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Optimization of Banks' Value - Practical Challenges

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ABSTRACT

The aim of the article is to verify the conceptual model of integrated optimization of a bank's value, which enables the integration of the risk management process with business processes while maintaining compromise between the safety (stability) of a bank's operations and striving to maximize its value.

The model is an attempt at a comprehensive solution to such dilemmas as shaping a bank's value ex ante, not ex post. Verification of the model has shown that the model works in accordance with the adopted assumptions and leads to the achievement of the basic goal for which it was constructed. In practice, it means the possibility of ensuring a compromise between the safety and effectiveness of a bank's operations, which, in the context of ongoing changes in its environment, allows for a long-term competitive advantage.

JEL classification: C61, G21, G32

Keywords: Bank management model, Integrated value optimization, Stochastic simulations, Decision support systems.

1. INTRODUCTION

The progressing globalisation and integration of financial markets as well as the recently observed tendency to regulate the phenomena have a number of consequences determining activities of banks (Basel Committee on Banking Supervision, 2011). As a result, the quantitative and qualitative changes taking place in the banking sector, and above all the growing competition on the financial services market, put a new light on the problem of managing the effectiveness of banks (Committee on the Global Financial System, 2018). The issue gained special importance

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as a result of the 2008+ financial crisis, the real effects of which and the adopted preventive solutions limited the effectiveness of banks (Oino, 2018). The construction of the new structure of financial supervision is a consequence of the imperfection of institutional supervision in many countries, which did not provide sufficient protection of financial stability to domestic markets in the conditions of crisis (World Bank, 2020). The crisis also revealed the need for greater coordination of supervisory activities at the supranational and global level in order to effectively counter arbitrage between individual countries (The de Larosière Group, 2009) and the contagion effect (Koleśnik, 2021). At the same time, the growing needs of the bank's environment, significant changes in the operating conditions and the dynamic situation on the financial markets make it necessary to formulate new operating strategies and develop new ways of managing banks (Andrle et al., 2017). The observed phenomena on the global financial market pose both an opportunity for banks and a threat to their development. Advantages are manifested in the possibility of diversifying activities in the context of customers and their segments, product groups, area of operation, levels and types of risks taken. On the other hand, the crisis, in addition to the imperfections of the global financial system, also revealed the insufficient quality of bank management methods used (Holland, 2010; Laurens, 2012). The vast majority of banks have so far been assessed through the prism of their financial results, disregarding the scale and level of risk taken. The effects of the practice are still felt by financial markets. In the light of it, the postulate to integrate the bank's business goals with the goals of risk management systems (Nishiguchi et al., 1998) should be considered correct, which enables the implementation of the concept of sustainable development on a microeconomic basis.

The above-mentioned phenomena taking place in the bank's environment have a number of implications that have become a challenge for each bank, in particular in terms of management (Härle et al., 2016; Jain et al., 2021). The phenomenon of globalisation, in a broad sense, exerts a significant pressure on the improvement of operational efficiency as a key element of competitive advantage (Balling et al., 2001). Even if some banks have adopted a market niche (specialization) strategy, they usually reach the growth limit set by the size of a given market segment after some time. Then the problem of strategic directions for further development arises. Of course, they can only stick to their own specialization, which is facilitated by the dynamically changing environment and the related possibility to meet new needs. However, in the longer term, this may prove insufficient due to the strong competition in the banking sector, including cross-border banks. In such a situation, a more advantageous solution is the evolution towards a universal bank with an offer for all market segments (Mergaerts and Vennet, 2016). An additional advantage of the solution is the possibility of a more flexible diversification of activities and the associated risks. However, the problem in this case is how to expand the bank's business profile. It can usually be achieved in two ways: mergers/acquisitions of other banks or through reorganization (changes) on your own. The first method, however, requires sufficient capital resources, which is usually very difficult in practice in the case of a specialist bank. The second, in turn, requires, above all, appropriately qualified personnel and technological innovation, which is also indirectly related to capital resources (Zaleska and Kondraciuk, 2019). Regardless of the chosen development strategy, the basic problem ultimately comes down to the issue of operational efficiency (Paula, 2002). It determines, in the long term, a bank's ability to develop its activities in the broad sense (territorial or segment expansion). An important issue in this context is also the effectiveness of competitors (the entire banking sector). Significantly lower efficiency than the average in the sector will have an impact on weakening the competitive ability of a given bank. Therefore, regardless of the profile of its business, each bank should take into account the issue of efficiency when designing all processes. In the current reality, it is important because technological progress constantly creates new opportunities and tools to increase the effectiveness of the bank's operations (Weigelt and Sakar, 2012; Le and Ngo, 2020). It applies to the sale of banking products process as well as to other aspects of the bank's operation, including, in particular, the management process.

In response to the described challenges facing the banking sector, the authors proposed a conceptual model of integrated optimization of bank's value (Koleśnik and Nadolski, 2021), which answers the question: how can a bank survive and develop in the conditions of strong competition, globalisation, financial markets integration (putting pressure on operational efficiency), while maximizing its value, as well as meeting the expectations of all stakeholder groups, including banking supervision? The purpose of the article is to verify the correct operation of this model and whether, as a result of its application, the bank can optimize its value (optimization should be understood as maximizing the value at an acceptable level of risk).

Due to the fact that the model is conceptual in nature, verification of the model will be carried out on the basis of a simulation method using pseudo-random numbers. High requirements regarding the detail of input data and the limited availability of relevant data limit the possibility of verification by authors to only one bank.

2. DESCRIPTION OF DATA

A simulation of the model's operation involved data of a specific bank from an EU Member State, hereinafter referred to as Bank X. The data was transformed in order to prevent identification. For the purposes of verification of model's operation, the Bank's initial balance sheet is presented in Table A.1 (Appendix A, Table 1). The parameters of the selected bank, including size, type and scale of operations and balance sheet structure, were similar to the average value of analogous parameters of a typical European bank, which is not identified as systemically important nor is it subject to direct supervision by the ECB within the banking union.

The balance sheet of Bank X does not show all the balance sheet items, which could actually occur and is presented in a simplified form, mainly to limit the duration of the simulations. This does not mean, however, that the results obtained will not be representative. From the point of view of the goal and structure of the model, neither the degree of balance sheet complexity nor the number of balance sheet items is important. The aspects affect only the duration of individual simulations but they have no impact on the final results obtained in different simulations, and thus obtained in the whole test. The simplification will also allow us to highlight proper effects of model operation without dispersing them excessively.

For the model to operate correctly, it is necessary to specify all the transactions carried out by the bank, including respective levels of income and risk. In order to verify the model, specification of parameters of the transactions (Table A.2) whose level was estimated on the basis of 7-year time series and characteristics of the transactions effected by Bank X were used.

The necessary input parameters of the model, which determine the target structure of transaction/balance sheet, are: ROE and total capital ratio (rate of return and risk appetite/bank security level). For the purposes of the simulations, it was assumed that the parameters are: 8.00% and 13.00%, respectively. Moreover, in order to determine the income value (regarded as the financial result of core activity) on the basis of the minimum ROE value, it is necessary to define the share of the remaining bank activity in the result obtained from core activity, as well as the rate of income tax. It was assumed that they are: 79.11% and 21.11%, respectively (values estimated on the basis of Bank X data).

Simplification made for the purposes of the simulations is based on a constant algorithm of off-balance sheet items, which is compatible with the observations made so far. On the basis of Bank X data, it was estimated that the degree of utilisation of off-balance sheet items was as follows: Z01 - 80%; Z02 - 70%; Z03 - 95% and Z04 - 25%. Furthermore, participation of the off-balance sheet items in creating the risk rate of individual off-balance sheet items is shown in Table A.3.

3. MODEL DESCRIPTION

Verification covers only the strategic and management modules, which have a direct impact on stimulating the activities focusing the bank value optimization. Operational module derives from the other two modules and is designed to stimulate the desired behaviour of sales structures in the process of product sale (shaping the bank's balance sheet structure) and to implement a mechanism of participation in the effects of wrong decisions. The level of profits is directly related to the level of dynamic margin, which is the main tool of internal demand transmission and a stimulator of the desired structure of products/transactions sale. Therefore, in view of the goal of the model, its verification will be limited to the abovementioned modules, while its operation effectiveness will be tested by means of such measures and ratios as:

- ROE,
- ROA,
- total capital ratio,
- income rate,
- income to risk ratio.

The said measures, calculated to simulate the final outcome of the model's operation will be analysed, i.e. they will be compared with the measures calculated for the initial and target level.

In order to ensure reliability of model operation, including accuracy of final results, as well as to minimize fault tolerance, the number of simulations was set at 1000, while the number of steps in a single simulation – at 100 (N = 100). The course of a single step of model operation simulation can be related to one working day of bank activity and it includes: generating optimizing and related transactions (each time 10 transactions are generated – n = 10), generating other transactions and adjustments, and solving the optimization problem.

The model verification process assumes that different kinds of transactions will be effected; they are supposed to simulate events occurring during normal operation of every bank. It requires that the transactions are each time recorded in the balance sheet (balance sheet valuation). For the purposes of the simulation process, they are shown in the amount of the concluded transaction (without balance sheet valuation), which can only slightly affect the results obtained. Moreover, we can assume that simulated operations resulting from normal bank operation effectively eliminate the adopted simplification.

The adopted simulation mechanism of bank operation envisages the following types of transactions (arbitrary terminology):

- optimization transactions,
- transactions related to optimization transactions,
- random transactions,
- transactions related to random transactions,
- manual transactions,
- transactions of financial result revaluation,
- transactions related to transactions of financial result revaluation.

Optimization transactions are designed to be a set of transactions occurring on the market, which are possible to be made. They can be regarded as representing the current market demand. The transactions, however, are only a set of available transactions, out of which transactions of the most desired (in terms of bank value maximization) parameters are selected. The assumption adopted for the type of transactions is the following question: which transaction should be selected if we could choose only one from a quite numerous set? Each choice of a transaction of the most advantageous parameters should help the bank obtain the target transaction/balance sheet structure, at the same time eliminating unwanted transactions. Naturally, in real circumstances, it is difficult to imagine such a situation, but this approach is connected with the need of verification of model operation. In other words, whether the adopted criteria for selecting a transaction and

thereby shaping the main factor motivating the sales structures (benefits) are appropriate and whether they will contribute to an increase of the bank value.

An assumption was made that optimization transactions are the ones which can be made by sales structures, i.e. receivables from the non-financial and public sector (A041, A042, A043, A05), debt securities (A06), securities (A07) and obligations to the non-financial and public sector (P031, P032, P032 and P04). The types of transactions are subject to the dynamic margin mechanism and they are the main factor affecting the transaction/balance sheet structure.

The process of generating optimization transactions is based on the mechanism of pseudorandom numbers, which involves random selection of a number from uniform distribution, which is a basis for creating the transaction amount, income rate and risk. The parameters are created by means of the quantile function of normal distribution, assuming that a higher transaction carries greater risk but has a lower income rate. The assumptions are based on empirical observations, which indicate that a higher transaction amount usually carries greater risk (resulting also from higher concentration, liquidity or credit risk). A reverse trend can be observed in the case of income rate, where higher transaction amounts are usually connected with lower margins as compared with transactions involving low amounts. Large amounts are usually given preference by a possibility to negotiate interest rates, which results in reduced transaction income. Conversion of random numbers from uniform distribution into the parameters of optimization transaction is based on the assumptions presented in Table A.4.

The process of generating optimization transaction each time involves a random selection of 100 numbers for every type of transaction. In effect, the optimum transaction is each time selected from a set of 1000 new transactions (10 types of optimization transactions, and 100 transactions per each type). At the same time, in order to prevent a set from reducing its number, the transaction amounts expressed in negative numbers, which can be created as a result of random selection mechanism, are converted into amounts expressed in positive numbers.

When an optimization transaction is effected, adjustments to the balance sheet items are required. It is due to the fact that crediting actually involves indication of balance sheet sources of financing of such a transaction (change in the balance sheet structure on the assets side). On the other hand, when a deposit is made, the balance sheet total increases and its structure is changed (change on the side of assets and liabilities). In the verification model, the type of transactions which introduce necessary adjustments after an optimization transaction is made are transactions connected with optimization transactions. The main assumption for the type of transaction is the fact that each optimization transaction, when effected, is settled by the amounts due from the financial sector (A03) and debt securities (A06). However, some limitations were applied with regard to the balance sheet items and the very optimization transaction. The limitations are supposed to reflect the actual conditions in which the bank operates. An optimization transaction is controlled to check whether it will or will not cause the limits established for a given type of transaction (the limits constitute limiting conditions for the bank value optimization) and the target risk rate. It is also checked whether it is possible to settle the optimization transaction by means of the abovementioned balance sheet items (control of acceptable limits). If the two conditions are met, the selected optimization transaction may be effected (otherwise, it is returned and the selection process is repeated). If the transaction is made, there arises a problem of indicating its sources of financing (active transactions) or its allocation (passive transactions). The adopted solution is presented in Table A.5.

The above model of related transactions typology should be interpreted in the following way: in the case of an active transaction, if it can be financed from items A03 and A06 (difference between their balance sheet total and the minimum level resulting from the limit), the A03 financing variant is adopted (for A03 > 0 and A06 = 0; A03 > 0 and A06 < 0; A03 = 0 and A06 < 0), the A06 variant (for A03 = 0 and A06 > 0; A03 < 0 and A06 > 0; A03 < 0 and A06 = 0) or the A03 and A06 variants – in proportion to the surplus/deficit (for A03 > 0 and A06 > 0; A03 = 0 and A06 > 0; A04 = 0; A05 = 0; A05

A06=0; A03 < 0 and A06 < 0). If the effected optimization transaction involves a purchase of debt securities (A06), such a transaction is fully financed from item A03. On the other hand, in the case of passive transactions, the algorithm is analogous to the presented one, except that the upper limit for A03 and A06 is examined (whether the limits of maximum engagement will be exceeded or not after the transaction is made).

In result of the presented algorithm, related transactions (one or two) are created. They have opposite signs (+/–) to the optimization transaction (total of the optimization transaction and the related transactions equals zero) if the optimization transaction refers to the assets. If the optimization transaction refers to the liabilities, they have the same sign. This is supposed to reflect the real mechanism of recording operations adopted by the bank. Moreover, in accordance with accounting principles, the algorithm ensures that the total of assets and liabilities will be consistent. On the other hand, the income and risk rates for related transactions are generated by means of pseudo-random numbers of uniform distribution using the quantile function of normal distribution. The difference in respect of the parameters for optimization transactions lies in the independent character of the random number for the income and risk rates. In principle, this should reflect varying conditions which often occur on the market, as well as the need to perform regulatory and hedging transactions in the dynamically changing reality. Average income and risk rates necessary to generate their random values for items A03 and A06 are compliant with Table A.2, while standard deviation for the income rate is 0.05%, as well as A03 – 0.10% and A06 – 0.00% for the risk rate.

So far, the transactions discussed in the article have reflected only a simulation of making transactions which are desired from the point of view of bank value maximization and the transactions resulting therefrom (the need to adjust the balance sheet and/or the balance sheet total). However, normal bank operations involve a series of other transactions, which are only a consequence of decisions made by the clients and booked economic events. For a simulation to better reflect the actual conditions of bank operation, such operations must be generated and shown in the balance sheet. The transaction category is arbitrarily referred to as random transactions and it is supposed to make the simulation more dynamic. Every day, in the bank there occur operations which are not necessarily desired from the bank's point of view but the character of services offered by the bank offers essentially unlimited opportunities for the clients to use the funds they deposited. Furthermore, there are a number of ongoing processes in the bank, including management of assets and liabilities, which also affect the bank's balance sheet structure. In order to reflect the operations, a mechanism of random generation of transaction parameters was applied to all balance sheet items, analogously to the case of related transactions connected with optimization transactions (independently generated amount, profit and risk rate). Generated transaction amounts can have both negative and positive values. They cannot, however, cause a negative balance (then the transaction amount equals 0). The parameters applied to generate random transactions amounts are shown in Table A.6.

Average values used for generating income and risk rates for different types of balance sheet transactions each time derive from the closing balance sheet (balance sheet which includes all the transactions effected within one simulation event). The standard deviation was established at 0.05%. It is worth noting – in Table A.6 – that an average greater than zero means that a balance sheet item is likely to rise in a long-term perspective.

In order to book random transactions, application of related transactions is required, like in the case of optimization transactions. Related transactions are supposed to finance the effected random transactions and to make the balance sheet total consistent. Also here, the effected transactions are settled from items A03 and A06, but it is done collectively (as is the case in reality). Settlement of individual balance sheet items is usually done at the end of the business day, not after each effected transaction. The amount to be settled is calculated as a difference between the total of active and the total of passive random transactions. If there is a surplus, items A03 and A06 are

diminished in proportion to the current balance by the obtained value (decline in the balance sheet total value). Otherwise, they are increased (rise in the balance sheet total value). Related transactions are booked simultaneously with random transactions, which ensure compatibility of the balance sheet total. On the other hand, the parameters necessary to generate income and risk rates are analogous to those in random transactions (the same source of data).

Manual transactions (arbitrary term) are supposed to reflect settlement transactions performed at the end of every business day. It was assumed that only items A01, A03 and A06 are subject to such operations. They consist solely in settling the balance between the items and clearing them in proportion to the structure of their target levels in order to ensure the lowest possible mismatch between the balance sheet structure and the target structure, as well as to eliminate the effects of all the previous transactions. The income and risk ratios are generated analogously to those in the previous transaction type.

All the previous transactions cause changes in the balance sheet structure, balance of individual balance sheet items and their average weighed income and risk rates. It naturally affects the value of the financial result, which has not been discussed herein yet, but undoubtedly, it is changed too. According to the adopted solution, financial results depend on the average weighed income rate (all the previously described transactions considered). The product of this rate and the value of balance sheet total represents the result obtained from banking operations. The net financial result is obtained after an adjustment for the ratio of the other bank activity to the banking operations and for the income tax rate. The difference between the obtained value and the financial result achieved so far has to be recorded in item P10.

Inclusion of the transaction which involves revaluation of the financial result will make the balance sheet total inconsistent. It is therefore necessary to make another adjustment (transaction related to the transaction of financial result revaluation). It is carried out in exactly the same way as manual transactions are made, the only difference being that the amount to be recorded (increase/decrease in net financial result) is divided only between two items, i.e. A03 and A06.

Record of the transaction types described above is supposed to reflect their influence on the balance sheet structure, income and risk rates of individual balance sheet items. The parameters obtained in result of subsequent transactions being made are subject to continuous change. For this reason, it is each time necessary to solve the optimization problem since the input parameters, which considerably affect the final effect of model operation, are changed. The objective function, formulated on the basis of a simplified balance sheet and assumptions described above, can be presented in the following way:

$$F(x_i, y_j, z_k) = B \times \left(\sum_{i \in A} x_i D_i + \sum_{j \in P} y_j D_j + \sum_{k \in Z} z_k D_k \right), \tag{1}$$

where:

F() - objective function, B - value of balance sheet total, $D_i, D_j, D_k - \text{ income rate for a given transaction/item/product}$ $x_i, y_j, z_k - \text{ share of assets (A), liabilities (P) and off-balance item (Z) in balance sheet total,}$ $A = \{A01, A02, A03, A041, A042, A043, A05, A06, A07, A08, A09\},$ $P = \{P01, P02, P031, P032, P033, P04, P05, P06, P07, P08, P09, P10\},$ $Z = \{Z01, Z02, Z03, Z04\}.$

The objective function is maximized using the following limiting conditions:

$$B \times \left(\sum_{i \in A} x_i R_i + \sum_{j \in P} y_j R_j + \sum_{k \in Z} z_k R_k\right) \le WR$$

$$\tag{2}$$

$$\sum_{i \in A} x_i = \sum_{j \in P} y_j = 1 \tag{3}$$

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$$\sum_{k \in \mathbb{Z}} z_k \le 0.20 \tag{4}$$

$$L_d \le x_i, y_j, z_k \le L_g \tag{5}$$

$$x_{A041} + x_{A042} + x_{A043} \le 0.75 \tag{6}$$

$$y_{P031} + y_{P032} + y_{P033} \le 0.85,\tag{7}$$

where:

- R_i, R_j, R_k risk rate for a given transaction/item/product, WR admissible value of risk calculated on the basis of the target total capital ratio and current own funds,
- L_d bottom limit of share of a given balance sheet item in the balance sheet total,
- L_{g}^{-} upper limit of share of a given balance sheet item in the balance sheet total.

Assumptions (4), (6) and (7) were adopted by the authors arbitrarily for the purpose of verifying the operation of the model and are intended to reflect, respectively:

- the permissible share of off-balance sheet items in the carrying amount is 20%,
- credit exposures to the non-financial sector at a level not higher than 75% of the carrying amount.
- financing the bank's operations with deposits from the non-financial sector at a level not higher than 85%.

Upper and bottom limits $(L_d \text{ and } L_g)$ for individual balance sheet items are presented in Table A.7.

The income and risk rates used for calculating the value of objective function and boundary conditions each time derive from transaction parameters specification (Table A.2), not from the balance shown after the transaction is effected (current). Otherwise, the model would cause greater exposure of the bank to the economic cycle (the structure would be maximized on the basis of current parameters of profit and risk, not on the parameters estimated in long time series).

It can also be noted that Table A.7 does not include all the balance sheet items which are subject to limitations. It is due to the fact that the missing balance sheet items are limited on the basis of the current structure, being exogenous parameters for the optimization problem. This approach is based on the assumption that some balance sheet items can be shaped by the motivational system, while others are only a consequence of specific events and phenomena occurring in the bank and its environment. In practice, the calculated share of an item which is not subject to limitations constitutes a boundary condition for the goal function. In other words, x_i , y_i equal the calculated share of a given item in the balance sheet total.

The balance sheet total (current balance sheet total) also constitutes exogenous data for the optimization problem, as well as the share of off-balance sheet items, where a constant algorithm of its creation was adopted.

Microsoft Excel including Solver software was used to solve optimization problems. The obtained results are presented in Appendices B and C hereto.

4. SIMULATION RESULTS

On the basis of the obtained results (Table B.1 - Appendix B, Table 1), we can conclude that the model causes growth of the balance sheet total by an average of 2.26% (average growth amount 6,766.58 thousand monetary units /K MU/) at the median which differs from the average only by 26.60 K MU. The level of standard deviation, which is only 0.58% in respect of the average, is relatively low. Analysis of a frequency diagram (Figure C.1 – Appendix C, Figure 1) indicates that in the case of 50% of performed simulations, the final balance sheet total oscillated between 305,181.40 and 307,519.40 K MU.

The off-balance sheet items, which increased by an average of 20.77%, showed greater growth dynamics (with an average growth amount of 9,480.31 K MU). The difference between the median and the average was only 4.84 K MU. As was the case of the balance sheet total, the level of standard deviation, which was 1.27% in respect of the average, is relatively low. In the case of approx. 80% of performed simulations, the off-balance sheet total oscillated between 54,192.41 and 56,006.12 K MU.

With regard to the balance sheet structure, we can therefore conclude that the model stimulates growth of the bank book value. At the same time, results of individual simulations show considerable concentration, which means that the model operation is stable while the obtained results do not indicate substantial dispersion.

The net profit recorded average growth of 16.14% (amount of 326.59 K MU), which – with regard to an increase in bank value – is a desirable outcome. The difference between the median and the average remained at quite a low level of –0.02 K MU while the level of standard deviation in respect of the average was only 0.76%. It means that each time the model causes growth of bank value while the generated financial result is characterised by very low dispersion. It is demonstrated in the frequency diagram (over 95% of simulations generated net financial result with the range between 2,316.65 and 2,384.15 K MU).

Similar conclusions can be drawn in respect of income, from which the financial result derives (due to the assumed stable relative level of profit encumbered with the result from non-banking activity and with the income tax). Differences refer only to absolute values while the relative ones remained at a similar level.

The average value of risk expressed as an amount reached the level of 15,406.80 K MU and it was higher that the initial value by 6.47% (936.80 K MU). It should be noted that the recorded increase in risk value was lower than in the case of income (income rose by an average of 1,917.18 K MU). It is quite significant if we consider that the basic goal of the model was to increase the bank value exactly, among others, by the selection an algorithm which gives preference to the transactions of desired income/risk ratio. In other words, the model causes a change in transactions carrying very high risk into transactions carrying lower risk while maintaining appropriate profitability level. The difference between the median and the average remained at quite a low level of 12.02 K MU while the level of standard deviation in respect of the average was only 1.63%. In the case of approx. 90% of the performed simulations, the amount of risk generated by the bank oscillated between 15,001.28 and 15,826.18 K MU, which indicates – like in previous cases – low dispersion of simulations results.

In the case of income and risk value, the observed phenomena are reflected in the ratio between the values. As a result of the model's operation, the income/risk ratio followed the expected values recording an average increase by 8.53% (7.27 percentage points). In practice, it would mean an improvement in bank operation profitability and an increase of bank value, i.e. realization of the abovementioned basic goal of the model. The absolute difference between the median and the average was -0.04 p.p., at standard deviation to the average ratio of 1.06%. It indicates a big concentration of the obtained results, which is also confirmed by the frequency diagram (over 90% of observations oscillate between 91.03% and 94.32%). Stability of the model's operation may be additionally confirmed by the figures illustrating the course of different simulations (Figures C.12–17). In the case of income/risk ratio, but also other values, a curve illustrating the course of this ratio during the simulation can be plotted. The important fact is that each simulation course has a quite characteristic and similar shape, while individual results (of different steps, as well as of any other simulation) show a considerable concentration.

Although income and risk rates were analogous to the income and risk values, effects of the model's operation are more spectacular in this case. In other words, they better illustrate

the mechanism of the model's operation. The income rate increased on average by 11.56% (an increase of 0.22 p.p.) while the risk rate rose only by 2.81% (an increase of 0.06 p.p.). **It means that the transaction selection mechanism gives preference to low-risk and high-profitability rate transactions, which was one of the fundamental assumptions for the model.** The medians for the two ratios do not differ from the average values, which were: 2.13% and 2.31% for the income and risk rates, respectively. On the other hand, the standard deviation in relations to the average income rate showed a much lower value (0.60%) than for the risk rate (1.52%), which results from the applied random selection mechanism. Nonetheless, stability of the model's operation is confirmed by frequency diagrams (Figures C.7–8), which demonstrate that over 90% of observations for the income rate oscillate between 2.1111% and 2.1564%, while for the risk rate – between 2.2479% and 2.3655%. The figure plotting the risk rate value at individual steps of the simulation indicates even greater dispersion of the obtained results. Nevertheless, different data series allow us to plot the characteristic shape of the curve. In the case of income rate, the shape of the curve is markedly easier to plot, and the results of individual simulations are characterised by a pronounced concentration.

The most important synthetic bank security ratio is the total capital ratio. As a result of the model application, its average value from all the performed simulations was 12.74%, which means a decrease by 5.29% (0.71 p.p.) in respect of the initial value. The fall in the value of total capital ratio below the target value (for the purposes of the simulation its value was adopted at 13.00%) results exclusively from the lack of boundary conditions in respect of risk (lack of risk limits). The step was made only because it was necessary to obtain unambiguous results of the model's operation with regard to the bank financial effectiveness while limiting the number of steps in individual simulations at the same time. It should be noted, however, that in no case did it reach a value below the required regulatory minimum, which – for Bank X – is 9.25% (own funds requirements – 8%, capital conservation buffer – 1.25%, countercyclical capital buffer – 0.00%, systemically important institution buffers – 0.00%, systemic risk buffers – 0.00%). The difference between the median and the average was only 0.01 p.p., while the standard deviation level in relations to the average, which was 1.63%, should be regarded as relatively low. Over 90% of the recorded results oscillate between 12.38% and 13.11%, while the diagram plotting the course of individual steps in each simulation confirms stability of the results generated by the model.

Return on equity (ROE) – a very important ratio for bank investors – oscillated around 9.86%, which is higher than the initial value by 15.90% (1.35 p.p.). It means that an increase in profitability of bank operations was markedly higher than the decrease of the abovementioned total capital ratio, which is in turn an important ratio for other bank stakeholders. We can therefore conclude that the extreme increase in benefits was higher than the extreme increase of potential risk costs. There was no difference between the median and the average while the standard deviation level in relation to the average should be regarded as relatively low (0.76%). Results of over 90% of performed simulations oscillated between 9.74% and 10.00%.

Another reliable ratio illustrating an improvement in bank operation profitability is return on assets (ROA), which recorded an average increase by 13.58% (average increase by 0.09 p.p.) with no difference between the median and the average. The standard deviation level was relatively low with an average level of 0.005%, and in respect of the average – only 0.65%. An analysis of the frequency diagram (Figure C.11) indicates that in the case of over 90% of performed simulations the final ROA value oscillated between 0.7581% and 0.7760%. The figure illustrating the value at different steps of each simulation has a very specific shape and is characterised by a considerable concentration of results, similarly as the figure for the ROE ratio.

Correctness of the model's operation and accurate simulation of the conditions of bank operation can be evaluated on the basis of identified correlation relationships between profitability and risk ratios. Table B.2 shows Pearson's correlation between profitability/income ratio, total capital ratio and risk ratio observed for every simulation. As can be seen, total capital ratio,

representing the bank security level, in each case shows a negative correlation with profitability/ income ratio. As per J. Guilford's classification, the strength of the relations can be described as very high. The return on equity ratio demonstrates the strongest relationship with total capital ratio, which means that a change in the bank security level will undoubtedly be reflected in the return on capital level. The relationship, however, is in inverse proportion. Differences in the levels of correlation between total capital ratio and different profitability/income ratio are due to methodological aspects of ratio determination (different reference base – the higher the base, the weaker the relationship). Regardless of the differences, the observed correlations between income/profits and risk show the expected trend, this means that both the model assumptions and the mechanism of random and selecting transactions were designed correctly.

On the other hand, the risk ratio has a high (ROE) and very high (ROA, profitability) positive correlation with the profitability/income ratios. The phenomenon is compatible with the previously mentioned statement with regard to profitability and risk. It is worth noting that the strongest relationship occurs with the ROA ratio and only slightly less strong – with income rate. It means that the ratios may serve as perfect predictors (stimulants) of the effects of the model's operation. In contrast, correlation with the ROE ratio shows a lesser but still quite strong relationship with the risk rate. In other words, the risk rate affects the value of ROE, which is a key measure for bank investors, to a lesser extent but it significantly determines other profitability ratios.

The correlation relationships shown in the figures (Figures C.18–23) confirm the conclusions presented above. Very strong correlation relationships between ROE and total capital ratio, ROA and risk rate as well as between the income and risk rates can be observed. In the case of the other relationships, greater dispersion of individual observations can be noted. However, relatively small ranges between extreme values for individual variables must be emphasized.

At the basis of the model structure there was an underlying assumption that the model mechanism would cause a reconstruction of the initial balance sheet structure tending to a balance sheet structure which is an optimum in terms of bank value maximization in the long-term perspective. Therefore, apart from the financial effectiveness and risk rates, the mismatch between the final balance sheet structure and the optimum structure is also a measure of the model's operation effectiveness. The mismatch was measured by dispersion measures, namely the range and standard deviation. When calculating the range, differences between the initial or final structure are determined in the first place, and then the maximum and minimum mismatch values are differentiated.

As can be observed on the basis of the obtained results (Table B.3), the model causes a decrease in the range of assets in respect of the initial structure by an average of 80.90% (average decrease of range by 19.91 p.p.) with the median differing from the average only by 0.01 p.p. The standard deviation level, which is 19.24% in respect of the average, should be regarded as relatively significant. An analysis of a frequency diagram (Figure C.24) indicates that in the case of over 90% of simulations performed, the final range value oscillated between 3.09% and 6.10%, which – in comparison with the initial value of 24.61% – is a very good result. In practice, it means that the model significantly affects the reduction of the existing mismatch; maintaining high operation stability at the same time.

In the case of liabilities, where the range decreased only by 5.35% (a decrease by 0.41 p.p.), with no difference between the median and the average, the model showed a definitely lower level of mismatch reduction. A lower value was also observed in the case of the coefficient of variability, which totalled 8.33% and was twice lower than in the case of assets. In respect of over 90% of the performed simulations, the final range of liabilities oscillated between 6.25% and 8.32%, however, approx. 26% of the observations exceeded the initial value. The situation was caused in the first place by the transaction selection mechanism, which first selected active transactions and only when the engagement limits were finished, it effected passive transactions. In the context of reducing the number of steps in individual simulations, it resulted in a lower number of passive

transactions being made, and thereby a smaller impact on the structure of liabilities, which was regulated by random transactions to a greater extent (hence the cases of exceeding the initial range value).

In the case of off-balance sheet items, which – due to the simulation model assumptions – derived from the effected active transactions, a similar (to the case of assets) model's operation was observed.

The range for the off-balance sheet items recorded a medium decrease of 48.89% (change by 0.62 p.p.), with no difference between the median and the average. Like in the case of assets, standard deviation level, which is 20.61% in respect of the average, can be described as relatively significant. An analysis of a frequency diagram (Figure C.26) indicates that in the case of over 90% of the performed simulations, the final range value of the off-balance sheet items oscillated between 0.42% and 0.87%, and it did not exceed the initial value. In practice, it means that the model has a significant impact on the reduction of the existing mismatch in respect of the off-balance items.

As can be observed, the model causes a decrease in the standard deviation of the final assets structure in respect of the target structure by an average of 82.15% (average deviation reduction by 5.11 p.p.), with the median differing from the average only by 0.01 p.p. The level of coefficient of variability, which is 20.20%, should be assessed as relatively significant. An analysis of frequency diagram indicates that in the case of over 90% of the performed simulations, the final value of standard deviation of the mismatch oscillated between 0.74% and 1.49%, which – in comparison with the initial value of 6.23% – is a very good result. In practice, it means that the model has a significant impact on the reduction of mismatch in respect of the target structure, maintaining high operation stability at the same time.

The model showed a decisively lower level of mismatch reduction in the case of liabilities, where standard deviation decreased only by 3.33% (a decrease by 0.06 p.p.), with no difference between the median and the average. A lower value was also observed in the case of the coefficient of variability, which totalled 6.59% and was three times lower than in the case of assets. In the case of over 90% of the performed simulations, the final range of liabilities oscillated between 1.54% and 1.92%, while over 30% of the observations exceeded the initial value. The reason for the situation is analogous to the one mentioned in the liabilities range analysis.

The standard deviation for the off-balance sheet items recorded a medium decrease of 55.17% (a change by 0.33 p.p.), with no difference between the median and the average. Like in the case of range measure, the level of variability coefficient, which is 20.51%, can be assessed as relatively significant. An analysis of a frequency diagram indicates that in the case of over 90% of the performed simulations, the final value of standard deviation of off-balance sheet items oscillated between 0.18% and 0.36%, and it did not exceed the initial value. It confirms the thesis that the model has a significant impact on the reduction of the existing mismatch in respect of the off-balance sheet items.

Essentially, the model should reduce the final balance sheet mismatch in respect of the target structure. On the other hand, the target structure should not exceed the engagement/concentration limits determined by the bank. It is therefore necessary to examine whether the final balance sheet structure is consistent with the limits set by the bank in order to ensure that they are not exceeded by the model's operation.

For the purposes, a mismatch measure calculated as a total of absolute differences (occurring only when limits are exceeded) between the initial or final structure and the (upper and lower) limits for the assets, liabilities and off-balance sheet items was used.

The mismatch between the balance sheet structure and the limits set by the bank in result of the model application was an average of 0.44 p.p. with no such mismatch recorded for the initial balance sheet. The difference between the median and the average was only -0.04 p.p. On the other hand, the standard deviation to the average ratio, which was 66.28%, should be

assessed as particularly significant. An analysis of a frequency diagram indicates that in the case of 95% of performed simulations, the final value of limit mismatch does not exceed the value of 0.99%, while all observations exceeded the initial value. The indicated effect is caused by an implemented mechanism generating random transactions, which cause a slight overrun of the limits set by the bank when the effected optimization transactions exhausted them. In terms of the model's operation, it is acceptable, especially that the observed overruns were not higher than 2 p.p. and the transaction selection mechanism did not continue effecting transactions with limit overrun once the limit was exceeded.

The performed simulations indicate that the model's application and implemented transaction selection mechanism (a parameter controlling the level of dynamic margin) enable an increase of the bank value (financial result) and better financial effectiveness of the bank. Naturally, it should be remembered that the effected transactions had a random character. Nonetheless, the transaction selection algorithm worked correctly, selecting transactions which reduced the difference between the initial and the target balance sheet structure, at the same time improving financial ratios of the bank. In practice, it means that regardless of real transaction parameters (other than random ones), the model will give preference to the transactions of expected characteristics and will stimulate the bank sales structures to perform expected operations. The model operational stability, proved by quite low values of dispersion measures, should also be positively assessed. It means that - despite the different transaction parameters and random selection mechanism generating random operations, in each case the model ensures an increase in bank value and improvement of bank operations effectiveness, while the values achieved during individual simulations are similar. The simulation model also reflects the real conditions of bank operation in a way which should be positively assessed in the light of our analysis of correlation between profitability/income and risk.

5. CONCLUSIONS

The conducted verification of the conceptual model of integrated optimization of a bank's value has shown that the model works in accordance with the assumptions adopted by the authors and leads to the achievement of the basic goal for which it was constructed (Koleśnik and Nadolski, 2021). The model was designed to stimulate the bank's sales structures to conclude transactions that consequently maximize its value. The model was designed for it and only it. A separate issue is whether concluding such transactions will be possible (demand and supply). A simulation is intended to demonstrate only whether the model works correctly and achieves the intended goal within certain constraints. The applied boundary conditions in the defined optimization problem, as well as their process location, not only reflect regulatory prudential requirements, but also increase flexibility of the model in the context of its implementation in banks with different organizational and competence solutions. In the algorithmic layer, they are an element that implements a compromise between the conflicting goals of various groups of bank stakeholders. It is also worth noting that with their help it is possible to adapt the model to possible future prudential requirements without the need to change the structure of the model.

The simulations carried out showed that the model increases profitability of the balance sheet while preferring transactions with a lower risk rate, which in turn leads to optimization and an increase in the value of the bank in the long term. It also effectively reduces the mismatch between the structure of the initial balance sheet and the target structure, while maintaining the limits applicable in the bank (the small excesses found were caused only by random transactions, which were exogenous to the model). The obtained results confirmed stability of its operation (small dispersion scale of observations of key financial efficiency and security indicators) and the correctness of the transaction selection mechanism, which is a key element of the entire model.

In conclusion, the model proposed by the authors is a successful attempt to integrate the risk management process and the bank's business activity based on the current solutions used in the banking activity and their creative synthesis enabling the automation of the bank management process. The inclusion of risk in the process of making decisions of an operational, managerial and, above all, strategic nature as an important criterion (equally important as the profitability criterion) allows for the optimal allocation of capital from the point of view of the sustainable nature of the business, and above all from the point of view of building a sustainable competitive advantage.

References

- Andrle, M., Tomšík, V., & Vlček, J. (2017). Banks' Adjustment to Basel III Reform: A Bank-Level Perspective for Emerging Europe. *IMF Working Paper*, 17(24), 1–23. https://doi.org/10.5089/9781475577525.001
- Balling, M., Hennessy, E., & Hochreiter, E.H. (2001). Adapting to Financial Globalisation, Routledge.
- Basel Committee on Banking Supervision. (2011). *Basel III: A global regulatory framework for more resilient banks* and banking systems. https://www.bis.org/publ/bcbs189.htm
- Committee on the Global Financial System. (2018). *Structural changes in banking after the crisis*. https://www.bis. org/publ/cgfs60.pdf
- de Larosière Group. (2009). The High Level Group on Financial Supervision in the EU de Larosiere Report. https://ec.europa.eu/economy_finance/publications/pages/publication14527_en.pdf
- Härle, P., Havas, A., Kremer, A., Rona, D., & Samandari, H. (2016). The future of bank risk management. *McKinsey Working Papers on Risk*, *1*, 1–7.
- Holland, J. (2010). Banks, knowledge and crisis: a case of knowledge and learning failure. Journal of Financial Regulation and Compliance, 18(2), 87–105. https://doi.org/10.1108/13581981011033961
- Jain, R., Nauck, F., Poppensieker, T., & White, O. (2021). Meeting the future: Dynamic risk management for uncertain Times. *McKinsey Working Papers on Risk*, 10, 1–9. https://www.mckinsey.com/capabilities/risk-and-resilience/ our-insights/meeting-the-future-dynamic-risk-management-for-uncertain-times
- Koleśnik, J. (2021). The Contagion Effect and its Mitigation in the Modern Banking System. European Research Studies Journal, XXIV(1), 1009–1024. https://doi.org/10.35808/ersj/2008
- Koleśnik, J., & Nadolski, J. (2021). Optimization of the Bank's Value in Conditions of Globalisation and Permanent Crisis. European Research Studies Journal, XXIV(3B), 118–140. https://doi.org/10.35808/ersj/2454
- Laurens, F. (2012). Basel III and prudent risk management in banking: continuing the cycle of fixing past crises. *Risk governance and control: financial markets and institutions*, 2(3), 17–22. https://doi.org/10.22495/rgcv2i3art1
- Le, T. DQ., & Ngo, T. (2020). The determinants of bank profitability: A cross-country analysis. *Central Bank Review*, 20(2), 65–73. https://doi.org/10.1016/j.cbrev.2020.04.001

Mergaerts, F., & Vennet, R.F. (2016). Business models and bank performance: A long-term perspective. Journal of Financial Stability, 22, 57–75. https://doi.org/10.1016/j.jfs.2015.12.002

- Nishiguchi, K., Kawai, H., & Sazaki, T. (1998). Capital Allocation and Bank Management Based on the Quantification of Credit Risk. *Economic Policy Review*, 4(3), 83–94. https://doi.org/10.2139/ssrn.1029625
- Oino, I. (2018). Impact of regulatory capital on European banks financial performance: A review of post global financial crisis. *Research in International Business and Finance*, 44, 309–318. https://doi.org/10.1016/j. ribaf.2017.07.099
- Paula, L.F.R. de. (2002). Expansion strategies of banks: does size matter? Nova Economia, 12, 133-146.
- Weigelt, C., & Sarkar, M. (2012). Performance implications of outsourcing for technological innovations: managing the efficiency and adaptability trade-off. *Strategic Management Journal*, 33(2), 189–216. https://doi.org/10.1002/ smj.951
- World Bank. (2020). Global Financial Development Report 2019/2020: Bank Regulation and Supervision a Decade after the Global Financial Crisis. https://openknowledge.worldbank.org/entities/ publication/71ec90e9-08f3-52be-b0be-63f136719243
- Zaleska, M., & Kondraciuk, P. (2019). Theory and practice of innovation development in the banking sector. *Financial Sciences*, 24(2), 76–87. https://doi.org/10.15611/fins.2019.2.06

APPENDICES

Appendix A – INPUT DATA

Table 1

Initial balance sheet of Bank X

Item	A sector		Profitability rate	Risk rate	
	Assets	Balance	(%)	(%)	
A01	Cash	4,143.93	-1.02	0.00	
A02	Cash at Central Bank	0.00	0.00	0.00	
A03	Receivables from financial institutions	80,275.09	0.89	1.62	
A04	Receivables from non-financial sector	125,642.53	6.64	7.23	
A041	Corporate	23,167.18	3.94	9.06	
A042	Small and medium enterprises	76,140.40	6.99	6.48	
A043	Retail	26,334.95	8.02	7.77	
A05	Receivables from governmental and self-governmental				
	institutions	20,784.17	0.97	1.47	
A06	Debt securities	53,668.91	1.38	0.00	
A07	Securities	0.00	0.00	0.00	
A08	Intangible and legal assets and tangible fixed assets	13,062.19	0.00	8.26	
A09	Other assets	2,021.98	0.00	2.16	
	TOTAL	299,598.80	3.32	3.94	
	Liabilities				
P01	Liabilities payable to the Central Bank	0.00	0.00	0.00	
P02	Liabilities payable to financial institutions	3,139.87	-0.40	0.70	
P03	Liabilities payable to non-financial sector	244,383.16	0.90	0.65	
P031	Corporate	12,071.59	0.72	1.27	
P032	Small and medium enterprises	58,764.27	0.71	1.07	
P033	Retail	173,547.30	0.98	0.46	
P04	Liabilities payable to governmental and self-governmental institutions	16,985.62	0.54	1.77	
P05	Liabilities due to financial instruments	0.00	0.00	0.00	
P06	Provisions	266.00	0.00	0.00	
P07	Subordinated liabilities	780.00	-0.46	0.00	
P08	Share capital	23,782.51	0.00	0.00	
P09	Reserves and other liabilities	8,238.72	0.00	0.00	
P10	Net profit (loss)	2,022.92	0.00	0.00	
	TOTAL	299,598.80	0.76	0.63	
	Off-balance sheet items				
Z01	Low risk items e.g. undrawn credit facilities (unconditionally				
	cancellable)	14,426.56	0.10	0.00	
Z02	Medium/low risk items e.g. undrawn credit facilities with an original maturity of up to and including one year	21,642.42	0.20	1.01	
Z03	Medium risk items e.g. undrawn credit facilities with an original maturity of more than one year	2,334.18	0.20	2.73	
Z04	Other items	7.234.23	0.50	6.61	
	TOTAL	45,637.39	0.22	1.67	

Source: Authors' calculations based on Bank X data.

Specification of transaction parameters (%)

Item	Name	Profitability rate	Risk rate	Transaction Time
A01	Cash	-1.02	0.00	4.17
A02	Cash at Central Bank	-0.57	0.00	33.33
A03	Receivables from financial institutions	0.90	1.61	66.67
A041	Corporate	3.98	9.05	100.00
A042	Small and medium enterprises	7.06	6.44	66.67
A043	Retail	8.10	7.75	33.33
A05	Receivables from governmental and self-governmental institutions	0.99	1.45	66.67
A06	Debt securities	1.48	0.00	8.33
A07	Securities	5.57	9.04	8.33
A08	Intangible and legal assets and tangible fixed assets	0.00	8.06	10.42
A09	Other assets	0.00	2.06	8.33
P01	Liabilities payable to the Central Bank	-0.30	0.00	4.17
P02	Liabilities payable to financial institutions	-0.40	0.67	50.00
P031	Corporate	0.82	1.22	4.17
P032	Small and medium enterprises	0.91	1.05	3.13
P033	Retail	1.06	0.45	2.08
P04	Liabilities payable to governmental and self-governmental institutions	0.74	1.75	6.25
P05	Liabilities due to financial instruments	-1.73	0.46	66.67
P06	Provisions	0.00	0.00	8.33
P07	Subordinated liabilities	-0.46	0.00	66.67
P08	Share capital	0.00	0.00	4.17
P09	Reserves and other liabilities	0.00	0.00	4.17
P10	Net profit (loss)	0.00	0.00	12.50
Z01	Low risk items	0.10	0.00	
Z02	Medium/low risk items	0.20	1.01	
Z03	Medium risk items	0.20	2.73	
Z04	Other items	0.50	6.61	

Source: Authors' calculations based on Bank X data.

Balance sheet	Off-balance sheet items					
items	Z01	Z02	Z03	Z04		
A03	40.00	40.00	20.00	0.00		
A041	13.33	20.00	26.67	5.00		
A042	16.67	25.00	25.00	2.00		
A043	66.67	16.67	16.67	0.00		
A05	40.00	30.00	30.00	0.00		

Effect of balance sheet items on the risk rate of off-balance sheet items (%)

Source: Authors' calculations.

Table 4

Conversion parameters for optimization transactions

Transaction	Deveryeter	Value			
type	rarameter –	Amount	Profitability rate (%)	Risk rate (%)	
A 0/1	Average	1,000	3.98	9.05	
AU41	Standard deviation	500	1.00	0.80	
4.0.42	Average	250	7.06	6.44	
AU42	Standard deviation	100	1.30	0.25	
4.0.42	Average	50	8.10	7.75	
A043	Standard deviation	15	0.50	0.20	
4.05	Average	300	0.99	1.45	
AU5	Standard deviation	50	0.10	0.05	
1.00	Average	500	1.48	0.00	
AU6	Standard deviation	200	0.05	0.00	
A 07	Average	150	5.57	9.04	
AU/	Standard deviation	50	1.00	1.00	
D021	Average	600	0.82	1.22	
P031	Standard deviation	200	0.10	0.20	
D022	Average	200	0.91	1.05	
P032	Standard deviation	50	0.15	0.25	
D 022	Average	100	1.06	0.45	
P033	Standard deviation	35	0.20	0.04	
D 04	Average	200	0.74	1.75	
ru4	Standard deviation	70	0.10	0.50	

Source: Authors' calculations.

Classification of transactions related to optimization transactions

	A06>0	A06=0	A06<0
A03>0	proportionally	A03	A03
A03 = 0	A06	proportionally	A03
A03<0	A06	A06	proportionally

Source: Authors' calculations.

Table 6

Parameters of random transactions generation

Transaction type	Average	Standard deviation
A01	0.00	100.00
A02	0.00	0.00
A03	0.00	50.00
A041	0.00	250.00
A042	0.00	80.00
A043	0.00	50.00
A05	0.00	150.00
A06	0.00	300.00
A07	0.00	0.00
A08	5.00	35.00
A09	2.50	20.00
P01	0.00	0.00
P02	-2.50	5.00
P031	0.00	100.00
P032	0.00	80.00
P033	0.00	40.00
P04	5.00	30.00
P05	0.00	0.00
P06	0.00	2.00
P07	-1.00	4.00
P08	0.50	0.20
P09	4.00	30.00
P10	0.00	0.00
FW	2.00	0.50

Source: Authors' calculations.

Engagement limits for balance sheet items (%)

Item	Name	Bottom limit	Upper limit
A01	Cash	1.00	2.00
A02	Cash at Central Bank	0.00	0.00
A03	Receivables from financial institutions	10.00	30.00
A041	Corporate	5.00	10.00
A042	Small and medium enterprises	15.00	30.00
A043	Retail	5.00	35.00
A05	Receivables from governmental and self-governmental institutions	5.00	15.00
A06	Debt securities	10.00	20.00
A07	Securities	0.00	5.00
P01	Liabilities payable to the Central Bank	0.00	0.00
P02	Liabilities payable to financial institutions	0.00	15.00
P031	Corporate	0.00	15.00
P032	Small and medium enterprises	15.00	30.00
P033	Retail	30.00	60.00
P04	Liabilities payable to governmental and self-governmental institutions	5.00	20.00
P05	Liabilities payable to the Central Bank	0.00	10.00

Source: Authors' calculations.

APPENDIX B – RESULTS OF THE MODEL VERIFICATION: TABLES

Table 1

Results of performed simulations

	On an in a halan aa	Closing balance			
Specification	Opening balance	Average	Median	Standard deviation	
Balance sheet total	299,598.80	306,365.38	306,391.98	1,779.46	
Total off-balance sheet items	45,637.39	55,117.70	55,122.54	700.70	
Net profit	2,022.92	2,349.51	2,349.49	17.82	
Income (amount)	12,339.50	14,256.68	14,256.63	108.12	
Risk (amount)	14,470.00	15,406.80	15,418.82	250.65	
Income/risk ratio	85.28%	92.55%	92.51%	0.9796%	
Income rate (D)	1.91%	2.13%	2.13%	0.0128%	
Risk rate (R)	2.24%	2.31%	2.31%	0.0350%	
Total capital ratio	13.45%	12.74%	12.72%	0.2078%	
ROE	8.51%	9.86%	9.86%	0.0748%	
ROA	0.68%	0.77%	0.77%	0.0050%	

Source: Authors' calculations.

Correlations between selected profitability and risk ratios

	Total capital ratio (TCR)	Risk rate (R)
ROE	-0.854147049	0.662126973
ROA	-0.763037971	0.879222567
Income rate (D)	-0.706471799	0.847636647

Source: Authors' calculations.

Table 3

Balance sheet structure mismatch (%)

Specification	Opening balance –	Closing balance			
Specification		Average	Median	Standard deviation	
Range ASSETS	24.61	4.70	4.69	0.90	
Range LIABILITIES	7.70	7.29	7.29	0.61	
Range OFF-BALANCE	1.27	0.65	0.65	0.13	
Standard deviation ASSETS	6.23	1.11	1.10	0.22	
Standard deviation LIABILITIES	1.80	1.74	1.73	0.11	
Standard deviation OFF-BALANCE	0.60	0.27	0.27	0.05	
Mismatch between limits	0.00	0.44	0.40	0.29	

Source: Authors' calculations.

APPENDIX C – THE MODEL VERIFICATION RESULTS: DIAGRAMS

Empirical distributions of the results of performed simulations



Figure 4



Figure 7





Source: Authors' elaboration.



Figure 5







Figure 11



Figure 3



Figure 6



Figure 9



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Selected profitability and risk ratios in the course of individual simulations









Figure 17



Source: Authors' elaboration.

Scatter plots of correlations between selected profitability and risk ratios

Figure 19







Figure 20



Figure 23



Source: Authors' elaboration.

Histograms of the results of model impact on the balance sheet structure



Source: Authors' elaboration.







Figure 29



