Stress testing as a tool for simulating the effects of crisis in banks

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Emergence of crisis in financial markets, especially banks, have forced a change in approach to risk management. It has become necessary to develop new or refine existing models of early bankruptcy threat warning, as well as establishing the potential impact of bank failures. One of the tools, indicating that resistance to the phenomenon of crisis is "stress testing". Its aim, at least in the case of banks, is concerned with estimating the level of economic resistance towards the occurring risk. Some of these risks are: the non-payment of loans due to deterioration in the economic situation of a country, fluctuations in interest rates, exchange rates and a fall in prices of securities which are traded on stock exchanges. This article discusses the nature of stress testing and shows the current legislation in Poland and presents the results of a stress testing conducted on the largest U.S. banks in May 2009. The rank and results of these studies show the importance of the role of stress testing as a complementary research of a diagnostic and prognostic nature.

Introduction

Risk is inherent in any business, including banking, which aims at managing money entrusted by depositors. The effectiveness of this management requires profitable and safe transfer of money between the donors and recipients. Profitability of banks' activities should be associated with the expectations of its owners, and banks' safety with expectation of depositors.

The events associated with the last global financial crisis show that in terms of economic downturn, owners and managers of banks assign the profits to themselves only, explaining the success by means of their ability to anticipate and the excellent management of skills as well as general financial operations, not to mention the impact of favorable and beneficial environment, and even sometimes the bankers present themselves as creators of the economic downturn. In crisis, these same owners and same boards of banks claim to be equally brilliant, but in their view, only adverse ambient conditions are to be blamed for the financial crisis, which gives the bankers the right to expect help from the outside, while holding in his hands the weapon in the form of deposits from millions of customers who do not have an equivalent amount to cover the loss of their assets, which in the end serves as an effective instrument for blackmail and extortion inflow of capital from the state budget.

Even though the Polish banking system had not yet been affected by the crisis, as was the case of Baltic countries and Iceland, a common saying was established about "privatization of profits and nationalization of losses in banks". Behaviors of banks around the world are in fact the same as noted by De Soto from the University of Juan Carlos in Madrid who stated that "banking is based on the partial reserve in the form of deposits" (De Soto, 2009), which confirms the earlier conclusion about the superiority of the safety over the risky business, which is not necessarily related to the real economy .

Risk is un uncertainty which can be measured (Knight, 1921). Ex post assessment is however only a statement of the already known fact and gives a picture of what has already happened. Modern, reliable and well-managed bank is the one which is not only capable of assessing the existing threats, but which is also aware of the size of the risk involved and which is able to assess whether this risk is acceptable or rather the expected level of security has been exceeded. The concept of acceptable risk is to be understood as the one in which the selling money does not endanger the viability of the safety deposit maneuverability. Stress testing is one of the effective ways to use research in the management of banking risks. It is in fact a mandatory tool for the implementation of banking systems in Capital Requirements Directive (CRD), also known as Basel II.

One of the shortcomings of modern banking seems to be its major "theoretical" nature, namely the application of increasingly sophisticated mathematical models, as a result of ever-increasing complexity of financial operations. Although these models take into account the large number of variables and are often based on the results of statistical analysis, the economic reality is unpredictable and the results of the forecasts are correct to a degree of a relative stability. These algorithms fail in extreme situations; hence it is necessary to obtain a simple identification of key risks, their scale and impact, and in banking, linking these effects with the capital requirements.

For example, the structure of financing of Polish banks shows (KNF, 2009) that the owners finance 10.3% of their activities through equity while the rest of the funding is allocated to depositors in (84.5%) and other to creditors (5.2%). On a practical level, such funding structure means that the owners with a negligible share of ownership may undertake risky investment decisions (such as lending) as in relation to the adopted by the bank deposits, bearing little of the financial responsibility. This situation, although typical for companies, needs proper risk management.

This article presents the theoretical basis of stress testing, supervisory recommendations related to the Polish banking system, and the results of stress testing, carried out in May 2009 in nineteen largest U.S. banks.

The concept of stress testing and the reasoning behind it

Jones et al. (2004) define stress testing as a series of analytical techniques, which measure the sensitivity of the "system" of financial institutions on risk factors. The term "system" is understood most commonly as a balance, and the stress-testing refers the various risk factors, such as price (impairment), which causes certain economic consequences. Stress testing is a tool that allows to estimate sensitivity towards the changes of examined economic categories and it allows the interpretation of these changes but it does not give answers to the likelihood of the phenomenon, even though such tests may include sources that cause a shock.

In its simplest form, stress testing is a way of revaluation of the assets portfolio and / or liability with the adoption of a specific set of variables serving to enable to learn bank's sensitivity, and therefore also immunity of the "system" with respect to risk changes. What is important is to make the shock changes conducted occur in reality. As a reliable test results are not those which have been designated for unreal variables. It should also be noted that the testing process cannot be reduced solely to the application of specific mathematical formulas. Stress testing is a broader concept because it also includes the selection and analysis of the variables that determine the output parameter.

In this study, the notion of risk is understood as a threat, and its existence has a negative effect on the "system" of banks, in particular the financial outcome which charges directly equity, and hence the value assigned to the owners. Such an assumption should be regarded as legitimate, because the owners are responsible for the nature and scale of the risk undertaken by the bank. But regardless of whether the source of risk is the environment (for example, a crisis), whether this is due to bad decisions of the owners, the negative effects of should not charge depositors and other creditors of the bank (e.g. payroll liabilities, tax, customs, insurance and other liabilities). This means that the equity of banks should be sufficiently high to protect deposits and other liabilities of a possible inability to pay. This follows from the fact that banks are institutions of public trust believed to be given a special supervision and special rules. In such circumstances it is difficult to overestimate the policy and the role of supervisors, because the rules formed by the surveillance will depend on whether the banks' future losses will be subject to the "nationalization", or rather they will be covered by the capitals of the owners.

The significance of these assumptions was presented in Figure 1. The situation "I" represents a bank's balance sheet, whose assets consist of five main components: cash, bonds, stocks, credits and fixed assets, while liabilities consist of three groups: deposits, other liabilities and equity. Suppose that a variable exposed to the risk of loss will involve loans only, while stocks, bonds and cash are not threatened by this phenomenon. In addition, no decline of deposits and other liabilities is assumed.

Supposing that some borrowers do not make credit payment (position "II"), and the reason for these conditions is an economic crisis which has caused job losses of the borrowers. In these circumstances, the bank is obliged to create provisions for outstanding claims, which will charge financial results and reduce the amount of loans. Total assets will therefore also be reduced.

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FIGURE 1. THE ESSENCE OF STRESS TESTING IN THE INVESTIGATION OF CREDIT RISK
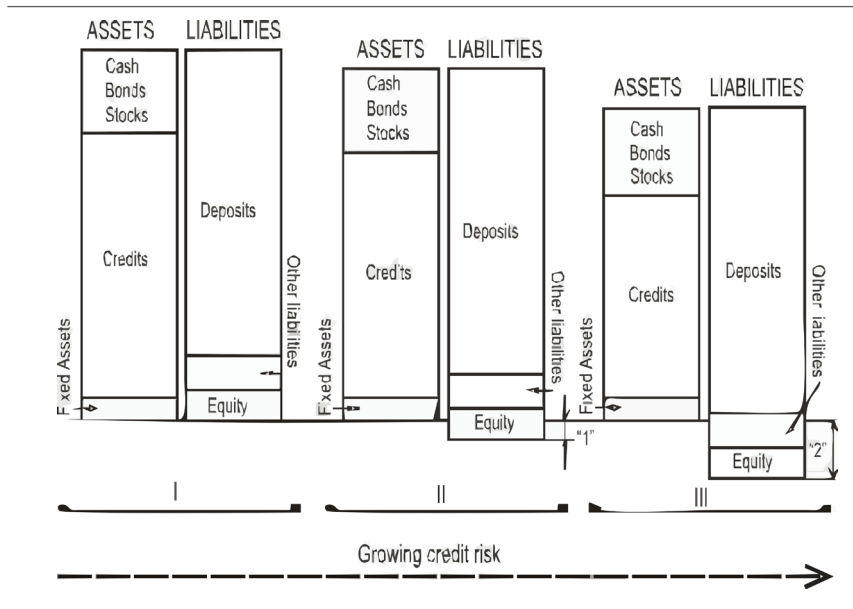
Source: own.

State of deposits and other obligations, however, will not change! This is due to two reasons. First, the banks are very reluctant to inform about their failures, and if this fact already does happen, such information is delivered very late. Second, depositors, who are both entrepreneurs and budget units, and above all, the society, expect a timely payment of the amounts deposited, while the creditors, including the banks employees, expect to be paid on time. In this case, the role of stress-testing is to set a scenario in which the losses which emerged from the non-repaid loans are absorbed by shareholders' equity.

Option "II" presents a situation where equity has not yet been completely "consumed" by the loss ("1") caused by unpaid loans. It is important in this situation is the proper monitoring of the loan portfolio, especially in the classification of the different risk-weighted credit exposures. This would have a direct impact on the solvency ratio, a minimum amount of which is 8%, and a decrease of the ratio below the threshold mentioned causes the existence of the following three cases:

1. Support for banking supervision or the government, designed to recapitalize the bank under risk;

2. Overtaking of the affected bank by another bank, which is also connected to the disbursement of money by the government but to the transferee bank;

3. Bankruptcy of the bank.

In Polish conditions, the decision about each of the above mentioned scenarios is taken by banking supervision. The first two scenarios occur when the loss still leaves a chance for bank to repair effectively. The third case, indicated in the figure as a variant III deals with a situation in which losses exceed the value of bank equity, and hence the solvency coefficient is negative. In such circumstances, a bank's assets do not cover the deposits and liabilities. In other words, the bank does not have sufficient amount of money to pay depositors and other creditors. Polish Financial Supervision Authority in the large scale of this shortfall may decide to turn such a financial institution into receivership. The bank's role in the of deposits is taken by Guarantee Fund, while other creditors are satisfied under the provisions of bankruptcy law. In Poland, the guaranteed amount of deposits now stands at 50 000 Euros, so those depositors who invest a higher amount in the bank should consider the possibility of losing their part of their money.

The role of stress testing for the case discussed here will be concerned with establishing such credit loss boarder for capital so that adequacy ratio was not below 8%. Of course, stress testing does refer to stimulating a one value for the resulting single variable. In practice, the test is also resistance to the loss of the bank's liquidity, profitability, and failure to achieve other projected indicators, depending on the variables such as stock prices fall, bond, currency fluctuations, fluctuations in

interest rates, changes in market value credit insurance or the above-described negative trend is in the loan portfolio. Macro-economic phenomena are also examined. Those involve inflation, unemployment rate and gross domestic product. Only the results of the analysis of many variables affecting the situation of a bank can give information about its actual resistance to extreme danger.

Legal regulations in Poland and the conditions for the use of stress tests

The carrying out of stress testing may be considered in two categories: internal suitability for the financial institution and in the process of supervision. The first category is mainly aimed at improving the management of the bank and should be treated as an important element of corporate governance behavior. This contributes to the understanding of potential risk by the bank, to develop strategies for reducing the risk and to assess the capital adequacy properly. The second category refers to an external audit carried out by banking supervision.

In March of 2007 the Committee of Banking Supervision has implemented into the Polish law decisions of the Capital Requirements Directive (CRD), and then after amendment and adjustment of supervisory authorities, the Financial Supervision Commission in December 2008 updated the previously issued statements (UKNF, 2008). Stress testing in the domain of capital adequacy serves to forecast the impact of extremely negative chains of events that shape the solvency ratio. According to the recommendations of the supervisors (GINB, 2005), the extent of shock changes should include:

- extremely adverse but still real conditions;

- bank's individual "appetite" for the risk;

- at least one complete economic cycle, for a particular sector economic sector.

There is no doubt about the necessity of testing of negative input parameters for establishing bank's condition. However, it is difficult to understand the concept of "risk appetite", and in the event of no clear definition of the forecasted period, banks can develop stress tests only to meet the formal requirements, assuming short time horizons. Regarding the "risk appetite" banks, being institutions of risk, will always seek to maximize the risk, because these quantities are closely correlated. This implies a clear definition of both the level of "risk appetite" and the forecasting period. It seems that the sensible approach would be to adopt the solvency ratio as a measure of "risk appetite", while the level of co-factor for testing purposes should be higher than the minimum required by law, for example 10%. The remaining 2% the size of the threshold would be a kind of "safety valve", allowing banks to more easily survive the crisis, and central government to spend lower amounts of money on rescuing private financial institutions.

The above mentioned issue also draws attention of Basel Committee on Banking Supervision, which in May 2009 published "Principles for sound stress testing practices and supervision" which set guidelines for proper management of banks, using the stress testing. This was also the Basel Committee's answer to questions directed by banks and supervisors, about whether existing practices under stress testing are sufficient to prevent the loss of financial stability. In assessing the Basel Committee, the current financial crisis exposed the inadequacy of previously used tests of stress, especially in the regulatory area. Banks apply stress tests on a routine basis and in isolation from the real business profile. This resulted in a situation when the outcome of the analyses were not reliable and did not indicate a real threat coming from different risk categories.

Apart from legislations relating to the implementation of the provisions of the Capital Requirements Directive, the Polish banks are required to comply with recommendations issued by the Financial Supervision Commission (formerly Banking Supervision Commission). Issues related to the stress test are addressed in Recommendation "G" and Recommendation "S (II)". The first concerns the interest rate risk management in banks and the model adopted there introduces the necessity of "standard stress test". However, this model dates back to 2002 and requires a updating. Recommendation S (II) was adopted by the Financial Supervision Commission on 17th December 2008 and relates to credit exposures secured by mortgages. This document recommends the use of stress tests to determine the internal limits, including economic cycles, real estate market, fluctuations in interest rates and exchange rate, and also it requires banks to composing an annual (at least) report of the impact of credit exposures secured by mortgages on the situation of the bank when assuming the decline of the zloty against other currencies by 30% and assuming changes in interest rates by 400 basis points. Furthermore, Recommendation S (II) requires banks to take into account the impact of changes in the real estate market on the situation of the bank, when stress testing (Wiszniowski, 2009).

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A fundamental problem associated with banks stress tests was basing the data source on historical data. Adoption of this assumption, especially if its base is a short time horizon which involves the period a boom, will result in a strong correlation of the historical events with the future. Such a model is burdened with a mistake, because just as during the boom period positive events cumulate, in times of crisis, negative phenomena overlap. Assumptions for stress testing cannot assume subjective and short-term trends, based on once good and once a bad times. Banks should therefore seek new approaches to identify potential threats, as well as links (correlations) of specific risks with each other, as well as determine the timing of ongoing and forecasted research, including estimating possible outcomes and results of the analyzed phenomena.

Principles of stress tests modelling

While building up tools, which serve to test the bank's resistance on the shock changes environment, one should consider a few basic conditions which will help a particular financial institution. It should be noted that although the banks operate on a similar basis, the differences between them can be considerable. As a result, depending on the institution, different emphasis on parameters is needed when conducting economic analyses. These are primarily the differences in the size of banks (for example the size of capital), the geographical area of operation, international activities of the bank as well as its activities on capital markets. From the viewpoint of the examination and presentation of analysis, stress tests can be divided into two groups: sensitivity tests and scenarios testing (Figure 2).

FIGURE 2. THE BASIC CRITERIA FOR THE CONDUCT OF STRESS TESTING
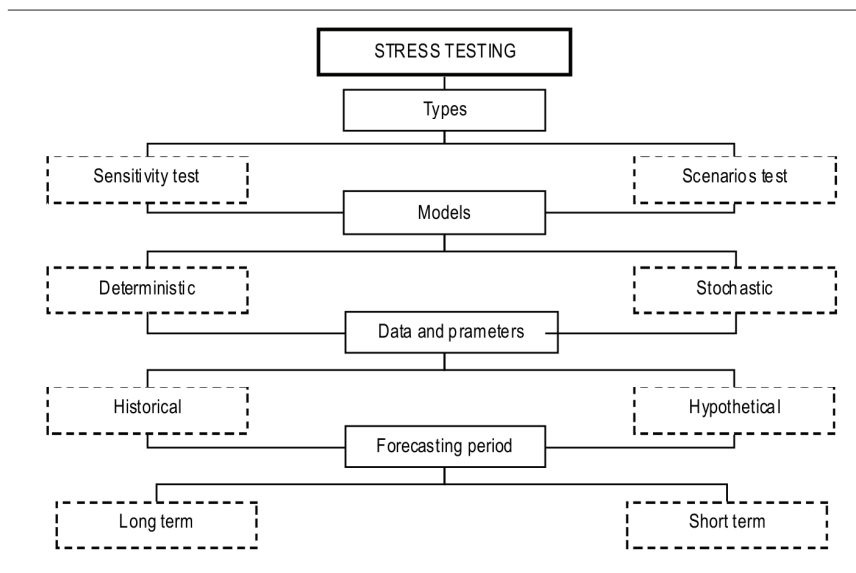
Source: own study based on (Basel Committee, 2009).

Sensitivity test assesses the impact of one or more risk variables on the financial situation of a bank. An example of this was presented earlier in Figure 1. Scenarios tests are characterized by a more complicated structure and include a simulation of several variables at the same time, while such an analysis is more valuable than the previous one, because it takes into account the possible inverse correlation between the impacts of individual risks. For example, increased bank lending increases its profitability, but it also increases liquidity risk and credit risk.

Both the scenarios test and sensitivity test may be subject to the same mathematical model, which generally can be divided into two types: deterministic models and stochastic models (O'Brien, 2009). Deterministic models allow an analysis without taking into account the probabilities of events that shape the score size. Their main advantage is primarily comprehension, reliability of the results and the fact that they provide clear answers to the problems in certain conditions. The main disadvantage is the generation of a large number of scenarios, which may create the impression of information chaos.

On the other hand, stochastic models are more sophisticated, are they take into account the likelihood of occurrence of certain risk factors. It is assumed that these factors are random variation based on the assumed degradation. One of the more frequently used simulations in the stochastic approach is the Monte Carlo method (Chylinski, 1999). The most important advantage of stochastic methods is to take into account the interaction between individual risks, which are affected by the results of the analysis of low error. The disadvantages should include the need for long lasting analysis and work, resulting from the need to consider many variables, individuality of application of specific models, the difficulties in understanding formulas and detailed assumptions and the need to apply advanced mathematical methods, long-term research and higher cost as compared to deterministic methods.

A very important factor is to determine the amount and consequently the reliability of the shock parameters. Determinations of most of these parameters are done through historical analysis of examined variables. The extreme volume in this case can be the most unfavorable volume recorded, but it should take into account the period of its occurrence and to find its justification in the current economic realities. For example, in Poland in 1992, the lombard credit rate in the Central Bank was 37%, and in February 1998, 27%. Reference to the interest rates of this period or assuming these values in the analysis made for example for the current year 2010, would mean simply testing of absurd data.

Another way to determine the limits is a hypothetical scenario, which does not refer to past events but is based on the structure of the shock variables, which have not yet occurred in reality. Such an assumption seems to be more flexible, however due to its relation to the events which did not appear, it seems impossible to assess the likelihood of emergence of the risk factor. Another element that should be taken into account in the determination of stress testing is the time horizon covered by the study. It seems that to obtain reliable data, it is necessary to carry out the stress testing for short-term forecasts (for example, up to 1 year) and long-term (i.e. 1 to 5 years). With all certainty, the criteria presented in Figure 2 do not cover all issues. They only the main factors and methods to be taken into account when using stress tests.

Stress testing, and Value at Risk (VaR)

Stress testing is an analysis whose purpose is to conduct studies on the most adverse but likely conditions. This is a complementary tool used in banking and it does not replace or eliminate the other research method. Stress testing is not to be associated with, for example, Value at Risk (VaR), which is used to estimate market risk, understood as a loss on a portfolio of financial instruments due to a change in price parameters, assuming that the probability of achieving or exceeding the losses in a given time interval is equal to the adopted level of tolerance. Mathematical dependence of VaR is described using the following model:

$$P(W \leq W_0 - VaR) = \alpha$$

where:
P - probability of incident,
W_0 - variable at the beginning of the period,
W - value of the variable at the end of the period,
a - coefficient of tolerance (1 - α) - confidence interval.

This dependence is shown graphically in Figure 3 and it can be interpreted as follows: with probability equal to the adopted level of tolerance of 1%, which corresponds to an adopted confidence interval of $a = 99\%$, then the value of the variable at the end of the period (W) will be less than or equal to the present value (W_0) minus the *VaR*.

Analysis of risk is the appointment of the maximum loss that a bank may be exposed at a given time for a pre-determined probability. This assumption implies that when the tolerance is decreasing, the bank's losses will be higher. Polish regulations require that the probability is 99% (tolerance 1%). To build up the VaR model is necessary to use historical data concerned with the types of loss, their height and correlation with other parameters. Value at risk should therefore be used where there is a possibility of conducting surveys, particularly along with the planned allocation of the portfolio, or retrospectively to assess the bank's activities. Usefulness of VaR is also high in predicting the limits of such credit.

Stress testing analysis fills a gap, which arises when considering the value of the risk, since it refers to extreme events, which occur very rarely, if at all, making it impossible to conduct the analysis based on statistical material.

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FIGURE 3. GRAPHICAL PRESENTATION OF THE VAR
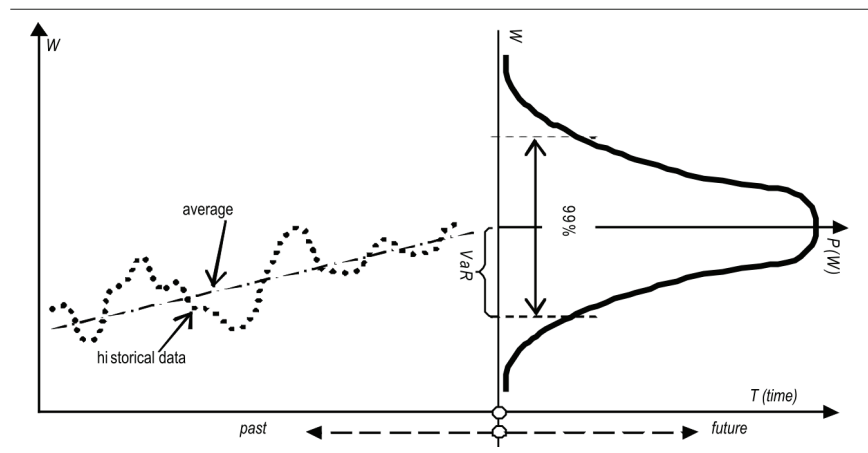
Source: own

The financial crisis versus stress testing

Cognitive value, resulting from the use of stress testing can not be overestimated, particularly during the financial crisis, because one can at least approximately assess the size of possible future losses based on the variables determining the negative developments and estimating the duration of the financial collapse.

On 7 May 2009 the results of stress testing for the 19 largest American banks were published. Objective of the study was to determine whether in the event of deterioration of the economic situation overseas, banks will need further strengthening of the capital, and if so, what would be the amount. The results of these studies were presented in tables 1 and it is can clearly be seen from them that the 19 largest financial institutions will require approximately 75 billion USD recapitalization, of which 10 banks will need 70 billion USD.

TABLE 1. PRELIMINARY ESTIMATES OF SELECTED BANKS IN MAY 2009, IN THE EVENT
OF EXTREMELY NEGATIVE SCENARIO (BLN. USD)

Bank	Recapitalization in May, 2009	Estimated losses	Recapitalization needed
JP Morgan Case	136.2	97.4	
Citigroup	118.8	104.7	5.5
Bank of America	173.2	136.3	33.9
Wells Fargo	86.4	86.1	13.7
Goldman Sachs	55.9	17.8	
Morgan Stanley	47.2	19.7	1.8
GMAC	17.4	9.2	11.5
American Express	10.1	11.2	
Fifth Third Bancorp	11.9	9.1	1.1
Regions Financial	12.1	9.2	2.5
Total (position 1-10)	669.2	501.0	70.0
Total	836.7	599.2	74.6

Source: http://money.cnn.com (07.05.2009).

The concept of recapitalization should be understood primarily as an increase in the capital al by means of issuing new shares. The authors note that during the period of prosperity, issue and sale of new shares of banks is not a problem, but in times of crisis, big buyers of holdings are unlikely to be interested in shares due to the questionable liquidity of such securities, as well as their possible depreciation . Table 1 shows that the volume is not so much about the magnitude of the risk, because this is enormous, but the necessary amounts which banks should secure so that in case of

an extreme situation they do not show insolvency. These figures also provide a false or rather a fat too optimistic forecasts of the input variables use in stress testing in previous periods, because the size of the losses projected in May 2009 far exceeded the losses previously disclosed and covered.

When analyzing the values in Table 1, it is also worth noting that the ratio of the amount required for recapitalization of banks (74.6 billion USD) compared to the estimated future loss (599.2 billion USD) arose mainly as a result of reserve write-downs for assets, is 12.4%. This means that when making this report, the analyzed solvency of banks might have been lower than the officially presented. Supposing that U.S. banks are striving to maintain the solvency ratio at 8%, and disclosed losses that may occur in the future are concerned solely with the risk of weight-bearing loans equal to 100%, the amount of capital injection (recapitalization) would be: 8% * 599.2 million USD = 47.9 billion USD. Potential loss of over 599 billion USD has been designated for stress testing based on an analysis of possible non-repayment obligations by the debtors to the banks and their basic groups are listed below:

TABLE 2. THE STRUCTURE OF THE POTENTIAL LOSSES AT U.S. BANKS ON 7TH MAY 2009

Listing	Potential loss (billion USD)	Structure
Commercial real estate	53	9%
Commercial loans	60	10%
Credit card loans	82	14%
Securities	35	6%
Residential mortgages	186	31%
Trading	99	17%
Other loans and obligations	84	14%
Total	599	100%

Source: http://money.cnn.com (07.05.2009).

To determine the scale used in the shock stress testing, data from Table 1 were confronted with information about the U.S. banking system on 30th June 2009, published by the Federal Deposit Insurance Corporation (FDIC).

TABLE 3. RESULTS OF THE TESTING OF THE U.S. BANKING SYSTEM

No.	Listing	All Commercial Banks 30.06.2009 (mln. USD)
1.	Total assets	11 895 077
1.1.	Cash and due from depository institutions	858 346
1.2.	Securities	2 032 152
1.3.	Federal funds sold & reverse repurchase agreements	535 236
1.4.	Net loans & leases	6 519 346
1.5.	Trading account assets	750 911
1.6.	Bank premises and fixed assets	111 212
1.7.	Other real estate owned	28 854
1.8.	Goodwill and other intangibles	407 388
1.9.	All other assets	651 633
2	Total liabilities and capital	12 494 277
2.1.	Total deposits	8 077 230
2.2.	Federal funds sold & reverse repurchase agreements	758 106
2.3.	Trading liabilities	273 628
2.4.	Other borrowed funds	1 030 255
2.5.	Subordinated debt	165 914
2.6.	All other liabilities	314 686
2.7.	Total equity capital	1 275 258
3	Shock loss (results of stress testing for 19 banks)	599 200
4	3/(2.7.)	47%
5	Required amount for recapitalization of 19 banks	74 600
6	5/(2.7.)	5.8%

Source: FDIC, 2009.

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Had the stress test scenario of a deepening economic and financial crisis came truth and the banks wouldn't have received the necessary recapitalization, they would have faced the loss of 599.2 billion dollars, affecting their own equity, then their loss would by at the level of 47%. It appears that in these circumstances, the solvency of banks would have been questioned. In addition, it should be noted that the "shock loss" was related only to 19 banks, rather than the entire U.S. banking sector. On 30th June 2009 the U.S. banking system consisted of 6 995 banks. In the period from 1st January to 25th October 2009 bankruptcy was declared in 106 banks, while another 416 banks considered to be at risk by the FDIC. For comparison, there were only 25 bankruptcies of banks in the entire 2008, and only 3 in 2007 (www.wp.pl, 25.10.2009).

Conclusion

Economic globalization has increased the vulnerability of financial markets towards difficult to predictable phenomena, and the collapse of the financial system in one country causes negative consequences in other parts of the world. The current experience with the critical financial system is a proof that economic phenomena should also be tested for extreme situations. Although the Capital Requirements Directive provides for the compulsory stress testing to be carried in banks, these studies were not sufficient enough to determine what will be the actual effects of a possible crisis. Stress testing should foresee scenarios, assuming the extreme and adverse but still possible course of events in order to allow for a complete formulation of assessments carried in banks, banking systems and financial stability.

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