earnings. Interest rates fluctuations might influence the fundamental economic value of the assets, liabilities, and off-balance sheet instruments of a financial institution, by affecting the present value and amounts of future cash flows and a bank's earnings by augmenting or diminishing its net interest income (NII) as well as the amount of other interest-rate-related income and operating expenses (Basel Committee on Banking Supervision, 2016).

Publishing of the final IRRBB guidelines in 2018 was the initial step for enhancing a proper implementation for these standards.

However, The Final Standards poorly define the sophistication level of the IRRBB measurement quantitative techniques. Thus, the employment of the principles requires financial institutions to set and describe clear risk management and measurement techniques to demonstrate what regulators will expect from banks (Deloitte, 2017b). So the main problem we are rising in this paper is the lack of a unified model at least for one part of the IRRBB measurement matrix.

Not only each department at a bank, as stated by Jeroen Doorsselaere, "is likely to view and calculate risk from the perspective of its primary mission at the firm" (Doorsselaere, 2018), but also each bank will rely on different assumptions, using different information sources, different tools for creating risk assessment models. The survey conducted by Deloitte in 2016 among 37 leading banking groups of different sizes, employing various business models, indicated a wide range of practices and approaches towards modeling and also emphasizes the desire for common modeling and data frameworks due to the range of observed practices and divergent results (Deloitte, 2017a).

A universal model would enable a more straightforward analysis that makes it easier to evaluate the connection among different financial organisations of the same category, simplifying the adoption of the model and diminishing the demand for human resources.

There are three main sub-types of IRRBB (European Banking Authority, 2018b):

(a) Gap risk results from the term structure of interest-rate-sensitive instruments that arise from differences in the timing of their rate changes.
(b) Basis risk arises from the impact of relative changes in interest rates on interest-rate-sensitive instruments that have similar tenors, but are priced using different interest rate indices.
(c) Option risk arises from options, namely the risk arising from interest rate sensitive instruments where the holder will almost certainly exercise the option if it is in their financial interest to do so and the risk arising from flexibility embedded implicitly or within the terms of interest rate sensitive instruments.

All three subtypes of IRRBB potentially change the price/value or earnings/costs of interest rate sensitive assets, liabilities, and/or off-balance sheet items in a way, or at a time, that can adversely affect a bank's financial condition (Basel Committee on Banking Supervision, 2016).

There is a set of principles banks should be following while revising IRRBB (European Banking Authority, 2018b):

IRRBB is an important risk that arises from banking activities and is encountered by all banks. Management of a bank's IRRBB should be integrated within its broader risk management framework and aligned with its business planning and budgeting activities. (Fessler, 2016). Our proposed model for assessing earnings-based gap analysis under unconditional cash flows for category 4 institutions (small local banks) could be the solution for small local banks in reducing needs for human resources.

The governing body of each bank is responsible for the oversight of the IRRBB management framework and the bank's risk appetite for IRRBB. Therefore, the unique calculation proposal provided in this paper could not only ease the process but also be cost-efficient for local banks, as the costs of developing complex IRRBB instruments for local banks are relatively higher compared to the big international financial institutions.

The banks' risk appetite for IRRBB should be articulated in terms of risk to both economic value and earnings. In the model proposition below, we provide the assessment of IRRBB for earnings-based measurement. In this paper, we focus on developing a model for forecasting net interest income which allows us to forecast the change of earnings at a given interest rate level change.

The measurement of IRRBB should be based on outcomes of both economic value and earnings-based measures, arising from a wide and appropriate range of interest rate shock and stress scenarios.

In measuring IRRBB, key behavioral and modeling assumptions should be fully understood, conceptually sound, and documented. The most significant assumptions underlying the system must be documented and understood by the governing body or its delegates (Fessler, 2016). In the model proposed below the assumptions on historical interest rate spread should be checked at each calculation period.

Measurement systems and models used for IRRBB should be based on accurate data, and subject to appropriate documentation, testing, and controls to give assurance on the accuracy of calculations. As pointed out

by Jeroen Van Doorsselaere, to offer regulators a total risk picture, an institution must speak with one voice, and that calls for an integrated data management system telling it what to say (Doorsselaere, 2018).

3. Supervisory requirements for IRRBB modelling NII forecasting methodology

Before starting the methodology part one just must be careful about categorisation of financial institutions, based on the institution's size, structure, and internal organisation, and the nature, scope, and complexity of its activities. According to EBA Guidelines on common procedures and methodologies for the supervisory review and evaluation process and supervisory stress testing released on July 2018 (EBA/GL/2014/13) the categorization of the institutions is as follows (European Banking Authority, 2018a):

- Category 1 – institutions referred to in Article 131 of Directive 2013/36/EU (global systemically important institutions (G-SIIs) and other systemically important institutions (O-SIIs)).
- Category 2 – medium to large institutions other than those included in Category 1 that operate domestically or with sizable cross-border activities, operating in several business lines, including non-banking activities, and offering credit and financial products to retail and corporate customers.
- Category 3 – small to medium institutions that do not qualify for Category 1 or 2, operating domestically or with non-significant cross-border operations, and operating in a limited number of business lines, specialised institutions.
- Category 4 – all other small non-complex domestic institutions that do not fall into Categories 1 to 3 (e.g. with a limited scope of activities and non-significant market shares in their lines of business).

According to the category of the financial institutions (which we will use from EBA SREP guidelines published in 2018) there are also 4 Indicative supervisory expectations regarding IRRBB metric and modeling depending on the institution's sophistication category indicated in the Final EBA guidelines on IRRBB. Two modeling indicators distinguished upon the cash flow: 1) *unconditional* cash flows (it is assumed that the timing of cash flows is independent of the specific interest rate scenario) and 2) *Cash flows partially or fully conditional* on interest rate scenario (timing of cash flows of options, of instruments with embedded, explicit options).

For both types of cash flows, different metrics are specified.

For the *Unconditional* cash flow *Earnings based* (gap) *analysis* and *Duration analysis* must be implemented by financial institutions using the models advised accordingly to the category of the financial institution.

For the *Partially or fully conditional cash flows* two metrics shall be used *Earnings based* (Net Interest Income analysis) and analysis of the *Economic Value of the Equity* also accordingly to the category of the financial institution.

In this paper, the modeling will be provided to the category 4 financial institution (all other small non-complex domestic institutions) and the metrics used will be under the circumstances of the unconditional cash flow earnings-based (gap) analysis.

Interest rate forecast. NII forecast model is based on 3 month Euro Interbank Offered Rate (EURIBOR) projections and market interest rate of new loans and new deposits projections dependence on 3 month Euribor (Figure 1, X axis – Vilibor and Euribor, Y axis – banking market new loans interest rate). This equation could be used in order to calculate banking market new loans forecasted interest rate under the 3 month EURIBOR projections.

Regression equations of banking market new deposit and 3 month EURIBOR and banking market new loans and 3 months EURIBOR were based on regression analysis of market new deposit interest rate and 3 month EURIBOR and banking market new loans for business clients and 3 month EURIBOR shown in Figure 2.

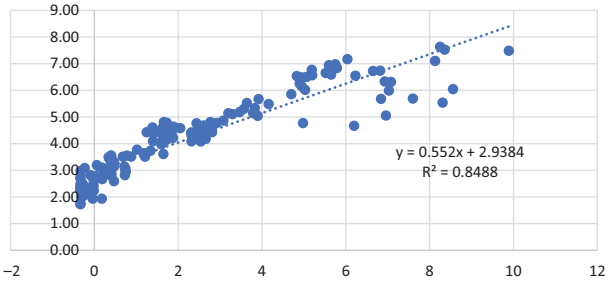

Figure 1. Relation of banking institutions new loans interest rate and three months VILIBOR-EURIBOR 2004–2017 (source: created by authors)

The 3-month EURIBOR projection was used as an independent variable x in our regression model (the projection rate was selected from the Bloomberg terminal using the BYFC function). As a result, forecasts of the banking market's new deposit interest rate (IR_{BMND}) and new business loan (IR_{BMNL}) were calculated. The equation shown in figure 2 (X axis – Vilibor and Euribor, Y axis – banking market new deposit interest rate) could be used in order to calculate banking market new deposits forecasted interest rate under the 3 month EURIBOR projections.

Usually, commercial banks pay an extra interest rate premium above the market interest rate that they could raise deposits. In addition, commercial banks set a lower interest rate than the market average to advance more loans. It is possible to calculate the new deposit interest rate (IR_{ND}) and new loan interest rate (IR_{NL}) of the particular bank according to the banking market interest rate.

$$IR_{ND} = IR_{BMND} + IR_{Spread}; \quad (1)$$

$$IR_{NL} = IR_{BMNL} + IR_{Spread}. \quad (2)$$

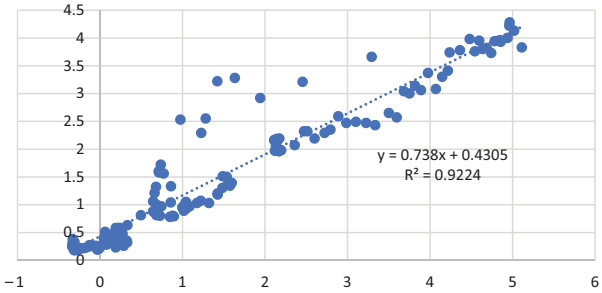

Figure 2. Relation of banking institutions new deposit interest rate and three months EURIBOR 2004–2017 (source: created by authors)

In this paper, we considered interest rate premium as the spread between an average interest rate of the last 12 months banking market new deposit and the bank's new deposit interest rates for the deposits and as the spread between an interest rate of banking market new business loans and the banks' new loans interest rate for the loans.

The new interest rate which will be used in repricing (IR_{RL}) a certain part of the loan portfolio is calculated subtracting the 3 month Euribor at the last repricing date (3m. $EURIBOR_{t-1}$) from the current weighted average of loan portfolio interest rate (IR_L) plus the 3 month Euribor projection at repricing date (3m. $EURIBOR_{t+1}$).

$$IR_{RL} = IR_L - 3m.EURIBOR_{t-1} + 3m.EURIBOR_{t+1}. \quad (3)$$

Yield projections for the new invested debt securities portfolio part are calculated according to average rating and maturity of the Bank's debt securities portfolio, also investment strategy included.

The sum of new loans, deposits, and investments is forecasted. After the calculation of predictive new deposit interest rate and predictive new loan interest rate, the calculation of deposit needs to be raised and new issued loans amount should be done. The extent of the new deposit amount (ND_{SUM}) was estimated according to the following information:

The change of deposit portfolio could be calculated as a difference between this year's projected depost amount (D_t) and deposit amount of last year (D_{t-1}):

$$\Delta D_t = D_t - D_{t-1}. \quad (4)$$

The amount and terms of the deposits slotted in to time buckets (over night, up to 1 month, 1–3 month, 3–6 month, 6–12 month, up to 2 years, up to 3 years, up to 4 years, up to 5 years, from 5 to 10 years, higher than 10 years) according to their contractual maturity.

Deposit term = Cotract. maturity – Reference date. (5)

Statistical information on deposit termination. The expected deposit termination could be seen here:

Deposit termination =
Deposits terminated / Total deposits. (6)

The amount of the new loans (NL_{SUM}) and reprised loans (RL_{SUM}) were estimated according to the following information:

The amount of new loans could be calculated as a sum of this year's projected loan portfolio delta (ΔL_t) and loans portfolio amount of last year (L_{t-1}):

$$NL_{sum} = \Delta L_t + L_{t-1}. \quad (7)$$

The number of projected loans repayments.

The amount of loans that will be paid slotted in to time buckets (over night, up to 1 month, 1–3 month, 3–6 month, 6–12 month, up to 2 years, up to 3 years, up to 4 years, up to 5 years, from 5 to 10 years, higher than 10 years) according to their maturities.

Loan payment term =
Cotract. maturity–Reference date. (8)

The amount of the projected loan portfolio part, which would be reprised using the new interest rate.

Loan repricing term =
Interest rate repricing date – Reference date. (9)

While calculating the new investment in debt securities demand (NI_{SUM}), the following information is required:

The projected amount of total debt securities portfolio is reported in the strategic planning of the bank. The amount of debt securities could be calculated as a of this year's projected debt securities delta ($\Delta Debt_t$) and debt securities portfolio amount of last year ($Debt_{t-1}$):

$$DEBT_{sum} = \Delta DEBT_t - DEBT_{t-1}. \quad (10)$$

The projected amount of debt securities portfolio redemptions. Debt securities slotted in to time buckets (over night, up to 1 month, 1–3 month, 3–6 month, 6–12 month, up to 2 years, up to 3 years, up to 4 years, up to 5 years, from 5 to 10 years, higher than 10 years) according to their maturities.

Loan payment term =
Cotract. maturity–Reference date. (11)

NII forecast model. The forecast of the bank's net interest income is calculated using the following formula:

$$NII = NL_{SUM} \times IR_{NL} + RL_{SUM} \times IR_{RL} + NI_{SUM} \times NI_{Yield} - ND_{SUM} \times IR_{ND}. \quad (12)$$

According to Matz (2008): "prudent risk managers should not make any decisions about their rate-risk exposure unless they have confidence that their models are at least reasonably accurate". Confidence is one of the most important requirements for model results that is why a back-testing method will be used to evaluate model reliability. According to Matz (2008) common output, backtests include the comparison of the forecasted NII for a subsequent period to the "normalized NII" actually observed for that period.

NII model's forecasted data will be compared to actual data during the back-testing procedure. The forecasted data of the new loans, deposits, and investments are created using historical data such as bank liquidity reports, statistics of the deposit termination, interest rate GAP

analysis, and using forecasts from the strategic planning. The model risk arises from assumptions used in the model, which occurs in two directions. Firstly, historical trends would not necessarily recur leading to actual deviation of *NII* from predictions. Secondly, possible actual deviation from the strategic planning such as slower or faster growth of the predictive deposit, loans, or investment portfolio could lead that the actual *NII* will be different from forecasted *NII*. Having in mind the presence of model risk and that model error is unavoidable, a 10% level of the forecasted *NII* deviation from the actual NII is considered as an appropriate deviation because it is impossible to construct a model, which will forecast with 100% probability. Under these circumstances, actual *NII* (NII_{act}) could not differ from predictive *NII* (NII_{frc}) data by more than 10%. If this condition is met, the model is considered acceptable and reliable.

$$Dev = NII_{act} - NII_{frc} \leq \pm 10\% . \quad (13)$$

4. Results

According to the model that was detailed in this paper's methodology part, the *NII* forecast was calculated for 6 quarters. Three months Euribor forecast was used to calculate interest income and interest expenses. Forecasted interest income on loans and debt securities also interest expenses on term deposits and their deviation from actual results are shown in the table below.

Table 1. The forecast of interest income and expenses with a change of a 3 month Euribor and debt securities yield (source: created by authors)

Period		Interest income on loans	Interest income on debt securities	Interest expenses on term deposits
1Q	Forecast (m, EUR)	14,834	4,077	1,827
	Actual (m, EUR)	15,589	4,496	1,850
	Deviation	–4,85%	–9,32%	–1,24%
2Q	Forecast (m, EUR)	14,855	4,084	1,830
	Actual (m, EUR)	16,200	4,132	1,850
	Deviation	–8,30%	–1,17%	–1,06%
3Q	Forecast (m, EUR)	16,689	4,022	1,749
	Actual (m, EUR)	16,049	4,124	1,830
	Deviation	3,98%	–2,46%	–4,43%
4Q	Forecast (m, EUR)	15,997	3,956	1,799
	Actual (m, EUR)	17,536	3,982	1,863
	Deviation	–8,78%	–0,65%	–3,43%
5Q	Forecast (m, EUR)	17,315	4,078	1,821
	Actual (m, EUR)	18,505	4,008	1,863
	Deviation	–6,43%	1,75%	–2,26%
6Q	Forecast (m, EUR)	18,515	3,844	1,875
	Actual (m, EUR)	18,976	3,969	1,909
	Deviation	–2,43%	–3,15%	–1,77%

End of Table 1

As can be seen from the forecasts presented in Table 1, the deviation of the fact did not exceed the deviation target of 10% throughout the analyzed period (the maximum deviation was 9.32%). The deviations in forecasts could be explained by the fact that not all assumptions of the model are realized as forecasted before (changes of loan, deposits and debt securities portfolio, termination of deposits before the final term, etc.). Model deviations are possible, so in order to achieve higher model reliability, the possible deviation of model assumptions from the fact should be evaluated and involved in a model assumptions construction.

Figure 3 shows the NII forecast and comparison with the actual data for that quarter.

The figure shows that the obtained NII forecasts are close to the actual results of the analyzed period, confirming that the model forecast NII accurately and reliably. This can be seen from the Table 2, which shows the deviation of the forecasted and actual NII.

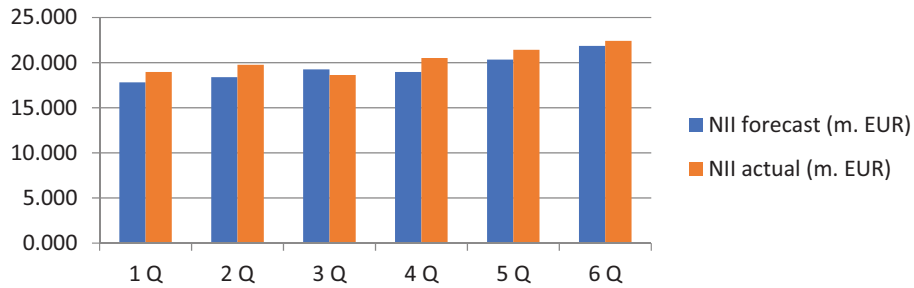

Figure 3. NII forecast and comparison with the actual data for that quarter (source: created by authors)

Table 2. NII forecast deviation from actual results (source: created by authors)

Period	NII forecast (m, EUR)	NII actual (m, EUR)	Deviation (%)
1 Q	17,800	18,952	–6,08%
2 Q	18,375	19,748	–6,95%
3 Q	19,246	18,627	3,32%
4 Q	18,959	20,506	–7,54%
5 Q	20,333	21,410	–5,03%
6 Q	21,851	22,403	–2,46%

Because the deviation of the NII forecast did not exceed the acceptable level ($\leq \pm 10\%$) during the whole analyzed period, it could be stated that the created NII forecasting model allows to properly and reliably predict NII. It was also found that the model reliably predicts not only the final size of the NII, but also the interim rates of interest income on the loan portfolio and investment portfolio, as well as interest expense on term deposits. Analyzing the recorded differences between the forecast and actual data, it was found that the main deviations are due to several reasons:

Predictions of loans, deposits, and debt securities portfolios from the Bank's strategic plan are used in forecasting NII. Analyzing the actual size of the NII, it is noted that actual portfolio volumes may differ from those in strategic planning, which in turn leads to higher or lower NIIs.

Forecasting of NII is based on the expected termination of deposits and repayment of loans during the period. It has been noted that there are some possible deviations between the planned and actual expected termination of the deposits, which is influenced by interest rate fluctuations. The deviation of the amount of loans repaid during the period may also lead to a change in the NII because these deviations could lead to different volumes of newly issued loans.

A final comment on the limitations of this study appears warranted. To increase the accuracy of the model, the reasons for the deviation described above should be evaluated, and the model should include possible deviations from the actual data of the assumptions used in the model. However, without these improvements, the model reliably predicts NII up to ± 10% tolerance level of NII deviation.

Conclusions

Concerns about the potential rise in interest rates and their impact on bank performance are particularly relevant in the current economic scenario, where interest rates are at historically lowest levels in many countries and negative in some. If interest rates rise in the future, banks may face high-interest rate risk. One way to eliminate these risks is through effective management and control of the IRRBB.

The principles applied to individual banks cover the key issues of data consolidation and management, IRRBB performance measurement and regulation, and business reporting. Importantly, the IRRBB assessment criteria apply to all banks, regardless of size, and the guidelines do not specify the exact methodology. Thus, small local banks face considerable human resources challenges, as their risk assessment must also match that of large, international banks. Key challenges are expected to arise from the risk management system, management model, and skill/competency level. The model proposed in the article is specifically tested and applied to small local Baltic banks, which would facilitate them in developing the IRRBB methodology, creating a balance between unequal human capital opportunities between large Scandinavian banks and small local capital banks.

In this paper, we create the model of risk assessment for Category 4 (all other small non-complex domestic institutions) according to EBA guidelines. In this paper, the modeling is constructed under the circumstances of the unconditional cash flow earnings-based (Net Interest Income) analysis and tested on the real data of one small domestic bank from the Baltics.

In this paper, proposed NII forecasting methodology includes forecasting of new deposit and new loan interest rates, as well as the calculation of deposit, need to be raised, new issued loans amount, and demand of new investment in debt securities. The concept of the model makes it possible to forecast NII and estimate the change in a bank's NII over a time period. The model error is unavoidable, so 10% of the forecast NII deviation from the actual NII is considered appropriate for the proposed model in performing back-testing analysis.

Back-testing analysis has shown that the proposed model allows reliable forecasting not only of NII but also of the interim rates of interest income on the loan portfolio and investment portfolio as well as interest expense on term deposits up to ±10% deviation tolerance level. Deviation of the NII forecast did not exceed the acceptable level ($\leq \pm 10\%$), so the model could be applied at this tolerance level for earnings-based analysis of IRRBB.

Disclosure statement

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