The Basel II Accord on Measuring and Managing a Bank's Risks

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Abstract. *The abundance of risk metrics stems from the effort to measure the difference between the expected and actual returns, under a hypothesis of normality. Under the assumption of risk aversion, investors are likely to quantify risk using metrics which measure returns lower than the expected average. These include the semi-variance of returns smaller than the average, the risk of loss – a return under a chosen level, usually 0%, and value-at-risk, for the greatest losses, with a probability of less than 1-5% in a given period of time.*

The Basel II accord improves on the way risks are measured, by allowing banks greater flexibility. There is an increase in the complexity of measuring credit risks, the market risks measurement methods remain the same, and the measurement of operational risk is introduced for the first time.

The most advanced (and widely-used) risk metrics are based on VaR. However, it must be noted that VaR calculations are statistical, and therefore unlikely to forecast extraordinary events. So the quality of a VaR calculation must be checked using back-testing, and if the VaR value fails in a percentage of 1-5% of the cases, then the premises of the model must be changed.

Key words: Risk; Value-At-Risk; Basel II; Capital Adequacy; Monte-Carlo Simulation.

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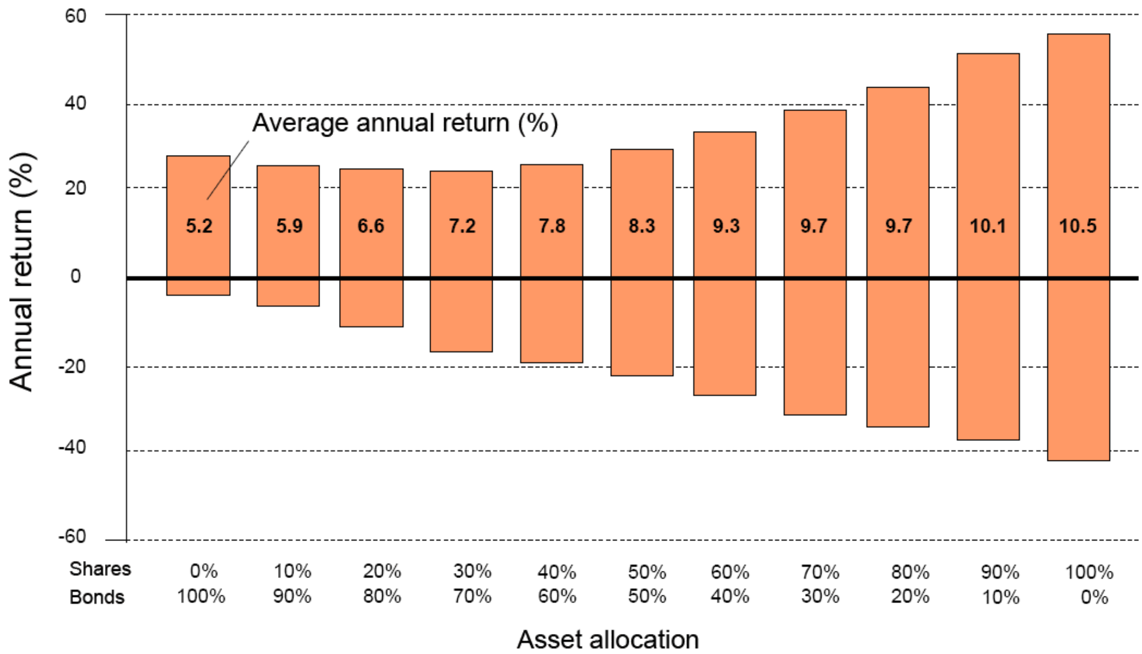
1. Defining Risk

Risk is defined as the uncertainty of an investment's rate of return – the probability that the realized return will vary from the expected return as a result of the influence of market and environmental factors. Some of the factors exerting influence on the investment's return can be forecasted, but most cannot. Risk is determined by the frequency and the size of the differences between expected and realized returns, and their distribution around the average expected return.

Risk metrics quantify the uncertainty of the expected return. These measures are important for portfolio construction and performance assessment, because a principal assumption if investing is that to achieve a given level of return; investments with lower risk are preferred over those with higher risks. Normally, investments with higher risks are expected to have higher returns than investments with lower risks.

Risk estimation is based on the historical data of different asset classes. Starting from the hypothesis that the past is a good predictor for the future, the historical data are the best foundation available for risk measurement. However, the future never quite repeats the past. The proverbial "hundred-year storm" can unsettle even the best predictions, based on the most advanced forecasting techniques.

Even if risk cannot be predicted with certainty, risk metrics provide critical information to help answer the most important questions for any investor: How should a portfolio be invested optimally, to achieve its objectives? Risk metrics have also proven reliable for comparing the relative risks of different asset classes. Figure 1 shows that increasing the percentage of stocks in the portfolio increases volatility (stocks have annual average returns of 10.5%, twice as large as bonds, but stocks also have negative returns of – 40%).



Source: Ambrosio Frank, 2007, *An Evaluation of Risk Metrics,* Vanguard.

Figure 1. *Range of returns for different stock and bond allocations, 1926-2006*

Risk metrics are classified in two categories: absolute and relative. Successful use of risk metrics depends on selecting measures that are consistent with a portfolio's objectives. The amount and the quality of available data are of great importance.

2. Risk Metrics

When using and quantifying risk metrics, we are assuming a hypothesis of normality – that is, that the returns are normally distributed around the average return. This hypothesis is usually true.

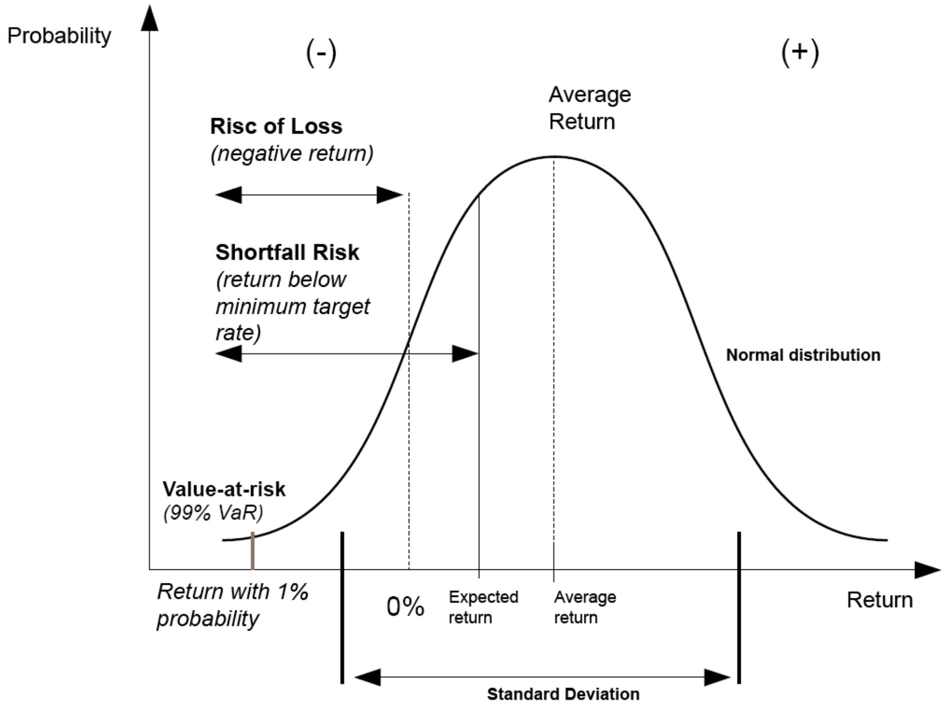
2.1. Absolute Risk Metrics

The most usual absolute risk metrics are the variance, standard deviation, value-at-risk, risk of loss and shortfall risk. Next we will define these metrics and comment on their limitations.

Variance (σ^2) is the average of the squared differences between the real and expected returns[(1)]:

$$\sigma^2 = \frac{(R_1 - R)^2 + (R_2 - \overline{R})^2 + ... + (R_T - \overline{R})^2}{T-1} =$$

$$= \frac{1}{T-1}\sum_{t=1}^{T}(R_t - \overline{R})^2$$



Source: Ambrosio Frank, 2007, *An Evaluation of Risk Metrics*, Vanguard.

Figure 2. *The different risk metrics*

The *standard deviation* (σ) is the squared root of the *variance*(2):

$$\sigma^2 = \sqrt{\frac{1}{T-1}\sum_t \left(R_t - \overline{R}\right)^2}$$

The standard deviation, which is a basic statistical metric, is commonly used to measure the fluctuation of a portfolio's return. A larger standard deviation shows a greater fluctuation in the returns of a portfolio, as compared to the portfolio's average return. For example, consider a portfolio with an average return of 10% and standard deviation of 15%. The portfolio's returns will be between – 5% and 25% in 68.3% of the cases, according to the normal distribution.

The standard deviation can be an useful measure for portfolios such as pension funds, which are concerned with the consequences of both positive and negative deviations from the specific target return. The standard deviation is less suited for investors concerned with negative deviations from the average. Also, this metric assumes a normal distribution, which limits its applicability somehow.

The symmetry of deviations from the average means that the number of observations higher than the average will be equal to the number of observations lower than the average and so the standard deviation is a measure of the total deviation from the average. Thus, some researchers propose semi-variance as the risk of lower than average returns. These negative deviations can be compared to the average (semi-variance), or, more interestingly, with the lowest accepted return ($R \leq 0 \Rightarrow$ zero return), which needs to be realized as a minimum-accepted condition (the safety-first criteria).

The *semi-variance* measures the risks that future returns will be less than the average, and the safety-first metric measures the risk that returns will be less than zero.

Actually, the "safety-first" metric is an expression of the return – risk metric, where risk is measured by the semi-variance of the deviations, or those under break even (BE), and not those both to the left and the right of the average (see Figure 3).

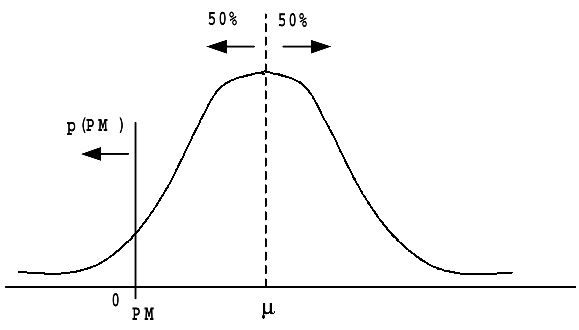


Figure 3. *Representation of the safety-first metric*

The safety-first metric is most widely used to measure the economic risk of a business, and the elasticity (Le) of the profit related to turnover. The economic risk is defined as the probability that the turnover (T) will be at a level where the profit will be zero (ZPT = zero-profit turnover).

$$Le = \frac{T}{T - ZPT}$$

In the context of financial management, the "uncertainty" is defined as the possibility of obtaining a varying profit, depending on the micro- and macroeconomic environment. Consider two businesses, A and B, with their forecasted profits X_A and X_B, respectively, and three economic environments:

Profit forecasts and historical data for the economic environment

Table 1

Nature states	p_A	X_A	$p_A \times X_A$	$p_A \times (X_{As}-\mu_{XA})^2$	p_B	X_B	$p_B \times X_B$	$p_A \times (X_{Bs}-\mu_{XB})^2$
Pessimistic	0,3	16	4,8	580,8	0,2	-5	-1	605
Constant	0,4	60	24	0	0,6	50	30	0
Optimistic	0,3	104	31,2	580,8	0,2	105	21	605
E(X)			**60**				**50**	
σ^2(X)				**1161,6**				**1210**

			A	**B**
$\beta_{neutral}$ =	0,206613	$V(X)_{neutral}$ =	300	300
$\beta_{risk\text{-}adverse}$ =	0	$V(X)_{risk\text{-}adverse}$ =	60	50
$\beta_{risk\text{-}taker}$ =	1	$V(X)_{risk\text{-}taker}$ =	1221,6	1260

Using a linear evaluation model, we obtain:

$$V(\tilde{X}) = E(\tilde{X}) + \beta \times \sigma^2(\tilde{X}).$$

The two outcomes for the businesses are equal only for $\beta = 0.206613$:

$$60 + 0.206613 \times 1.161,6 = 300 = 50 + 0.206613 \times 1.210$$

For $\beta \neq 0.206613$, the comparison must be done based on the investor's preference for risk. For b = 0, meaning a risk-neutral position, business A will be the preferred choice, as $V(\tilde{X}_A) = 60 + 0 > 50 + 0 = V(\tilde{X}_B)$. If the investor is risk-adverse, (anytime b < 0,206613), then the "uncertainty" offered by A is preferred, as it offers more return and less risk.

If the investor has a risk-taking attitude (any $\beta >$ 0.206613), then the uncertainty offered by B is more suitable.

For $\beta = 1$ we have $V(\tilde{X}_B) = 50 + 1 \times 1.210 = 1.260 > 1.221,6 = 60 + 1 \times 1.161,6 = V(\tilde{X}_A)$.

We should note, however, that the risk is used in our calculations by considering the entire variability of the profit, including both negative and positive deviations around the average (μ). Thus the uncertainty $V(\tilde{X}_A)$ is less interesting for risk-takers, who have a greater risk appetite, even though A always has positive returns, regardless of the nature states. But business A will be favored by risk-adverse investors.

The *Safety-First* risk metric is similar to the method used in the evaluation of the return – risk metric, with the single difference that the risk is evaluated on the probability that the profit is less than zero. Under these circumstances, business A would not be considered risky. Its evaluation will be done according to the expected profit $[V(\tilde{X}_A) = 60]$. However, business B, otherwise less risky, has a probability of 0.2 for obtaining profit less than zero (– 5). Its value is determined by the expected profit (50) and this new definition of risk $[0.2 \times (-5 - 0)^2 = 5]$:

$$V(\tilde{X}_B) = 50 + \beta \times 5$$

The two business become equivalent for $\beta = 2$. For any $\beta < 2$ (risk-adverse attitude), business A is more valuable. However, if a risk-taking investor finds that it is acceptable to replace the expected profit with the raised uncertainty of obtaining a higher return, then business B is a better alternative.

Value-at-risk (VaR) is a metric based on an asset's "worst performance" in a given period. The measure can be based on the worst 1% or 5% observations in a given period, or in a number of observations.

VaR offers an easy to grasp measure of risk. The worst year for the USA stock market was 1931, when the marked dropped by 43.1%. This can be understood by investors not familiar with risk.

Because VaR considers the worst results, but ignores their frequency, many risk analysts prefer to use VaR together with other risk metrics. Thus, VaR is frequently used in conjunction with the risk of loss.

In risk management, VaR is expressed as the probability x% of loosing more than VaR in the next t days. The negative deviations are to the left of the average, with the greatest losses being the furthest away from the average (see Figure 4). After we set the probability X and the interval t, VaR quantifies this loss of investing in an asset or a portfolio(3).

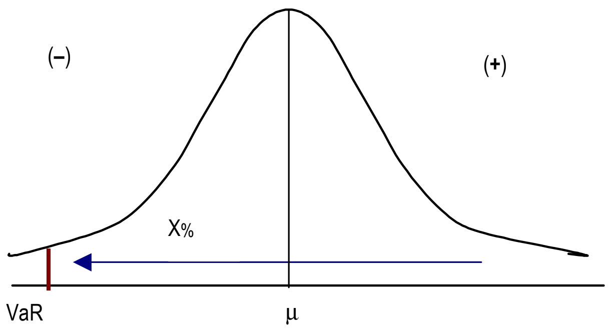


Figure 4. *Risk estimation using VaR*

VaR calculation methodologies are numerous and can be very complex(4). The results are tested against historical data (back-testing), and if the periods in which the losses are greater than VaR are not greater than 1% of the total measurements, then we can trust the computed value of VaR. However, if the numbers of periods where losses are recorded is significantly greater, we must then use other methods, such as GARCH or EWMA. At the end of article we will show how VaR for a loans portfolio is computed using the Monte-Carlo simulation.

Risk of Loss is a metric which is complimentary to VaR, because it shows the frequency of negative returns. Usually, it measures the percentage of returns smaller than a given benchmark, usually 0%. This metric most often describes the probability of the value of an asset falling under a certain index or under a reference asset. VaR and risk of loss can be used by almost any portfolio to measure risk tolerance.

Let's assume that an investor's goal is to maintain the value of a portfolio over a year. The risk of loss, showing that over the last 81 years, 30% of the time the returns on the stock market were negative, is an important information for the investor.

The risk of loss can also be measured in real terms, deducting the inflation. Table 2 shows that the losses in real terms can be quite different from the losses in nominal terms.

The returns of different asset classes on the USA market, 1926-2006

Table 2

Asset Class	(η) Nominal return			(η) Real return		
	Average annual return	% years with negative return	Highest annual loss	Average annual return	% years with negative return	Highest annual loss
Short-term tresury bills	3.8%	0.0%	0.0%	0.8%	35.0%	-15.0%
Long-term treasury bill	5.2%	9.0%	-2.3%	2.1%	38.0%	-14.0%
Stocks	10.5%	30.0%	-43.1%	7.2%	35.0%	-37.3%

Source: Ambrosio Frank, 2007, *An Evaluation of Risk Metrics*, Vanguard.

VaR and risk of loss have greater precision when more historical data is available. If the calculations of the two metrics are based on data which covers a shorter period and is less volatile, then the investor will get a false sense of security. Generally, the longer will be the period, the higher the probability of negative returns.

Shortfall Risk is the probability that an investment's value is less than is required to attain the specific objectives. This probability can be computed using several methods, including the Monte-Carlo simulation. Shortfall Risk is most frequently used to create an investment plan based on current assets and estimated future liabilities. This metric can show that, for example, the probability that a portfolio might be consumed before all disbursements are made is 25%.

Shortfall Risk can be used by an institution or an individual who is spending, or will spend from portfolio assets. Examples include foundations, pension funds, and persons investing in pension funds. Although the result is a simple percentage, it can be very complex to calculate and understand. Small changes in the premises might cause large changes in the end results. The quality of the calculation is strongly dependent on the initial data, and most of the time the initial data is not accurate and contains estimation errors.

2.2. Relative measures of risk

The most frequently used relative risk measures are excess return, tracking error, Sharpe ratio, information ratio, beta and Treynor ratio.

Excess return is the return of an asset above or below an index or reference security, for example a sovereign bond[5]. Excess return is calculated by subtracting the benchmark's return from that of the security, for example, if an asset has a return of 11% and its benchmark has a return of 10%, then the excess return is 1%.

Investment advisors use excess return to compare a portfolio's performance with its chosen index. The relevance of this calculation rests upon several premises: that the total risk of a portfolio is similar to the benchmark's risk, and that the returns of both portfolio and benchmark fluctuate in the same direction. If these two conditions are not met, the metric will be of little use. For example, a portfolio can be riskier than an index, but excess return cannot measure this risk.

Tracking error is the standard deviation of excess return. Like the standard deviation of the portfolio, tracking error assumes that the returns are normally distributed. This measure combines both positive and negative results. For example, consider a fund which has no excess return compared to an index, over the long term, but it has a tracking error of 0.1%. If the benchmark has a 10% annual return, then the asset's return will fall within 9.9% and 10.1% in 68% of the cases (according to the normal distribution law).

Tracking error is used to determine how close a portfolio's performance matches that of a benchmark. Fund managers which are tied to a benchmark can use tracking error to describe the deviation from the benchmark. The metric can also be used to monitor the performance of funds with controlled risk, which have objectives such as generating returns 0.5% above a certain benchmark. Like the standard deviation of a portfolio, tracking error is not suitable for those concentrating only on downside risk.

Tracking error is also less relevant for funds which are not tied to a certain benchmark. However, this metric is used for calculating the information ratio, which is used for comparing fund managers.

The *Sharpe ratio* represents the return of a portfolio adjusted for risk. Practically, profit is measured for every "unity" of risk. To calculate the Sharpe ration, an asset's excess return is divided by the asset's standard deviation:

$$Sh = (\overline{R}_{port} - \overline{R}_f) / \sigma_{port},$$

The Sharpe ratio can be negative if the asset's performance is worse than the market. For a long-term evaluation, the metric's values fall between 0 to +1. A larger value of the metric means a better performing asset. The metric is used to measure similar class of assets or assets with similar liquidity. The metric depends on the time period used for calculation, which is illustrated in Table 3:

Sharpe Ratio for different asset classes from 1970 to 2006

Table 3

	Sharpe Ratio		
	1970-1981	1982-1999	2000-2006
Commodities	0.3984	0.1654	0.3356
Real estate	0.2577	0.4724	1.392
International developed stock markets	0.0841	0.4809	0.0911
U.S. stock market	0.0301	0.7381	-0.0806
U.S. long-term Treasury bonds	-0.2743	0.5647	0.5914

Source: Marrison Chris, 2002, *The Fundamentals of Risk Measurement*, McGraw Hill.

However, the Sharpe ratio can lead to unwanted results if used without good consideration. As Table 3 shows, the metric has higher values during times of peak performance, as was the case with the stock market during 1999. However, the Sharpe ratio was a poor indicator at that point of the following period of market underperformance.

The *Information ratio* represents an asset's return adjusted for risk, compared to a benchmark. To calculate this metric, the excess return is divided by the tracking error relative to a benchmark. The metric is generally used to compare the performance of different fund managers.

An investment fund with excess return of 10% and a tracking error of 20% relative to an index has an information ratio of 0.5. Another fund with excess return of 10% and tracking error of 40% has an information ratio of 0.25. Everything else being constant, a higher value of the metric indicates better performance.

Like Sharpe ratio, the information ratio is very dependent upon the time period used for calculation. This metric can also show high values in periods of maximum performance, which can be misguiding.

Beta is a measure of an asset's volatility in relation to the rest of the market. The market is assumed to have a beta equal to 1. If a portfolio has a beta of 1.20, then the portfolio's value will rise or fall by 12% when the market rises or falls by 10%. Beta is used to measure systemic risk (or market risk) of an investment and can be used to aid in deciding whether an asset should be included in a portfolio.

Portfolio and hedge fund managers regard beta as a measure of risk. For example, managers who does not want to be exposed to market fluctuations will use neutralize the beta values of long positions with the beta of short positions, to reduce the portfolio's beta. However, when calculating beta, the choice of the benchmark is essential. Beta computed for a portfolio with a different risk profile will not be relevant for the total portfolio volatility. Also, the value of beta changes in time and therefore a periodical re-balancing is necessary to maintain a proper value for the metric.

The *Treynor ratio* describes return adjusted to risk, compared to the market. It is calculated by dividing excess return by beta:

$$Tr = (\overline{R}_{port} - \overline{R}_{f}) / \beta_{port},$$

The Treynor ratio measures return per unit of risk. The metric also assumes that all non-systemic risk has been diversified and that only systemic risk remains. Therefore, the Treynor ratio is used to compare funds which are very well diversified.

An investment fund with excess returns of 1% and a beta of 1.20 will have a Treynor ratio of 0.833. A higher value is better, all other factors being constant.

Because the Treynor ratio is based on beta, it will share the same limitations. Moreover, the Treynor ratio amplifies beta's change over time, and thus changes in the Treynor ratio do not always reflect major changes in risk.

3. The Basel II Accord on Risks and VaR

In June 2004, the Basel Committee has finalized a revision of Basel I. Owing to the development of risk evaluation methods which increased the complexity of banking operations, as well as the lack of operational risk in Basel I, the Basel II accord was issued at the end of 2003. From that point on, the banks had three years to implement the Basel II accord. The deadline for implementation was set for the end of 2006, with credit and operational risk set for 2007. The Basel II accord is based on three pillars, which are mutually re-enforcing:

Pillar I: Capital adequacy. The first pillar establishes the measurement methods for credit, market and operational risk. The Total Cost of Risk (TCR) is obtained by summing Credit Risk Cost (CRC), Market Risk Cost (MRC), and Operational Risk Cost (ORC), respectively, so that:

$$\text{Capital} > TCR = CRC + MRC + ORC$$

According to Pillar I, banks must calculate their solvency ratio:

$$\text{Bank Capital (min .8\%)} = \frac{\text{Total capital}}{\text{Risk weighted assets (r. credit + r. market + r. operational)}}$$

The changes brought by Basel II affect in most part the risk evaluation methods. Thus, the methods used for measuring credit risk are the most advanced, those for market risk are unchanged, and those for operational risk are introduced for the first time. The Accord contains three methods for measuring credit and operational risk and two for market risk.

Methods for measuring credit risk

1. Standard approach (a modified Basel I version)
2. Foundation internal-rating based (IRB)
3. Advanced fundamental internal-ratings based (A-IRB).

For credit risk, the standard approach is an extension of Basel I, and it uses weights determined by external rating agencies. Internal rating methods are more advanced and use data on losses affecting the bank. However, the most advanced methods are those based on VaR.

Methods for measuring market risk (similar to Basel I)

1. Basic indicator approach (BIA)
2. Internal methods.

Methods for measuring operational risk

1. Basic indicator approach (BIA)
2. Standardized approach
3. Internal based, with

3.1. Foundation IRB, and

3.2. Advanced IRB.

Each method is increasingly complex. It is appreciated that the increasing complexity will lead to more precise calculations and less required capital.

Pillar II: Supervisory review process. This pillar consists in the extended role assumed by the supervisory body, which includes assurance that banks operate with adequate capital, and that they have the functioning internal processes required to evaluate risks and take the necessary measures when required. According to this pillar, the BNR (the Romanian National Bank) requires that every financial institution creates and validates a set of internal processes used to calculate the required funds in accordance with each institution's risk profile.

This pillar is based on four principles:

1. Banks must evaluate capital requirements in accordance with the risks;
2. The supervisor must determine whether the bank's capital adequacy;
3. It is expected that banks will operate above the minimum capital level;
4. The supervisor must identify problems early on and apply the necessary measures.

Pillar III: Market discipline. This pillar defines a series of requirements regarding the transparency and communication of precise information regarding risk exposures, risk profiles and risk management. Banks are required to publish organizational and strategic information relating to risk, financial information (structure and total value of own funds, accounting methods for assets and liabilities), information relating to credit risk (total, structure), and information relating to operational risk (events leading to possible losses).

Banks must publish reports detailing risks and capital requirements. The transparency is expected benefit clients, stakeholders, and the banks themselves.

Requirements for the management of credit, market, and operational risk

Credit risk: even banks with enough capital reserves must analyze in detail their own capital positions. Risk management techniques include collateral, guarantees and derivatives (for banks dealing with derivatives).

The complexity of the required data is significant. Therefore, a robust and auditable database is required. Credit systems will not only have to respond to management queries, but also to external control and regulators. According to Basel II and to its new rating methodology, capital requirements have grown, which can have a negative impact for credit extension, with unwanted macroeconomic effects.

Operational risk must be treated in financial institutions according to the industry best-practices, making use of adequate risk modeling and reduction techniques, including outsourcing. Financial institutions and their internal audit departments must pay attention to defining, calculating, measuring and communicating risk.

Market risk: the reporting and aggregation of all risk factors at a market level should create a transparent environment. The Basel II accord creates the premises for conformity at an institution's level, as well as for the whole market. The Basel II accord aims to significantly increase transparency by requiring banks to issue yearly or quarterly reports which show losses and exposures generated by risk management. These measures are meant to control and stop unwanted events in the credit activity, enhancing market discipline.

In conclusion, we will present some of the new Basel accord's positive and negative aspects:

POSITIVE	NEGATIVE
▪ Encourages banks to build performing portfolios	▪ Mathematical models cannot emulate real-world events
▪ Recognizes advances in risk management	▪ There is a probability of lower external ratings
▪ Offers incentives for improving risk management	▪ Economic cycles will cause variations in capital requirement
▪ Increases the role of the markets	▪ The complexity of the new accord

Source: Jorion Philippe, 2007, *Value at Risk – The New Benchmark for Managing Financial Risk*, McGraw Hill.

Following are some more industry critics regarding the new Accord:

- The implementation of a risk management system can be very expensive;

- It is possible that "cascade" events take place when multiple institutions, using the same risk metrics (VaR, for example) effectuate similar operations. This behavior has been connected to the 1987 crash, and there is a probability that financial regulation amplifies market trends;
- Regulation can give a false sense of security.

4. Calculating VaR for a loan portfolio using the Monte Carlo simulation

Suppose a bank has a portfolio of 30 loans given out to customers. For each of these loans we know the size, the rating, and the probability of default in basis points. We are required to find out VaR 5%, simulating 1,000 possible values for the portfolio. The correlation factor ñ between the return factor F and the simulated value å$_i$ has the given value of 0.6. If a client defaults, then the whole sum is assumed to be lost.

Our first step is to calculate the loss threshold K for each loan, as the inverse cumulative standard deviation (see figure 5). K represents the number of standard deviations from the average until the default probability, assuming a normal distribution.

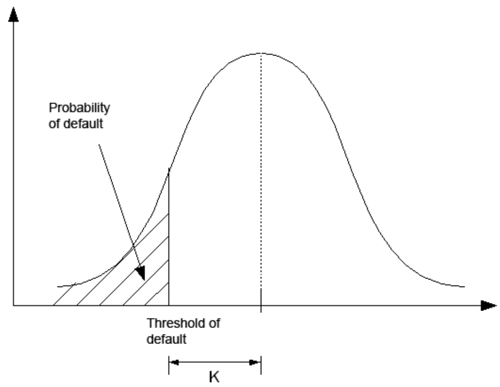


Figure 5. *The evolution of K loss threshold*

The calculation can be done using Microsoft Excel's NORMSINV() formula. The results are in the table below:

The credit portfolio

Table 4

Credit	Exposure	Rating	PD în BP
1	10,000.00	BBB	37
2	50,000.00	CCC	3414
3	160,000.00	AA	1
4	10,000.00	AA	1
5	10,000.00	A	5
6	120,000.00	BBB	37
7	300,000.00	BBB	37
8	160,000.00	BBB	37
9	10,000.00	CCC	3414
10	50,000.00	B	659
11	10,000.00	BB	145
12	300,000.00	B	659
13	50,000.00	A	5
14	10,000.00	A	5
15	160,000.00	B	659
16	300,000.00	AA	1
17	50,000.00	BBB	37
18	10,000.00	B	659
19	160,000.00	BBB	37
20	20,000.00	A	5
21	50,000.00	BB	145
22	10,000.00	B	659
23	300,000.00	BB	145
24	10,000.00	B	659
25	70,000.00	A	5
26	10,000.00	B	659
27	50,000.00	CCC	3414
28	140,000.00	A	5
29	300,000.00	CCC	3414
30	20,000.00	BB	145
	2,910,000.00		

K loss threshold of a bank portfolio

Table 5

Credit	Exposure	Rating	PD în BP	K
1	10,000.00	BBB	37	-2.678
2	50,000.00	CCC	3414	-0.409
3	160,000.00	AA	1	-3.719
4	10,000.00	AA	1	-3.719
5	10,000.00	A	5	-3.291
6	120,000.00	BBB	37	-2.678
7	300,000.00	BBB	37	-2.678
8	160,000.00	BBB	37	-2.678
9	10,000.00	CCC	3414	-0.409
10	50,000.00	B	659	-1.507
11	10,000.00	BB	145	-2.183
12	300,000.00	B	659	-1.507
13	50,000.00	A	5	-3.291
14	10,000.00	A	5	-3.291
15	160,000.00	B	659	-1.507
16	300,000.00	AA	1	-3.719
17	50,000.00	BBB	37	-2.678
18	10,000.00	B	659	-1.507
19	160,000.00	BBB	37	-2.678
20	20,000.00	A	5	-3.291
21	50,000.00	BB	145	-2.183
22	10,000.00	B	659	-1.507
23	300,000.00	BB	145	-2.183
24	10,000.00	B	659	-1.507
25	70,000.00	A	5	-3.291
26	10,000.00	B	659	-1.507
27	50,000.00	CCC	3414	-0.409
28	140,000.00	A	5	-3.291
29	300,000.00	CCC	3414	-0.409
30	20,000.00	BB	145	-2.183
	2,910,000.00			

Next, we simulate 1,000 values for 30+1 random normal variables. One of the variables is for the return factor F, the others correspond to the 30 loans. Then we calculate the values for the loans (V_i) by replacing the simulated values for F and ε_i and the correlation factor ρ in the following linear model:

$$V_i = \sqrt{\rho} \times F + \sqrt{(1-\rho)} \times \varepsilon_i$$

Next we are showing a part of the Monte Carlo simulation for 6 of the loans:

Loss simulation for the bank's portfolio

Table 6

Credit	1	2	3	4	5	6 ...
Exposure	10,000.00	50,000.00	160,000.00	10,000.00	10,000.00	120,000.00
Rating	BBB	CCC	AA	AA	A	BBB
PD în bp	37	3414	1	1	5	37
K	-2.678	-0.409	-3.719	-3.719	-3.291	-2.678
Value	-1.041	-0.078	0.575	0.525	0.864	-1.614
	-0.908	-1.401	-1.166	-0.896	-1.161	-1.825
	-0.880	0.055	-0.925	-1.259	-1.247	-0.999
	-0.012	-0.115	-1.163	-0.458	-0.450	-0.996
	0.076	-0.311	0.324	-1.694	-0.575	0.252
	-1.852	-3.099	-2.531	-1.814	-2.282	-2.363
	-0.218	-0.620	0.169	0.864	1.008	0.114
	-2.037	-1.202	-0.381	-0.100	-0.724	-0.714
	-1.977	-2.066	-0.478	-2.194	-1.714	-2.283
	0.454	-0.303	1.432	0.850	1.326	-0.231
	-2.479	-1.752	-0.631	-0.326	-1.850	-0.860
....						

If the simulated value $V_i < K_i$ (the calculated loss threshold) then the entire sum is lost. Next, we calculate the total losses for each of the 1,000 simulations, by summing the losses on each row; part of the data follows:

Total losses, simulated, of bank's portfolio

Table 7

Credit	1	2	3	4	5	6 ...
Exposure	10,000.00	50,000.00	160,000.00	10,000.00	10,000.00	120,000.00
Rating	BBB	CCC	AA	AA	A	BBB
PD în BP	37	3414	1	1	5	37
K	-2.678	-0.409	-3.719	-3.719	-3.291	-2.678
Total Loss						
300,000.00	-	-	-	-	-	-
880,000.00	-	50,000.00	-	-	-	-
410,000.00	-	50,000.00	-	-	-	-
400,000.00	-	50,000.00	-	-	-	-
360,000.00	-	50,000.00	-	-	-	-
1,920,000.00	-	50,000.00	-	-	-	120,000.00
...						

Finally, we order the losses according to size. Since we have 1,000 values, we need to look at the 50-th value, corresponding to 95% of the total number of values. This value is 720,000 and it represents the VaR value we are looking for.

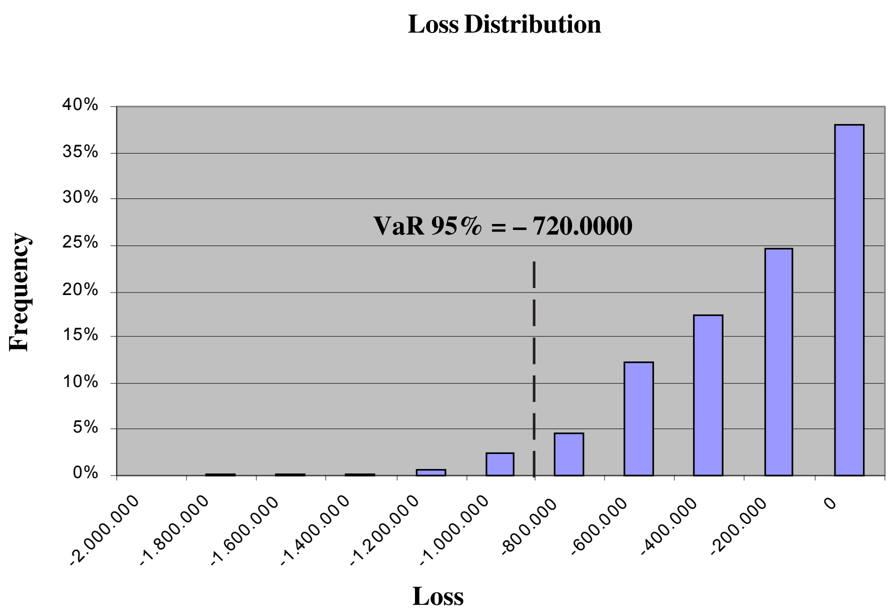


Figure 6. *Loss distribution and VaR*

This value signifies that the losses incurred by the bank will be greater than 720,000 only in 5% of the cases.

5. Conclusions and critical aspects

1. The realism of the hypotheses. Firstly, risk evaluation is undertaken assuming that financial events follow a known distribution (normal, triangular etc.) For example, the daily change in stock prices is assumed to have a normal distribution. In a general climate of risk aversion, multiple risk indicators are used, such as VaR, safety-first, semi-variance etc. Finally it is assumed that the future will repeat the past, and thus historical data is used. These premises, which do not always hold true, affect the precision of the forecasts and risk measurements.

2. Data integrity. The data we use in our models can represent an incomplete picture of the environment. In less liquid markets (such as non-EU countries or those of small-cap companies) the transaction costs can substantially affect total returns.

Quantitative risk metrics calculations can require a high level of data precision, which is not always available. Also, the returns of some strategies, such as hedge funds, are not frequently calculated, which makes their volatility appear artificially low.

The most widely-used risk metric is VaR, because it is expressed in terms which are very easy to understand. But VaR is obtained using statistical simulations, which cannot forecast extraordinary market events. Therefore, the quantity and quality of data is essential. Generally, the quality of a VaR calculation is tested using back-testing and stress-testing. Usually, if the model does not fit the data in more than 1% of the cases, then the premises or the modeling methods must be changed.

3. Any simulation is subject to *model risk*. This can be defined as the risk of losses resulting from using inadequate models, such as assuming that the distribution of events is normal, when instead it is strongly skewed. Moreover, the losses can be compounded by liquidity problems associated with selling a losing position.

4. Dependency on the time period. The 1987 stock market crash (as well as other major economical developments) suggests that risk is independent from the time period being analyzed. Risk metrics based on longer-term periods can be less influenced by the short term. Since the whole stock market history can be considered as a single period, the question is how we shield ourselves from the risk of “different” time periods. One solution would be to forecast risk based on both historical and current data; the forecast is affected by the number of the variables used and the length of the forecast. Another is to use the Monte Carlo simulation.

5. Metric selection and management risk. Selecting a metric is not an easy decision. Choosing a relative risk metric, such as excess return, tracking error or beta is only appropriate when the benchmark is representative of the portfolio’s performance.

In conclusion, risk measurement is a crucial part in building and managing a portfolio. The investment policy must identify the relevant risk metrics for the portfolio’s specific goals. In addition to choosing quantitative measures, experience in judging the qualitative aspects is paramount.

Given these factors, a top-down approach is recommended. First, the goal of the portfolio should be set. Given the fact that the major asset classes, such as bonds, stocks and cash have a long history, portfolio construction must start from finding the correct balance between the different asset classes. Specific decisions about investments should only be made at the end of the process, together with a risk analysis. This process will lead to a better understanding of the portfolio’s risks and evaluation of its performance.

Notes

(1) When variance is computed from a sample of realized returns, the sum of the squared differences is divided by T-1 periods, to compensate for the loss of one degree of freedom (Brealey and Myers, Principles of Corporate Finance, McGraw-Hill, 2000, p. 161). The differences between the observed returns are random and independent, but the last value can be dependent on the sum of the other T-1, so that their sum equals zero. Thus, a degree of freedom is lost.

(2) If the variance and standard deviation are computed from a sample of observed returns derived from periods shorter than a year (day, month, quarter), then the yearly variance is calculated as the product between the variance of the shorted period (σ_t^2) and the number of periods (t): $\sigma_{yearly}^2 = \sigma_t^2 \times t$, and the standard deviation is computed as

(3) For capital adequacy purposes, the supervisory body can require a bank to increase its capital by up to 3 times the value of VaR for 10 days at 99%.

(4) Among the VaR calculation methods there are:
- The variance-covariance method;
- The GARCH method;
- The historical simulation;
- The Monte-Carlo method.

(5) The Jensen Method for measuring portfolio performance is an illustration of Excess Return:
MJ = – [Rf + bport(EM – Rf)]. This represents the portfolios excess return compared to its reference according to the CAPM method.

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