eFinanse
financial internet quarterly

THE USE OF A VALUE AT RISK MEASURE FOR THE ANALYSIS OF BANK INTEREST MARGINS

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Abstract

The article describes the use of a Value at Risk measure to analyze the effectiveness of a bank. Among various existing possibilities of using this measure, the use of a new method has been proposed, namely, correcting various indicators of bank interest margins by using the Value at Risk measure. The newly established measures were then subjected to empirical tests, whose main objective was to test the capacity of the information resulting from the recourse to the proposed indicators. Using the data from financial statements of banks listed on the Stock Exchange in Warsaw in the years 1998-2012, two types of risk-adjusted bank interest margins were calculated, which provided a way to set the minimum levels that can be expected with the probability assumed in the calculation. The way in which these values are formed over time was then analyzed and they were finally compared with the typical values.

JEL classi ication: *G10, G21*
Keywords: *VaR, risk management, net interest margin*
DOI: https://dx.doi.org/10.65748/fiqf-2012-0031
Received: 13.11.2012 Accepted: 13.12.2012

Introduction

A sign of our times is a continuous increase in different types of financial risk, concerning particularly commercial banks. Global financial crises that have appeared in recent years are closely related to the functioning of the banking sector and they expose the weaknesses of risk management procedures used by banks. In this situation, the answer to the question of the proper way to measure and control risks in banks becomes an important issue. There is a need to construct risk measures that could be used for risk management at a global level, including various types of dangers.

This article discusses the possibilities of using the Value at Risk (VaR) measure in the risk management process and in the assessment of efficiency of banks. The idea of including VaR in the analysis of interest margins of banks through the creation of new indicators of interest margins – which would additionally take into account the risk, is widely presented here. The article consists of three basic parts. The first section provides an overview of research on the Value at Risk method. Then, the methodological assumptions about the idea of including VaR in the method of calculating interest margins imposed by banks are presented. In the following part, the newly-created measures for the analysis of the effectiveness of interest services offered by banks are used and their results are verified.

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The review of studies on the Value at Risk method

Value at Risk is defined as the maximum loss of market value to which an institution is exposed within a certain period of time and with a certain probability. The definition of Value at Risk is simple and seems to be intuitively understandable, however, a number of complex issues are connected with the use of this measure, like the problem of the many existing ways of estimating VaR, or the possibility of using this measure in further processes of risk management. The research on the VaR method is generally focused around one of three main areas.

The first area concerns the large number of different methods for calculating Value at Risk and the variety of results achieved by their use. When banking supervisors were recommending this method as a way to determine capital requirements for banks, they did not decide in any of their documents to provide a clear path for the calculation of VaR, and thus, they encouraged banks to shift to their internal models. The consequence of these decisions has become a constantly growing collection of methods for calculating Value at Risk, whose results may vary considerably. As shown by numerous studies, the use of different methods for the estimation of the same interest margin can lead to a 30-50% difference in the results obtained.

One of the first studies of the quality of VaR models was conducted by experts from the J.P. Morgan Bank (1996), who were the founders of the RiskMetrics ™ system. The model they created underwent verification tests in which they compared the expected and the actual level of losses, and they also examined its forecast unbiasedness. Allen (1994), Crnkovic and Drahman (1995), Hendrics (1997) and Best (2000) conducted the evaluation of variance-covariance and historical simulation methods. Similar studies of methods for determining the *VaR* were done and their results published by Butler and Schachter (1996), Mahoney (1996), Danielsson and De Vries (1997), as well as Jackson, Maude and Perraudin (1997). The results obtained by Allen, Crnkovic and Drahman, and Jackson, Maude and Perraudin, pointed to the advantage of the historical simulation method. Allen showed it using a number of test currency portfolios while Cmkovic and Drahman based their studies on a stock portfolio. Jackson, Maude and Perraudin constructed for this purpose four portfolios, three of which were based on actual bank data, and one was a hypothetical portfolio. The Value at Risk was calculated using the data from the periods of 3 to 12 months, always at the 99-percent confidence factor. The historical simulation method proved to have a greater ability to predict abnormalities, yet the authors cautioned that it requires the use of a sufficiently long series of quotations. Mahoney claimed the same arguing that the historical simulation method applied for a sufficiently long period of analysis provides a way, at any level of trust factor, to obtain the correct results, while the analytical method works well only with a 95-percent level of probability.

Hendrics, Butler, Schachter and Best who recommended the use of the variance-covariance method, provided that one takes into account a specific system of conditions, came to somewhat different conclusions. The widest range of such studies can be found in the work of Hendrics who carried them out for up to 1,000 random currency portfolios, using the data from the previous five years. He checked 12 VaR models, defined using the historical simulation method, variance-covariance method – taking into account a simple standard deviation as well as an exponentially weighted moving average, for which he further diversified the assumed confidence level and the length of the historical series, on which his estimate was based. The analysis showed that the transition from the 95-percent level of probability to the level of 99 percent significantly worsens the quality of forecasts, but it can be improved by extending the period of historical observation, accompanied at the same time by the decrease of the changeability of the forecasts. The study of unconditional unbiasedness of the forecasts did not give, however, good results: only one – the

VaR model, calculated using the historical simulation, met the prescribed requirements with the 99% level of probability and 1250 observations made. Summing up his verification, Hendrics concluded that the differences in the order of 30-50% can be considered as a standard phenomenon when the estimation of the values is made with the use of a variety of methods, whereas the variance-covariance method is best suited for linear positions, with the 95% confidence factor.
Butler and Schachter, who were comparing the standard (variance-covariance) methods with historical simulation for 12 portfolios, also pointed to the standard method. They came to the conclusion that the results of the estimation of Value at Risk with the use of all these methods can be considered correct, although there are important differences between them. The variance-covariance method generated the smallest number of errors with a simple standard deviation, but they suggest that this method introduces confusion as it rarely shows the occurrence of extreme events. Best verified the accuracy of the *VaR*, found with the variance-covariance method, using an ordinary standard deviation, varying the period of observation four times, and using the exponentially weighted moving average of the aging factor of 0.94 and 0.97, GARCH (1,1) model and the historical simulation method. The VaR value was calculated by him for 15 assets and for the portfolio combining them using the data from 5 years. The group of tested assets included interest rates, commodities, stock indices and exchange rates, and the criterion of selection was based on the number of items which in recent years had a significant tendency to deviate from the normal distribution. From his calculations he drew the conclusions that for estimating a VaR with a 95% confidence a 100-day or shorter period of observation is much more effective than longer periods, whereas the VaR with a 99% confidence works best for the period of 250 days or longer. Similarly, GARCH and EWMA models with the 0.97 factor give the best results with a 99-percent level of confidence. Best came to a final conclusion that the lack of normality, even in quite inconvenient data series, does not severely limit the ability to estimate VaR at a 95-percent level of confidence.
Another work of Berkowitz and O`Brien (2001), points to the problems arising from the estimation of the VaR with the use of the standard method. The authors compared sets of daily VaR with actual financial results, recorded at the time. The analysis showed that risk measures calculated in this way have a tendency to overestimate it, they are characterized by autocorrelation in time, and the replacement of the standard deviation parameter by GARCH gives significantly better results. Danielsson and De Vries, who focused on the comparison of popular methods for determining Value at Risk, i.e. the variance-covariance method and historical simulation with the method based on the theory of extreme values, went a little further in their research, and proved that this last way of estimating VaR was in this case the best. Of the other two methods, one (using the variance-covariance) underestimates the risks connected with the occurrence of events from the tail of the list, which means that it can give true results only whenever there is a low probability level, and the second (historical simulation) overestimates the significance of these events, due to the "long memory of the model". Longin (1994) made similar studies compiling the results of the estimation of VaR using the analytical method and the theory of extreme values. He indicated the latter as a better way to calculate *VaR*. M. Guidolin and A. Timmermann (2006) did research into less well-known methods of determining Value at Risk. They compared the results of the estimation of *VaR*, carried out using different types of the GARCH parameter with the effect of the application of the bootstrapping method, consisting in repeated sampling from the same original data set. The latter proved to be the best way, provided the use of a 95- or 99- percent confidence level[2].

[2] This method is sometimes used for the estimation of unknown or difficult to determine distribution statistics.

In addition, many authors have proposed various alternative approaches to traditional methods of estimating Value at Risk and have done research in order to evaluate the obtained results. One could mention here the work of Frye (1996), Zangari (1996), Boudoukh, Richardson and Whitelaw (1998) and Hosking, Bonti and Siegel (2000). Frye (1998), who dealt with the issue of interest rate risk, proposed the creation of scenarios of events based on the analysis of risk factors and he tested the method on a few randomly selected portfolios, including those that contained an option. He eventually came to the conclusion that this method of estimating VaR overestimates the risk measured with the 99-percent probability. Zangari analyzed possibilities of using the properties of distributions other than the normal distribution to calculate the value-at-risk. He used the mixed normal distribution and the distribution of GED (generalized error distribution) to model the distribution of profits, showing that both of these modifications allow one to model in a much better way the phenomenon of "fat tails", but in the case of really large price movements these approximations are not accurate enough. Boudoukh, Richardson and Whitelaw compared the results obtained using the historical simulation with a hybrid and RiskMetrics™ models. The tests were made for 95- and 99- percent probability levels and they were based on trading bonds, currencies, equities and commodities from the period of one year. In terms of the number of mistakes made, all computing methods gave comparable results, while the hybrid method gave the lowest average forecast error and the lowest autocorrelation. Hosking, Bonti and Siegel proposed a modified Monte Carlo method, the change consisted in replacing the approach of regularities in the distribution of log returns adopted in classical assumptions, and assuming that these returns have a t-Student distribution. It was compared with the typical Monte Carlo method, historical simulation and the variance-covariance method on the basis of six portfolios whose major risk factors were interest rates varied in time. This new way of VaR estimation proved to be the best while using a 0,99- and 0,975- percent levels of confidence.

The matter of selecting an appropriate method for calculating Value at Risk for an optional item is a separate issue, requiring extended analysis. Among those who investigated this problem were Fallon (1996), Jamshidian and Zhu (1996), and Rouvinez (1997). They tested delta and delta-gamma approximations for optional portfolios, and obtained much better results using the delta-gamma method, although in this case, for all the authors, the results aroused serious concerns. Jamshidian and Zhu also compared these two approaches with the full scenario simulation method, considering that this method gives the results of a similar quality as the delta-gamma approximation. The same authors (Jamshidian, Zhu 1997) combined the results from the scenario simulation method with the effects of Monte Carlo simulations, using both these ways for calculating swap transactions. The results they obtained were similar, but given the greater ease of calculation in the case of the scenario method, it may be considered a priority at this point. Sener, Baronyan and Mengütürk (2012) presented an interesting ranking of different methods for estimating VaR.

With such a wide range of different options for calculating VaR, any methods of verification of the results, including stress tests, are becoming extremely important. Such a study was made among others by Rosch and Scheule (2007) who analyzed stress loans in the United States. They calculated the variability of one-factor model parameters, which let them estimate the probability of insolvency in case of adverse conditions for the bank (see Siarka 2012). Other attempts of testing the VaR models in extreme conditions were made among others by: Alexander and Sheedy (2008), Wong (2008) and Breuer, Jandack, Rheinberd and Summer (2009).

The second area of research on the Value at Risk method focuses on its use in relation to the Polish market. It seems that the Polish financial market has been mature enough for testing the effectiveness of the use of modern methods of risk management. So far, several publications about risk management, referring to the data derived from the domestic market, have been published in Poland. One of the first works in this field of study was the empirical research done by Konieczny (1997) who, using the VaR method, dealt with the estimation of a price risk connected with fixed-time foreign exchange USD and DEM contracts. The estimation of the value-at-risk was carried out using the variance-covariance method with the EWMA (Exponentially Weighted Moving Average) algorithm. The analysis of distribution showed that the Polish financial time series behave in the same way as their counterparts from much more developed financial markets, namely, they are characterized by leptokurtosis and "thicker" tails than the normal distribution function. The assumption of the time-dependent variance was also justified in this case and the validation study, involving a comparison of the incidence of higher-than-expected changes to the adopted level of probability, confirmed the effectiveness of the method.

In their article Łach and Veron (2000) present the results of the effectiveness of the following testing methods: RiskMetrics™, mix-normal and a method using GARCH as a variance parameter. The research was based on the data from the Polish financial market from three previous years: USD/PLN exchange as well as T/N WIBOR and 1M WIBOR interest rates[3]. In the case of the exponentially weighted moving average, the effect on the result of six volumes of the information aging factor: 0.82, 0.85, 0.88, 0.91, 0.94, 0.97 was investigated. The effectiveness of all ways of estimation was assessed by comparing the estimated quantile distributions with the actual, known values of market factors and their changes, and, by the analysis of the frequency of exceedances and the difference between the quantiles and the actually observed data. The conclusion of the research was that the mix-normal method is the best for simple portfolios.

One of the largest studies made in this field were carried out by Jajuga, Kuziak, Papla and Rokita (2000, 2001) who assessed market risks of selected instruments from the Polish financial market, applying nine different risk measures, including VaR calculated with the use of variance-covariance, historical simulation, Monte Carlo and the generalized Pareto distribution methods, and using the Hill estimator. They analyzed daily and weekly logarithmic returns of 40 companies listed on the Warsaw Stock Exchange and WIG, WIG20 and WIRR indices, using the data from 12 semi-annual periods, 6 one-year periods, and 6 periods of varying lengths. Their calculations included tolerance levels of 0.05 and 0.01 in the case of daily returns and the level of 0.01 for weekly returns. The Monte Carlo simulation generated 1000 time series, assuming a normal distribution. The most similar results came from Monte Carlo and variance-covariance methods. On the basis of the results obtained, it was found that the VaR of 0.05, calculated using the Hill estimator, is the lowest in comparison with other methods, Monte Carlo simulation gives the lowest results at 99% probability level, whereas, historical and Hill estimator methods may in this case overestimate the risk. Furthermore, the results showed that the risk values at 0.05 level of tolerance, in the case of weekly return rates, are about twice as high as the daily rates of return, which combined with the verification of the received numbers, means that at a confidence level of 95% VaR calculated for weekly data is more accurate than for daily data. Also, the risk values calculated for indices gave better results than for single variables.

[3] Abbreviations T / N WIBOR and 1M WIBOR refer to the symbols of the interest rates of a banking transaction made and settled on the next day, and a monthly transaction in the interbank market.

Dubisz (2001) explored the possibility of applying the risk value for the analysis of exchange rate fluctuations on the Polish capital market, varying the length of the time span and the level of significance. He adopted the variance-covariance method as a way of estimation and the confidence levels of 0.90, 0.95 and 0.99, as well as 100- and 250-day observation periods. His article proved the usefulness of the value-at-risk method in taxometric analysis, with the variable and dynamic instability of time series, pointing out that the results from the latter depend on the relationship between the series of indicators and the empirical data or the series of other empirical indicators. The calculation of VaR for a sample portfolio was made by Szafarczyk (2001) who included there both debt instruments and currency positions and actions. The analysis uses the variance-covariance and historical simulation methods, highlighting the differences in the values of received estimates. Bałamut (2001) examined the three basic methods of calculating value-at-risk: historical simulation, variance-covariance and the RiskMetrics™ using the data on the ratings of the stocks of the Polish company Elektrim, U.S. equities of Microsoft, 13-week U. S. Treasury bills and 10-year U.S. government bonds. The comparisons included unbiasedness forecasts, autocorrelation of results and normality of extreme returns, in terms of differentiation of observation periods and a confidence factor adopted in the study. As far as unbiasedness is concerned, historical simulation proved to be the best method for which, in case of short and long observation spans, the proportion of VaR violations did not statistically significantly differ from the level of probability assumed in the analysis. The correlation analysis based on Ljung-Bax statistics, at 95% confidence level, allowed a rejection of it only for the *RiskMetrics*™ method with the information aging factor at 0.905, while at the 99% probability there was no such correlation in any case. The average value of returns over *VaR* from the historical simulation was, in this case, the closest to the value resulting from the normal distribution. The results of the study of the efficiency of Value at Risk estimation models developed by the RiskMetrics ™ group, GARH-class models and simulation methods, applied to the data of companies trading on the Stock Exchange in Warsaw, were presented by Mentel (2011). On their basis two models can be identified with considerable effectiveness, these are: the Monte Carlo simulation method and the RiskMetrics model with a random noise modelled by t-Student distribution.Another area of research into *Value at Risk* refers to the possibility of using this method at a further stage of risk management. There are concepts in which the *VaR* is a factor in making investment decisions (Kiani, 2011; Palomba and Riccetti, 2012; Ślepaczuk, Zakrzewski and Sakowski, 2011). It is worth paying attention to the need to create a measure that could be used for the evaluation of both the level of profit and the level of the risk involved. Integrated performance and risk management are the relatively least recognized fields of Value at Risk in the literature. Among those who wrote about the use of VaR in this area were Martten (2000), Best (2000), Kudlińska-Sadłocha (2003), and this topic was discussed in the most complex way in Polish literature by Iwanicz-Drozdowska (2012). The measures like RAROC or RORAC that use VaR to measure the risk-adjusted profitability (see, e.g., Buch, Dorfleitner and Wimmmer, 2011) function within the conceptions discussed above. These ideas could easily be extended to other similar measures, such as bank interest margins, thereby increasing the set of risk management tools.

Including Value at Risk in the analysis of bank interest margins

The Value at Risk method can be used in different ways in different areas of banking activity. Basically, it is a measure of the risk, and therefore it gives a picture of the danger, which can then form the basis for decisions. Although it is most often used on its own, it can also form the basis for the emergence of a variety of indicators for decision-making wherever there is an aspect of risk.

The methods for calculating interest margins of banks are generally not connected in any way with Value at Risk. However, it is possible to approach this issue in a slightly different way. All interest margins can be further corrected by the size of the risk that may be involved with such transactions. The result is a measure that provides an assessment of the effectiveness of a bank's interest policy, provided that the risk is taken into account. The Value at Risk method (see Gemzik-Salwach, 2006) is just what is needed to measure the level of the risk discussed above. The interest margin can be expressed as a percentage by dividing the difference between the interest income and expense, and average total assets. Another kind of the interest margin arises when the bank interest income is presented as a percentage of its interest revenues. The indicators must be modified so as to take account of the risk incurred[4]:

$$\text{adjusted net interest margin} = \frac{\text{interest income} - \text{interest costs} - \text{VaR}_w}{\text{average total assets}} 100$$

$$\text{adjusted net interest margin} = \frac{\text{interest income} - \text{interest costs} - \text{VaR}_w}{\text{interest income}} 100$$

The proposed measures relate to some extent to the concept of risk-adjusted measurement of performance (RAMP). If the count of presented expressions was divided by the amount of the capital that is necessary to cover this risk, as a result it would create a RAMP indicator, belonging to this group. The difference between these two approaches is the fact that the RAMP measures, as opposed to the risk-adjusted interest margins, always represent the relation of the risk incurred to the amount of the capital, as a buffer, which may neutralize its effects. Interest margins, in turn, show the minimum value resulting from interest activities of banks, which they can expect taking into account the incurred risk. The proposed risk-adjusted interest margins are therefore an expression of the integration of performance and risk indicators.
The presentation of risk-adjusted earnings as a percentage of assets or interest income has also the advantage that it allows, in addition to tracking changing trends of these quantities in time, comparisons between different banks. The newly established indicators can provide a landmark for banks, which allows them to specify their policies for pricing of their products. Both types of risk-adjusted net interest margins should have positive values. Otherwise, they would indicate that the risks associated with the actions taken is too large to be covered by the potential revenue.

Analysis of the interest margins of banks listed on the Warsaw Stock Exchange

The usefulness of the proposed interest margins was analyzed using the data from the banks listed on the Warsaw Stock Exchange in the years 1998-2012. It was a group of 9 banks: BPH SA Bank, Bank Handlowy SA, Millennium Bank SA, Bank of Environmental Protection, BZ WBK SA, BRE Bank SA, ING Bank Slaski SA, Credit Bank SA and Nordea Bank Poland SA. Quarterly financial results of each bank were taken into consideration while evaluating the effectiveness of their services. The main task was to present the possibilities of interpretation and the information capacity of the indicators obtained in the study.
In the first step, an estimate of the changeability and the VaR of interest rates was made, as its knowledge was necessary for all subsequent stages of the work. The analysis of these values preceded therefore the main research and served as a preparatory ground for it. Then, the effective-

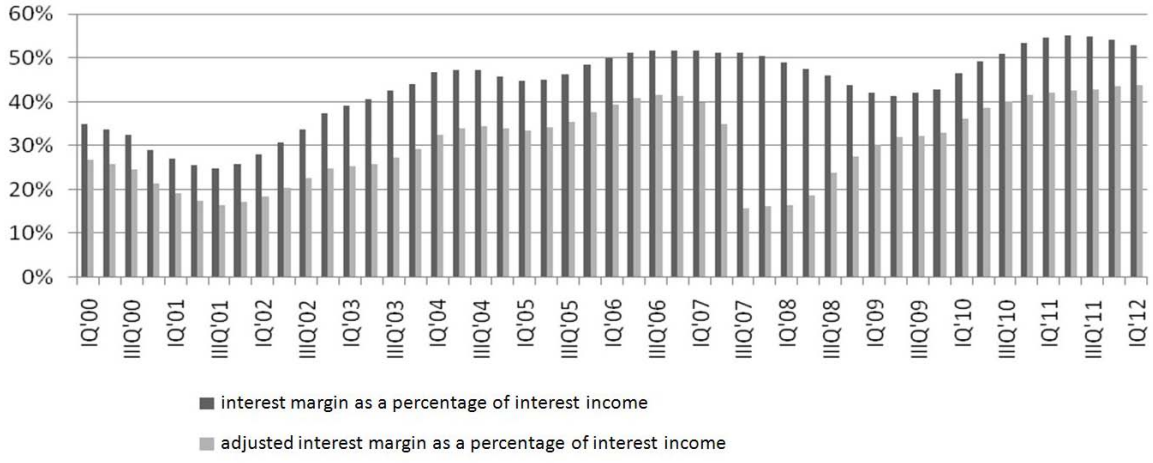
[4] Also, in the same way, an adjustment for the risk of partial interest margins can be made. It creates the basis for a comparison of active and passive products of interests and for creating efficiency rankings including the risk factor.

ness evaluation, including the estimate of an interest activity risk, was made with the use of the newly proposed indicators by comparing their size with the traditionally used metrics. Bearing in mind that all established indicators contain certain prognostic features, one can easily carry out their verification, comparing them to the actual values, which were recorded at a later time, and check in this way the accuracy of these predictions. Such research has been done in the last, third stage, which is at the same time the summary.

The analyzed time series consisted of 57 observations from financial statements published by the Internet service Notoria. In the case of WBK Bank Zachodni (WBK West Bank) its historic test series was shorter – consisting of 49 pieces of data, since the bank was not listed on the Stock Exchange in Warsaw until the first quarter of 2000. In the calculation of VaR a 95-percent level of confidence was assumed, and a simple standard deviation was used as a parameter of variation. The calculations were carried out using all available data and using the approach of a variable starting point. In the latter case, the Value at Risk was always based on eight consecutive values of interest income and, as a result, the first period of observation referred to the time span from the first quarter of 1998 through the fourth quarter of 1999, the second period of observation – from the second quarter of 1998 to the first quarter of 2000, etc., and the last period of observation – from the second quarter of 2010 through the first quarter of 2012. Thus, the period of the first quarter of 1998 – fourth quarter of 1999 was used only to determine the size of the first VaR and the value of risk-adjusted interest margins of banks whereas the focus of the analysis moved in time to the fourth quarter of 1999 – the first quarter of 2012. The results obtained were first used to evaluate the current effectiveness of interest services, including the risk of the banking sector as a whole and to make comparisons between different banks so as to subsequently check how these dependencies vary over time.

Figure 1 shows the evolution of bank interest margins expressed as a percentage of the interest income, calculated in the traditional way and the proposed method, additionally taking into account the risk calculated using VaR. The difference between these two values, resulting from the introduction of risk measures to the calculation, amounts on average to about 13%. These relationships are maintained over time at a relatively constant level, only the period from the third quarter of 2007 to the third quarter of 2008 is a period when the difference is still increasing, and is over 30%. Since 2009, one can watch the steady increase in the level of the interest incomes of banks, while the risk remains at a comparable level.

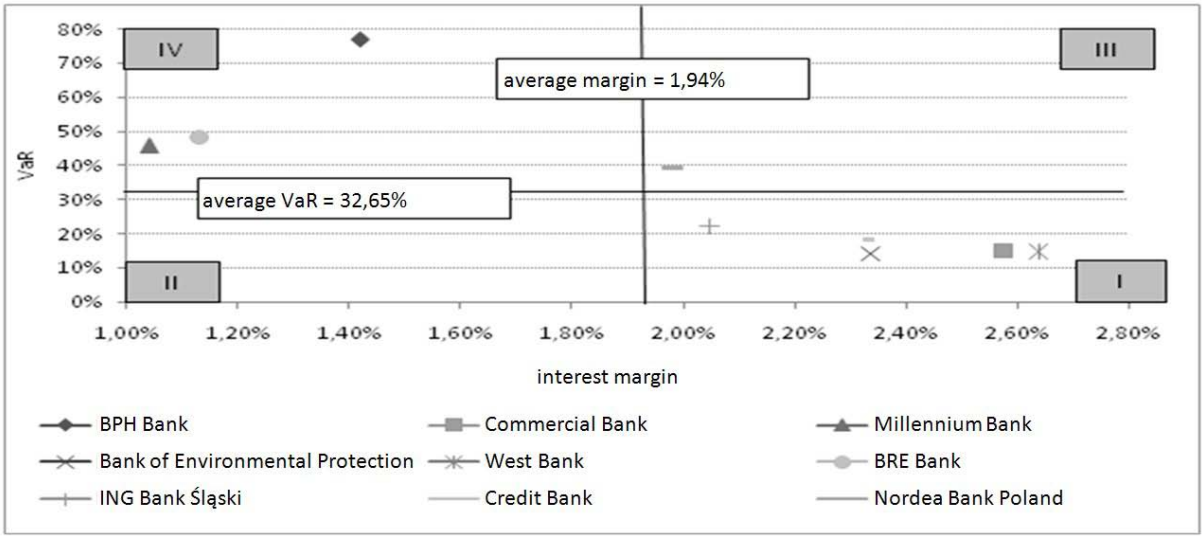
Chart 1: Adjusted net interest margin as a percentage of interest income



Source: Own calculations

Figure 2 shows these values for different banks. The banks considered to be the best have been placed in the first quarter. They have an interest margin higher than average, determined as a percentage of assets and a risk lower than average. Bank Zachodni WBK (WBK West Bank) is the leader in this approach, Bank Handlowy (Commercial Bank) also achieved similar results. Other entities that are included here are: Bank Ochrony Środowiska (Bank of Environmental Protection), Credit Bank and ING Bank Śląski. In the second group, which represents the banks with a low interest margin and a low risk, no banks were found.
Nordea Bank Poland has developed a high margin while taking a high risk, and, BPH Bank, BRE Bank and Millennium Bank achieved a lower interest margin than the average of the sector but they were characterised by a higher than average risk.

Chart 2: Average interest margins of banks and the values at risk



Source: Own calculations

The use of the approach of a variable starting point allows for a more detailed assessment of these issues and makes it possible to get an image of the formation of the values over time. In such an analysis the point at which there was a significant decrease in the efficiency of interest services is identified. It is illustrated by the results included in Table 1.

Table 1: Risk-adjusted interest margin as a percentage of average total assets

	BPH Bank	Commercial Bank	Millennium Bank	Bank of Environmental Protection	WBK West Bank	BRE Bank	ING Bank Śląski	Credit Bank	Nordea Bank Poland
IVQ'99	4,67%	2,27%	1,41%	5,04%	-	1,88%	4,44%	3,15%	4,06%
IQ'00	4,29%	2,27%	1,16%	4,93%	-	1,66%	4,16%	3,19%	3,89%
IIQ'00	4,16%	2,42%	1,04%	4,55%	-	1,53%	4,05%	3,08%	3,92%
IIIQ'00	3,83%	2,53%	0,78%	4,46%	-	1,60%	3,81%	2,86%	3,97%
IVQ'00	3,30%	2,66%	**-0,35%**	4,18%	-	1,47%	3,26%	2,63%	4,21%

	BPH Bank	Commercial Bank	Millennium Bank	Bank of Environmental Protection	WBK West Bank	BRE Bank	ING Bank Śląski	Credit Bank	Nordea Bank Poland
IQ'01	2,67%	2,31%	**-0,30%**	3,80%	-	1,50%	2,59%	2,18%	4,39%
IIQ'01	1,97%	2,25%	**-0,13%**	3,57%	-	1,28%	1,85%	2,02%	4,28%
IIIQ'01	1,56%	2,02%	**-0,10%**	3,37%	-	1,08%	1,39%	2,01%	4,14%
IVQ'01	1,15%	1,76%	0,80%	3,33%	1,91%	1,09%	1,11%	2,08%	3,71%
IQ'02	1,03%	1,76%	0,73%	3,42%	1,98%	0,90%	1,44%	2,25%	3,30%
IIQ'02	1,05%	1,53%	0,68%	3,40%	2,02%	0,87%	1,84%	2,26%	3,09%
IIIQ'02	1,26%	1,52%	0,77%	3,20%	2,06%	0,95%	1,96%	2,24%	2,95%
IVQ'02	1,68%	1,55%	1,20%	2,68%	2,22%	0,79%	2,11%	2,25%	1,77%
IQ'03	1,96%	1,65%	1,40%	2,18%	2,31%	0,58%	1,89%	2,22%	0,84%
IIQ'03	2,18%	1,78%	1,30%	1,80%	2,42%	0,54%	1,76%	2,15%	0,09%
IIIQ'03	2,22%	1,87%	1,41%	1,59%	2,61%	0,05%	1,81%	2,14%	0,17%
IVQ'03	2,15%	1,95%	1,01%	1,64%	2,74%	**-0,24%**	1,95%	2,12%	0,57%
IQ'04	2,33%	2,08%	0,99%	1,72%	2,95%	**-0,13%**	2,01%	2,10%	0,76%
IIQ'04	2,29%	2,17%	1,14%	1,89%	3,04%	**-0,18%**	2,08%	2,15%	0,95%
IIIQ'04	2,21%	2,20%	1,15%	2,01%	3,06%	0,11%	2,17%	2,10%	0,80%
IVQ'04	2,16%	2,26%	0,83%	2,07%	3,00%	0,42%	2,15%	2,00%	0,84%
IQ'05	2,16%	2,31%	0,87%	2,12%	2,89%	0,56%	1,96%	2,11%	1,03%
IIQ'05	2,30%	2,36%	0,85%	2,17%	2,85%	0,76%	1,77%	2,28%	1,30%
IIIQ'05	2,40%	2,45%	1,03%	2,10%	2,79%	0,83%	1,53%	2,51%	1,59%
IVQ'05	2,49%	2,58%	1,24%	2,05%	2,80%	0,89%	1,41%	2,81%	1,73%
IQ'06	2,41%	2,63%	1,21%	1,99%	2,82%	0,92%	1,53%	2,86%	1,81%
IIQ'06	2,45%	2,70%	1,22%	1,86%	2,88%	0,94%	1,59%	2,71%	1,86%
IIIQ'06	2,55%	2,69%	1,09%	1,85%	2,91%	1,08%	1,65%	2,60%	1,82%
IVQ'06	1,62%	2,72%	1,33%	1,85%	2,90%	1,21%	1,63%	2,47%	1,83%
IQ'07	0,69%	2,71%	1,46%	1,81%	2,86%	1,31%	1,59%	2,49%	1,78%
IIQ'07	**-0,40%**	2,73%	1,62%	1,85%	2,86%	1,39%	1,57%	2,58%	1,68%
IIIQ'07	**-1,59%**	2,73%	1,79%	1,88%	2,83%	1,39%	1,59%	2,64%	1,68%
IVQ'07	**-2,14%**	2,73%	1,87%	1,90%	2,80%	1,37%	1,66%	2,63%	1,67%
IQ'08	**-2,84%**	2,82%	1,89%	1,95%	2,75%	1,35%	1,67%	2,54%	1,66%
IIQ'08	**-3,62%**	2,84%	1,90%	1,92%	2,69%	1,35%	1,70%	2,46%	1,64%
IIIQ'08	**-4,06%**	2,98%	1,85%	1,93%	2,68%	1,38%	1,69%	2,41%	1,56%
IVQ'08	**-1,34%**	3,07%	1,74%	1,86%	2,53%	1,36%	1,62%	2,29%	1,48%
IQ'09	0,68%	3,05%	1,25%	1,85%	2,32%	1,36%	1,63%	2,04%	1,38%
IIQ'09	1,59%	3,09%	0,70%	1,84%	2,16%	1,40%	1,67%	1,93%	1,30%
IIIQ'09	1,00%	3,13%	0,43%	1,78%	2,11%	1,41%	1,73%	1,87%	1,35%
IVQ'09	0,61%	3,17%	0,17%	1,81%	2,20%	1,49%	1,81%	1,86%	1,43%
IQ'10	1,09%	3,34%	0,34%	1,68%	2,38%	1,50%	1,92%	2,02%	1,57%

	BPH Bank	Commercial Bank	Millennium Bank	Bank of Environmental Protection	WBK West Bank	BRE Bank	ING Bank Śląski	Credit Bank	Nordea Bank Poland
IIQ'10	1,24%	3,42%	0,64%	1,68%	2,56%	1,54%	1,98%	2,06%	1,66%
IIIQ'10	1,38%	3,47%	0,76%	1,66%	2,63%	1,62%	2,06%	2,09%	1,68%
IVQ'10	1,54%	3,59%	0,89%	1,50%	2,71%	1,67%	2,14%	2,12%	1,64%
IQ'11	1,28%	3,33%	1,00%	1,55%	2,82%	1,76%	2,22%	2,10%	1,62%
IIQ'11	1,27%	3,30%	1,25%	1,47%	2,88%	1,81%	2,27%	2,15%	1,65%
IIIQ'11	1,45%	3,29%	1,45%	1,38%	2,95%	1,77%	2,28%	2,19%	1,68%
IVQ'11	2,03%	3,19%	1,60%	1,42%	2,94%	1,74%	2,34%	2,19%	1,67%
IQ'12	2,60%	3,47%	1,71%	1,40%	2,99%	1,77%	2,37%	2,08%	1,66%

Source: Own calculations

The table shows some examples of the results of such studies for the risk-adjusted net interest income. The first thing that draws attention in the analysis of the values obtained are the negative values of risk-adjusted interest margins for those banks which were not visible at the broader spectrum of research. They indicate that the volatility of interest income and risks associated with it are so large that even the obtained result is not able to cover the Value at Risk to which a bank had been exposed during a period of time. This state of affairs can certainly be caused by increased competition among banks and a fierce battle for customers – factors which limit the ability to improve interest margins. These negative results of risk-adjusted interest margins were reported for BPH Bank, Millennium Bank and BRE Bank.

The above table shows that the worst time for BPH Bank was the period 2006 – 2008, which coincided in time with the beginning of the crisis on the U.S. market, which then turned into a global financial crisis. The bank achieved relatively good results after that period. BRE Bank's most difficult period in this respect were the years 2003 – 2004. At that time banks were exposed to the highest risk, and thus they failed to maintain such prices of their products that would ensure sufficiently high interest results. Consequently, in this area of activity the risk exceeded the generated profits. The poor performance of risk-adjusted interest margins at Millennium Bank in the fourth quarter of 2000 were quite obvious. They resulted from the interest business losses recorded by the bank in that period. Taking into account its risk-adjusted financial results, one can see that the loss was automatic.

The verification of the results showed in the majority of cases the correctness of the figures obtained using the discussed method. The calculations were carried out at the level of probability of 95%, so the situations in which the actual result would be lower than expected should not occur in more than 5% of all cases examined. This means that when we have the series of 49 values, it can be accepted that for each of these series, only two events will be different from the forecasts[5]. These results, however, should always be treated with caution. The results of the calculations are shown in Table 2.

[5] The exception here is WBK Bank Zachodni, for which, due to the shorter range of historical analysis, only 41 values of VaR and risk-adjusted interest income were received.

Table 2: Number of errors in forecasting interest margins of banks

Bank name	Adjusted interest margin as a percentage of assets	Adjusted interest margin as a percentage of interest income
BPH Bank	0	0
Commercial Bank	1	0
Millennium Bank	0	0
Bank Ochrony Środowiska (Bank of Environmental Protection)	0	0
WBK Bank Zachodni (WBK West Bank)	0	0
BRE Bank	0	0
ING Bank Śląski	0	0
Loan Bank	0	0
Nordea Bank Poland	1	0
Total:	2	0

Source: Own calculations

Having compared the interest income results to the average level of assets there were two misses and if the adjusted interest income is shown as a percentage of interest revenues, all minimum interest margins forecasts prove to be accurate. Thus, the number of errors both in the forecast of interest margins as a percentage of average total assets and as a percentage of interest income is within the limits of normal. In addition, there was a perfect hit for 7 of 8 banks. However, the results obtained should be treated with caution because of the relatively short time spans applied. Also, it must be pointed out that the adopted method of estimating VaR has a considerable influence on the received values of risk-adjusted interest margins.

Conclusions

The obtained results have confirmed the great usefulness of the proposed measures: the risk-adjusted interest margin as a percentage of average total assets and the risk-adjusted interest margin as a percentage of interest income. The presented indicators can be used in several ways, for the evaluation carried out by means of both the ex post and ex ante analyses. In the ex post analysis the formation of the values over the past time is evaluated, they can be used to make comparisons between different banks in terms of their business interest incomes, taking into account the amount of the risk involved. As was shown by the results of research, such an approach provides a bit more of a look into the area of banking, leading often to a different hierarchy of the best and worst players than in the case of the customary use of such values.

The research conducted ex ante is used to forecast, in an accepted time horizon, such values as the minimum interest income, which can be expected with e.g. a 95% probability set in the calculations. Similarly as in the ex post analysis, these measures can be used only for a single entity or for comparison.

Both ex post and ex ante analyses can refer to a single entity, a group of them, or to the entire banking sector. It should be noted, however, that the proposed measures should not be used on their own to evaluate the effectiveness of interest policies. The information carrying capacity of

the measures generated by them is certainly too low to give the full picture of this very complex problem and does not cover all its aspects. Such a task, moreover, was not the aim of the study, rather, it was to enlarge the set of tools that can be used in research on interest margins and risks involved with them.

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