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Implementation of the Stress Test Methods in the Retail Portfolio

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Abstract

Article refers to the issue of credit risk management in commercial banks. Particular attention is paid to the problem of stress testing. In addition, methods are presented that allow prediction of the losses of the portfolio in the context of extreme events relating to the crises of financial markets.
The author presented the results of research based on the extreme values theory, the conditional loss distribution function and the profitability analysis of the loan portfolio. The achieved outcomes has been shown in the context of the provisions of the New Basel Capital Accord and the subsequent consultation documents published by the Basel Committee on Banking Supervision. It was shown that losses caused by the rare but still plausible events could significantly exceed the minimum capital requirements estimated in accordance with IRB method.

JEL classification numbers: C13, C16, D81, G21, G32, G33
Keywords: Credit risk, Probability of default, Stress test, Profitability

1 Introduction

The beginning of the financial crisis is conventionally dated 15 September 2008. On that day the Lehman Brother went bankrupt, which started the panic in financial markets. Dramatic fall in share prices on world markets was accompanied by a decline in liquidity in the interbank market [1]. The deteriorating economic situation left no doubt that the slow down of economic growth is coming. These and many other factors contributed to the complex situation in which many banks stood on the verge of bankruptcy. The initial

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liquidity problems of Fannie Mae or Freddie Mac proved to be only the beginning of a tide of serious financial difficulties of companies, among which should be mentioned institutions like AIG, Merrill Lunch, Goldman Sachs, Morgan Stanley, Citygroup, and Royal Bank of Scotland.

The beginning of the crisis coincided with the changes made in global banking system by the Basel Committee. Adopted in 2006 the New Basel Capital Accord [2] was designed to introduce new standards in the area of credit risk management. The basis for this approach was that banks hold capital at the level protecting them from insolvency. In fact, it was assumed that bank insolvency can occur no more frequently than once every one thousand years. The crucial step for the banks was the possibility to estimate the minimum capital requirements based on statistical models. According to the Basel Committee, the new approach was to ensure greater stability of the banking system.

Implementation of the principles of credit risk management in line with the New Capital Accord was supposed to take several years. However it was assumed that the so-called. advanced methods will be used only by largest banks, which will be able to cope with the process of implementing a comprehensive risk management system. In this framework, risk assessment process provides an individual borrower approach and also the entire portfolio analysis. Furthermore, the processes of assessment of the forecast quality (back testing) and the stress testing, were considered to be complementary, but very important. Particularly the last one is important from the perspective of the events which begun in 2008. According to the stress test analysis the banks are required to analyze the impact of extremely adverse events on its financial condition. What's more, banks are obliged to take into account the results of these forecasts in the process of estimating and allocating the value of capital.

The term of stress testing includes a series of techniques which aim to assess the impact that rare, but still probable events may have on financial institution. The results, which are a consequence of changes of one or more market factors are tested here. In particular, a stress test refers to the assessment of the dangers of unexpected financial crises.

In 2008, it turned out, that some banks are not properly prepared to overcome the difficulties caused by the financial crisis. The Basel Committee has found that many of them did not perform stress testing, and if this procedure was performed, the results were not an integral part of a comprehensive risk management system. Therefore, the Basel Committee in the consultation document published in 2009 [3] decided to include detailed rules for stress testing. It was emphasized that the stress test methods should be complementary to the classical models used in the estimation of credit risk. Thus, their results should be used during the construction of risk forecasts. In addition, banks were required to have liquidity contingency plans in case of difficulties in obtaining funding from external sources. It was emphasized that all internal procedures relating to the bank's credit risk management process should be adopted by the board of the bank in writing. In particular, it should include descriptions of the statistical models, assumptions and parameter estimation techniques.

The key issue that the Basel Committee was referred to, is the tight integration of the stress test analysis in the framework of the risk management process. Hence, special emphasis was placed for further use of the results in the process of decision making. Also, the Committee's opinion was expressed that the prerequisite for an effective risk management system is a constant search for the factors affecting the risk. Among the basic macroeconomic indicators that require constant monitoring are: inflation, gross domestic product, interest rates and unemployment rates. Attention was also drawn to the

minimum frequency of stress test analysis. Retail banks should conduct stress-testing procedures at least once a year.

Within the scientific work on stress testing, there are many papers addressed to corporate banking. Peura and Jokivuolle [4] performed a simulation where they try to estimate the value of bank capital protecting it from insolvency. For this purpose they took into account the rating migrations reflecting the risk of the borrowers. Also, Virolainen [5] dealt with corporate loans. The subject of his research was the relationship between the probability of insolvency of borrowers and macroeconomic factors. In his work the author has focused on data from the Finnish banks. Among the factors affecting the change in the level of the insolvency of borrowers he distinguished GDP, interest rates and a debt ratio of enterprises. Also the same author in cooperation with Sorge in a later work [6] presented methods which then were used based on the data from the Finnish market collected in the years 1986-2003. The example included the Finnish financial market crisis, which occurred in the mid-nineties.

Pain [7] also dealt with the issue of the impact of macroeconomic factors on accounting items reflecting the level of credit risk in the bank. The author studied the relationship between the calculated risk provisions and macroeconomic factors. The conclusions of the study were similar to those drawn by Virolainena. It turned out that the changes in GDP and interest rates may significantly affect the level of credit risk.

Also, Rosch and Scheule [8] dealt with the analysis of stress test. The authors presented an innovative approach based on the simulation of variability of model parameters. For this purpose, they used one factor model, where the value of probability of default was dependent on external variables. The authors presented results of studies conducted on the basis of data obtained from the ABA (American Bankers Association). Significant contribution to the development of stress testing methods made Longin [9]. In his work he used the concept of estimating value at risk on the background of extreme value theory. In this way the author addressed the issue of estimating the value of losses at the level of probabilities, which observation is usually not possible due to the small sample size. This approach was then developed by researchers such as Martins and Yao [10], Amin and Kat [11], and McNeil and Frey [12].

Another type of research on issues of stress test is a comprehensive analysis of the entire banking system of individual country. Among the interesting publications, we should mention the study by Boss, Krenn, Puhr and Summer [13]. They presented the SRM model (Systemic Risk Monitor), which is used to analyze the credit risk of the Austrian banking sector. Thanks to implementation of this solution, it is possible to regularly monitor financial condition of the entire banking sector. Also the research for the entire banking system were conducted by Jurca and Zeman [14]. They analyzed the impact of the economic downturn on the condition of the banking sector in Slovakia. The results of the research showed, that unfavourable consequences of a significant economic slowdown can be amortized through appropriate actions in the area of monetary policy.

The purpose of this paper is to present the issue of the stress testing in retail banks. For this purpose the author refers to a number of approaches that can be applied in the process of assessment of credit risk in the context of highly adverse events. In addition, the author presented his concept on the reports, which may be applicable in the credit risk management systems. Moreover, the relationship between potential losses arising from rare but still plausible events, and the level of losses resulting from IRB approach recommended by the Basel Committee was examined. Thus, the hypothesis was verified which assumed that a comprehensive stress test analysis system requires the descriptive

approaches using the knowledge of experts especially when adverse scenarios need to be created.
In this article, after the introduction one presented the methods that can be used in the process of stress testing. The author described an approach based on the historical scenarios, as well as the extreme values theory. The article ends with conclusions drawn in order to indicate the directions of advance of the statistical methods used in the stress testing.

2 Stress Testing - Possible Approaches

One of the possible approach to analysis of stress test is to examine the impact of crisis events observed in the past, on the current financial condition of the bank. This approach is intended to provide replying to the following question: what would happen today if there was a crisis on a scale that has already taken place? The Basel Committee recommends that this type of stress tests [15] should mention the problem of the liquidity collapse in 1987 or Black Wednesday in 1992, when the UK government was forced to withdraw sterling from the ERM (European Exchange Rate Mechanism). Among other major events that significantly affected the financial condition of the banks, it is worth to include the crisis occurred in the bond market taking place in the first quarter of 1994.
Using historical scenarios in the stress test analysis, it is worth to consider a number of other events of a crisis including:

1973 oil crisis,
1979 Soviet intervention in Afghanistan,
1989 the Nikkei index correction,
1990 German reunification,
1992 global economic slowdown,
1994 crisis in Mexico,
1997 Asian crisis
1997 collapse of Hokkaido
1998 crisis in Russia,
1998 sale of the Japanese yen,
1998 collapse of LTCM,
1999 crisis in Brazil,
2000 crisis in Argentina,
2001 attack on the WTC
2001 slowdown of the index dot-com,
2001 collapse of Enron,
2003 the war in Iraq,
2004 the decline in shares on the Italian stock exchange,
2004 terrorist attack in Madrid,
2008 the collapse of Lehman Brothers,
2008, the collapse of Bear Stearns,
2010 the crisis in Greece,
2011 earthquake in Japan.

Crises observed in recent years, carry a lot of relevant information about the severity of the risks faced by financial institutions. During the disturbances occurring on the financial markets, there are seen not only significant changes in the prices of financial instruments, but also a dramatic decrease in liquidity. Very negative effect is also a rapid

transformation of one kind of risk to another. An example of shifting of credit risk into liquidity risk could be observed in 2008. This phenomenon has its source in the dynamic growth of credit risk, which ultimately results in problems with the fulfillment of obligations. Thus, even when the bank holds equity capable to protect it from credit risk, the spike in credit risk may cause the problems with some payments, which could lead to bankruptcy.

Implementation of the scenario method can rely on of past events, as well as hypothetical scenarios. In this approach, we can distinguish the sensitivity analysis, in which only one factor is being changed. Other risk factors remain constant. The extension of this method is to simulate potential crises through a simultaneous change of many factors depicting hypothetical financial market perturbations.

Hypothetical scenarios are particularly relevant for the efficiency of risk management systems. This allows the use of expertise and brainstorm methods, which greatly expands the scope of the analyzed scenarios. The historical events approach has several limitations. In this method, we focus on a finite set of events, which may lead to an underestimation of losses. Actually it is wrong to assume that history has revealed all the worst scenarios that may take place on the financial markets.

Slightly different approach to stress test forecasts present methods that model the credit risk in the context of extreme events [16], which probability of occurrence is very low. There are two basic methods. The first one consists in analyzing the distribution of the maximum loss of the loan portfolio, while the second uses the conditional distribution function of losses, assuming that the loss exceeded the given threshold limit. Both approaches allow to estimate the expected value of losses in highly unfavorable conditions for the bank.

In the extreme value theory, we model the minimum or maximum loss determined for n independent random variables $X_1, X_2, ..., X_n$ with the same distribution function *F* [9]. Within credit risk analysis, only the maximum values are considered. Hence the following statistics is analyzed :

$$M_n = \max(X_1, X_2, ..., X_n)$$

The distribution of this statistic can be presented in the following form:

$$P(M_n \le x) = P(X_1 \le x, ..., X_n \le x) = (F(x))^n$$

Let us denote the probability of occurrence of the maximum loss below a certain threshold limit, as a result of *n* experiments, by $p^{\max}$. It is known that the value of this probability depends on the number of observations *n.* In further analysis the probability of occurrence of the loss of the individual observations below the threshold limit will be denoted by *p* and the relationship between these probabilities can be presented as:

$$p^{\max} = p^n$$

In the extreme value theory, we use the scale parameter a_n and b_n. In this way, we

normalize the variable M_n. Then the distribution of the analysed variable is as follows:

$$\lim_{n\to\infty} P\left(\frac{M_n - b_n}{a_n} \le x\right) \to G(x)$$

One of the most important conclusions of the EVT theory of (Extreme Value Theory) is a theorem about of *G* function, which can be one of the three possible forms:
Type I

$$\Phi_a(x) = \begin{cases} 0 & x \le 0 \\ \exp\{(-x)^{-a}\} & x > 0 \end{cases} \quad a > 0$$

Type II

$$\Psi_a(x) = \begin{cases} \exp\{-(-x)^{-a}\} & x \le 0 \\ 1 & x > b \end{cases} \quad a > 0$$

Type III

$$\Lambda_a(x) = \exp\{-\exp(-x)\}$$

The above distribution functions of the maximum loss depend directly on the initial distribution function of loss of the portfolio. First presented form is called the Frechet distribution function. It is characteristic for the observations comming from the fat-tailed distribution functions such as Student's t distribution. Another is the Weibull distribution function, which is obtained when extreme values come from the distribution without tail (eg. when the values below a certain threshold limit are not possible to achieve). The last type corresponds to the Gumbel distribution, which is characteristic for the observations from the thin-tailed distributions such as normal distribution function.
It is worth noting that the distribution function of extreme value where $G(x) = H((x-b)/a)$, can be represented in general form [17]:

$$H_{x;\mu,\sigma,\xi}(x) = \exp\left\{-\left(1+\xi\frac{x-\mu}{\sigma}\right)_+^{-1/\xi}\right\}$$

Where $\xi, \mu \in R$, $\sigma > 0$. If $\xi > 0$, we obtain Frechet distribution function, whereas if $\xi < 0$, we obtain the Weibull distribution. For $\xi = 0$ we obtain Gumbel distribution function.
The Basel Committee in the New Basel Capital Accord recommended a one factor model [18] as the primary modeling tool for portfolio losses in the horizon of one year. The cumulative distribution function can be presented as follows:

$$P[L \le x] = N\left(\frac{\sqrt{1-\rho}\cdot N^{-1}(x) - N^{-1}(PD)}{\sqrt{\rho}}\right)$$

Where *L* is the loss of the portfolio defined as the percentage of loans that will default within the horizon of 12 months. PD is the probability of default of individual loans in the portfolio, ρ is the borrowers asset correlation. Furthermore *N*() denotes the cumulative distribution function of the standardized normal variable, and $N^{-1}()$ is its inverse function.

Assuming that the loss of the loan portfolio at the horizon of 12 months is modeled using a one factor approach, the cumulative distribution function of the maximum loss can be presented in the following form:

$$G(x) = \exp\left\{-\exp\left(\frac{-(x-b_n)}{a_n}\right)\right\}.$$

Key elements to estimate the distribution of maximum loss are numerical sequences a_n and b_n. Their values can be determined using the following formulas [19]:

$$a_n = \inf\left\{x : 1 - F(x) \le \frac{1}{n}\right\}$$

and

$$b_n = \frac{1}{1-F(a_n)}\int_{a_n}^{\infty}(1-F(x))dx$$

where *F* is the cumulative distribution function of portfolio losses, *n* is the number of random variables which were used to estimate the maximum loss. The parameter *n* can be interpreted as a forecast horizon, within which we analyze the distribution of the extreme losses. The basic loss distribution function concerns one-year period, hence *n* is the number of years during which the extreme loss is considered.

Figure 1 presents an example illustrating the use of extreme value theory in the process of stress testing. The report was drawn up based on car loans data acquired from a financial institution operating in Poland. In the analyzed portfolio, the probability of default was 4.8%, while the borrowers asset correlation was estimated at 2.79% [20]. The upper graph in Figure 1 shows the density function of portfolio losses resulting from one factor model [18] and also its cumulative distribution function. The graph below shows two distribution functions of the maximum loss calculated for variant horizons.

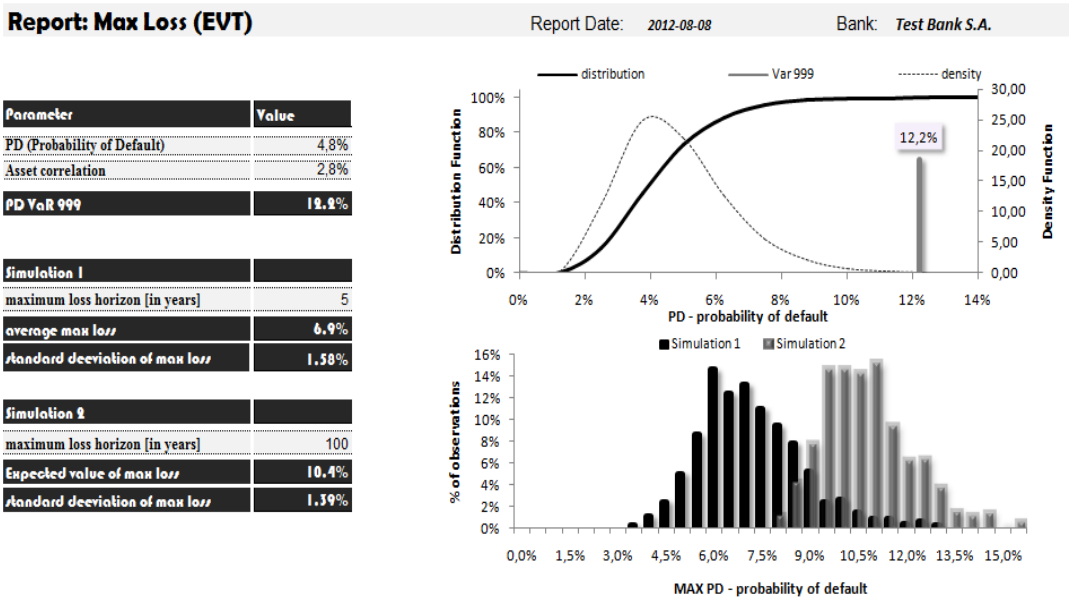

Figure 1: The results of the stress test analysis according to Extreme Value Theory. Source: author's work.

With black color were marked the results of simulation 1, which as described in the table in Figure 1, was carried out for five year horizon. Gray color represents the distribution of the maximum loss which the bank can be expected over the next one hundred years. In the first case, the expected value of loss was 6.9%, and by extending forecast horizon to 100 years, the loss increased to 10.4%. Standard deviations were estimated respectively at 1.58% and 1.39%, which shows that the higher forecast horizon we assume the standard deviation of the maximum loss is smaller. Both results indicate that the expected values of losses under adverse conditions, do not exceed VaR999 (table on figure 1). However, the estimated volatility of the maximum loss leaves no doubt that the observations of the maximum losses over VaR999 are highly probable (especially in the case when forecast horizon is 100 years). In this case, the probability of exceeding VaR999 was 17.1%.

Another approach which allows to analyse the results of extreme events is the conditional distribution function model. In this framework, the losses are examined that occur above a certain critical threshold *v*. The value of this threshold is usually taken at the level resulting from the estimation of VaR (Value at Risk). Hence, this approach enables the assessment of the scale of losses when it exceeds established in the New Basel Capital Accord threshold - VaR999.

In this approach, the distribution of losses *L*, provided that the loss exceeds the threshold value *v* [16] presents the following function F_v:

$$F_v(l) = P(L - v \le l | L > v)$$

On the basis of the cumulative distribution function *F* of the loss of the loan portfolio, it is therefore possible to present the conditional cumulative distribution function, in the following form:

$$F_v(l) = \frac{F(v+l) - F(v)}{1 - F(v)}$$

It should be emphasized that the cumulative distribution function is crucially dependent on the threshold value *v*. As we increase its value, we consider the more extreme cases in the analysis of the stress test.

Figure 2 presents report containing the results of the stress test analysis using the conditional cumulative distribution function of portfolio losses. Just as it took place in the previous example, the expected value of loss was equal to 4.8%, while the borrowers asset correlation was 2.79%. Also on the basis of one factor model, VaR999 and VaR99 were estimated at the level of 9.8% and 12.2% respectively. On this basis, one can assume that the loss of the portfolio should not exceed 9.8% more often than once every 100 years, while 12.2% threshold may be exceeded not more often than once every 1000 years.

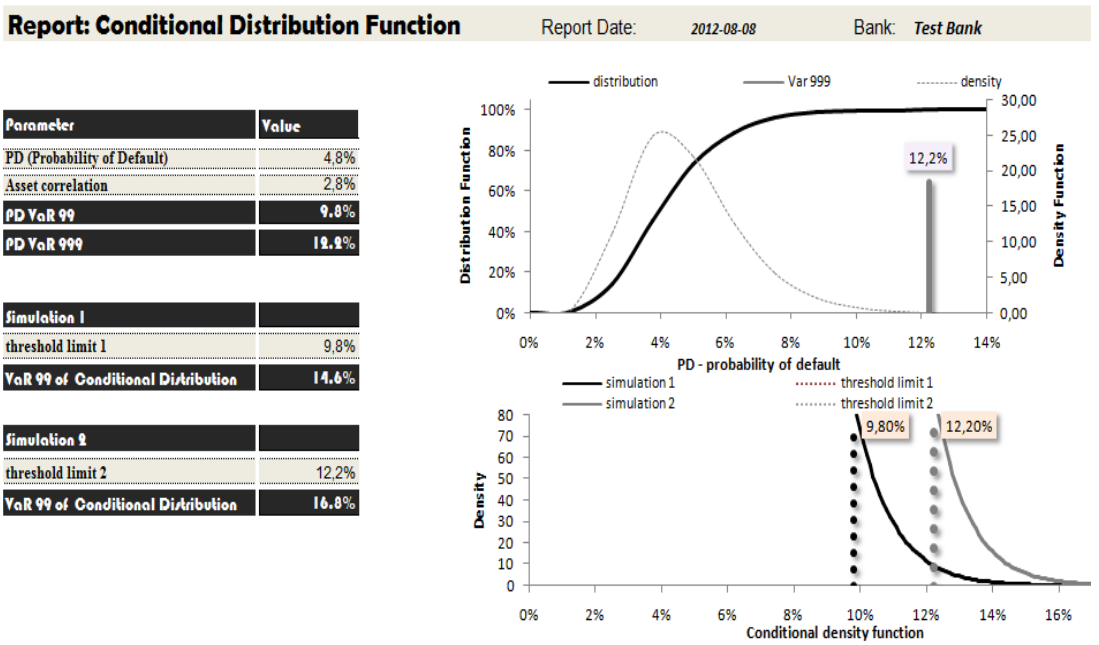

Figure 2: The results of the stress test analysis - the conditional distribution function approach.

Source: author's work.

Figure 2 shows the report presenting the results of two simulations addressing a critical value (threshold limit). These parameters indicate a threshold level of risk above which the conditional cumulative distribution function of portfolio losses is analyzed. The first simulation refers to the case when the loss is calculated when it exceeds the VaR99. On the basis of a conditional distribution function it was calculated that when the loss exceeds 9.8%, then we can expect with probability 95%, that it will not be higher than 14.6%. The second simulation examines the conditional cumulative distribution function of losses in case when loss goes beyond the level equal to VaR999. In this case, the

probability of higher losses than 16.8%, is only 5%. Critical thresholds included in the analyzed scenarios can be interpreted as realizations of potential crises of varying severity. Higher threshold value implies more extreme financial market shock. It is worth noting that the results obtained in both simulations exceed the value of VaR999 that is the basis for the minimum capital requirements in line with the New Capital Accord. Therefore, having regard to the stress test analysis, the bank should consider the possibility of incurring additional losses.

An alternative approach to the problem of stress testing reveal methods which use portfolio profitability analysis. Under this concept, the loan portfolio is treated as a debt instrument. So its internal rate of return it possible to determine. The profitability of the loan portfolio estimated in this way, allows to specify not only the future profits or losses, but also allows to determine the risk appetite which for the bank is the maximum acceptable level of credit risk.

By including the costs of funding in profitability analysis, we are able to estimate the effective margin, which the bank earns on the loan portfolio. In order to determine the margin, cash flows related to the loan portfolio have to be divided into two groups [21]. One of them is associated with portfolio represented in the balance sheet as an asset, while the second refers to its funding (liabilities).

Estimation of internal rate of return for a particular loan portfolio is carried out based on of all real cash flows [21]. The value of IRR (Internal Rate of Return) [16] of loan with *n* installments can be determined by finding the roots of the polynomial of *n*-th degree, which requires numerical algorithms. Monthly IRR can be calculated using the following equation:

$$X_0 = \frac{F_1}{(1+IRR)^1} + \frac{F_2}{(1+IRR)^2} + \ldots + \frac{F_n}{(1+IRR)^n}$$

where

X_0 - value of cash flows at the time of loan granting,

n- number of installments,

F_t - net value of cash flows at time *t*,

Cash flow at time zero is determined by the equation:

$$X_0 = Y - c + o$$

where:

c-sum of the net commissions and insurance premiums,

Y - The initial value of the loan,

o - operating costs,

Cash flows in subsequent periods are risk-adjusted nominal values of the schedule installments :

$$F_t = X_t - X_{kor,t}$$

The variable $X_{kor,t}$ is an adjustment of installment X_t arising from unpaid part of the principal as a result of credit risk, as well as the lack of due interest. The value of $X_{kor,t}$ is calculated based on the following equation:

$$X_{kor,t} = \begin{cases} l \cdot Y \dfrac{1}{\sum_{j=k+1}^{n} \dfrac{1}{(1+i_{nom})^j}} & t > k \\ 0 & t \le k \end{cases} \quad \text{for}$$

where:
l - final loss (credit risk measured as the ratio of irrecoverable capital and the initial value of loan),
k - the average time when the insolvency appears,
i_{nom} - nominal interest rate of loan,
X_t - installment in period t (t = 1,..., n).

Analogous estimates of the internal rate of return of cash flows related to funding must be carried out using the following equation:

$$IRR_P = (1-w) \cdot i_{ref} + w \cdot i_{kw} + \left(\frac{1}{1-res} - 1 \right) \cdot (i_{ref} - i_r \cdot (1-p))$$

where:
w - percentage of equity in total funding,
i_{kw} - cost of equity,
i_{ref} - interest rate of deposits,
res - the obligatory reserve ratio,
i_r - interest rate of obligatory reserves (0.9 of rediscount rate),
p - the rate of funds transferred to the EU Guarantee Fund (estimated on the basis of interest on obligatory reserve).

Based on the portfolio profitability approach, the value of the effective margin is calculated as the difference between the internal rate of return of loan portfolio and the funding liabilities. Thus, the effective margin is given by

$$EM = IRR_A - IRR_P$$

where:
EM - portfolio effective margin,
IRR_A - Internal rate of return of the loan portfolio,
IRR_P - Internal rate of return of funding liabilities.

Effective margin of the portfolio allows the assessment of its profitability in comparison to other instruments that are in the bank balance sheet. Moreover, it is handy tool in the process of stress testing. Profitability model takes into account such variables as average life expectancy of loans, the effect of early repayments causing reduction of the loan life, loan interest rate, credit risk, the cost of equity and many other factors. Hence the presented model can be used in the simulation of highly unfavorable events. Scenarios can be created both with respect to historical, as well as hypothetical changes in these factors. Another solution is to estimate the multivariate distribution function of risk factors, and then use its shape to specify extreme values characterizing usually the

financial crises.

Figure 3 presents the results of profitability analysis of the car loans portfolio as well as values of used parameters. The simulation was performed for a loan portfolio worth 30 mln EUR. The average nominal length of loans life expressed in months, was adopted at 60 months. Furthermore, it was assumed that due to the effect of early repayment, the effective average loan schedule will be reduced by 20%. Nominal interest rate of loans was 13.1% per year. In the area related to the commission, it was assumed that the average bank commission is 3%, of which one percent is paid to the financial intermediary who sells the loans. In addition, the financial intermediary is entitled to add their own commission by increasing the gross value of loan up to 4%, which is a negative flow for bank at the moment when the loan is granted. In the bank portfolio all loans are insured in case of death of the borrower and the fee is 2% of its value. Part of this fee (0,8% of the gross value of loan) is transferred to the the insurance company as its remuneration.

Due to the fact that banking activities are associated with many fixed costs, in the profitability analysis were assumed wage costs, depreciation costs and other costs amounting to 3%, 4% and 4% respectively. Another significant cost to the bank is credit risk. Based on the bank experience, it was assumed that 6% of the initial loans value will not be recovered. Furthermore, it was assumed that credit risk appears on average at around 20 th installment.

In order to determine the costs of funding, it was assumed that the equity is the source of 10% of the total financing. Due to the specific structure of equity in the considered bank, the cost of equity was set to zero. The most significant element of costs is the average interest rate of deposits, which was assumed at 5.5%. The additional cost for a bank is the obligatory reserve which has to be deposited at the central bank (2% of all deposits).

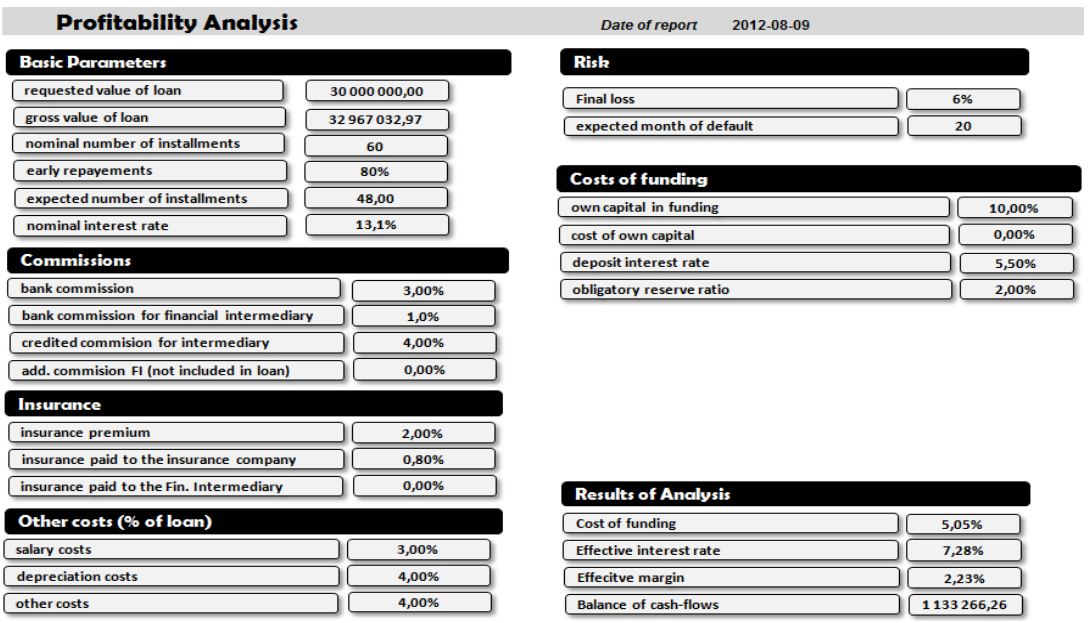

Figure 3: The results of the profitability analysis of the loan portfolio.
Source: author's work

On the basis of made assumptions, the bank cost of funding was estimated at the level of 5.05%, while the effective interest rate of the loan portfolio was 7.28%. The difference between these values is the effective margin, which in this case is 2.23%. This result should be interpreted as the average annual return of the assets obtained by bank during the entire life of the portfolio. A positive value indicates that the bank will generate profit, which in total will be equal to 1 133 233 EUR.
In order to perform stress test analysis, it is necessary to change the parameters affecting the profitability of the loan portfolio, which simulates a potential financial crisis. Table 1 shows the obtained results based on the changing of credit risk understood as a final loss.

Table 1: The results of the stress test analysis profitability approach.

		Final	Loss	
	6%	7%	8%	9.85%
Cost of funding	5.1%	5.1%	5.1%	5.1%
Effecitve interest rate	7.3%	6.7%	6.1%	5.1%
Effecitve margin	2.2%	1.7%	1.1%	0.0%
Balance of cash-flows	1 133 266	763 283	393 300	0

Source: author's work.

The simulation involved increase in the credit risk from the expected level of 6% to levels amounting to 7%, 8% and 9.85%. As it was expected, the value of the effective margin decreases with increasing risk. Similarly, the total amount of net cash flows generated by the loan portfolio is being reduced. For the bank particularly important is the value of risk threshold at which the bank stops generating positive sum of cash flows. The increase in risk above this value means incurring losses and the consequent reduction of bank capital. In the analyzed example due to the increase of final loss by 3.83 percentage points, the mentioned limit was reached. Thus, by examining the sensitivity of the portfolio profitability, the bank's positive financial result threshold was estimated at 9.85% of final loss. Obtained risk threshold seems to be much higher than expected level and consequently quite safe. However in the context of unfavorable but still plausible events, this value can be quickly reached and become a real threat.

3 Conclusions

The present paper addresses the issue of stress testing of bank loans portfolio. Currently the problem of maintaining an adequate level of liquidity, it is the most important challenge facing the global financial system in the opinion of the Basel Committee. The ability to determine the consequences of crises increases the stability of the banking system affecting the global economy. The guiding objective of the Basel Committee is to create such standards, the banks could cope with temporary perturbations of the financial markets without the need of support of public funds.
Stress testing methods presented in the article are essentially a development of the methods used in other research areas. It should be emphasized that approaches focusing on the modeling of rare events have also disadvantages. Most of them is based on the historical data that are used to estimate the parameters. Limited set of historical

observation raises legitimate concerns about underestimation of potential risks. We should not assume that all possible negative scenarios have already been realized. Therefore, the spectrum of methods used in the process of stress testing should be extended to approaches based on hypothetical scenarios. Creating a unique combination of macroeconomic variables on the basis of expertise, can enhance our understanding of the scale of a future crises.

Undoubtedly on the ground of stress testing, the profitability analysis of loan portfolio is very important from a practical point of view. The distribution of portfolio losses does not reflect the a complete picture of the economic situation of the bank. The knowledge about the losses is of course extremely important, but ultimately is only one element of the puzzle. The bank manager standing in front of the problem of decision making should take into account both cost and revenue aspects. Therefore, it is important to develop the area of statistical models that allow assessment of the financial condition of banks in a more comprehensive manner.

The results of the study indicate that the process of calculating the credit risk limited only to estimating minimum capital requirements is highly inadequate. By simulation of crisis events it was shown that the excess of VaR999 barrier that protects the banks from insolvency, it is quite likely. These results should encourage the authorities of many banks to implement the stress tests methods. Moreover, it is necessary to continuously monitor risk in the context of adverse events.

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