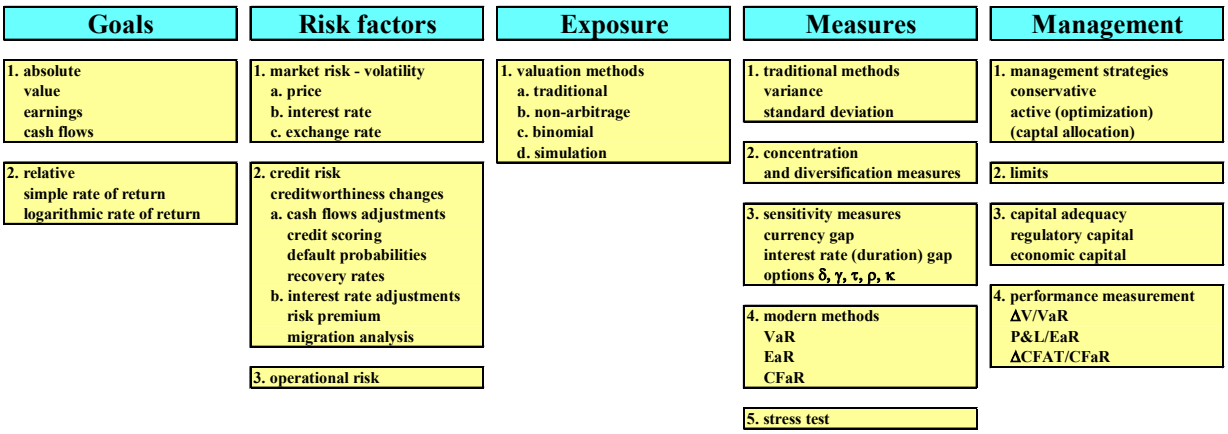
# 1. Risk Management System. Goals. Exposure

## RISK MANAGEMENT SYSTEM




### 1.1.1 Goals

#### 1.1.1.1 Absolute Goals

1.1.1.1.1 *Value*

1.1.1.1.2 *Earnings*

1.1.1.1.3 *Cash Flows*

1.1.1.1.4 *EVA*

**EVA for equityholders**

(1) $EVA_E = NI - R_E \times E_P$

or

(2) $EVA_E = (ROE - R_E) \times E_P$

where

NI – net income,

$R_E$ - cost of equity,

$E_P$ – equity at the beginning of period,

$ROE - NI/E_P$.

**EVA for the firm**

(3) $EVA_F = NOI\ (1\text{-}T) - R_A \times (E_P+D_P)$

or

(4) $EVA_F = (ROA - R_A) \times (E_P+D_P)$

where

NOI (1-T)– net operating income after tax,

$R_A$ - weighted average cost of capital,

$(E_P+D_P)$ – equity + debt,

ROA – NOI(1-T)/ $(E_P+D_P)$

### 1.1.1.2 Relative Goals

#### 1.1.1.2.1 *Simple rate of return*

The absolute return on a security between dates t and t-1 is defined as:

(5) $$P_t - P_{t-1} + D_t$$

The relative return, or percent return, for the same period (HPY, holding period yield) is

(1) $$R_t = \frac{P_t - P_{t-1} + D_t}{P_{t-1}} = \frac{P_t + D_t}{P_{t-1}} - 1 = \frac{\Delta P_{t\text{-}1} + D_t}{P_{t-1}}$$

Two different types of returns must be distinguished. An **ex ante** return is the uncertain return that an investor **expects** to get from an investment. The **ex post** or **realized** return is the certain return that an investor actually **obtains** from an investment. Investors make decisions on the benefits they expect from an investment. The actual outcomes may not match their expectations.

The equivalent annualized rate is equal to

(6) $$i = (1 + R_t)^{\frac{365}{t}} - 1$$

The gross return on security (HPR, holding period return) is just:

(7) $$1 + R_t = \frac{P_t + D_t}{P_{t-1}}$$

#### 1.1.1.2.2 *Logarithmic Rate of Return*

The log price change (continuously compounded return) of a security is defined to be the natural logarithm of its gross return:

(8) $$r_t = \ln(1 + R_t) = \ln\left(\frac{P_t + D_t}{P_{t-1}}\right) = \ln(P_t + D_t) - \ln(P_{t-1})$$

The relative price change and log price change have the same sign.

The absolute price change may be written as

(9) $$\Delta P_t = R_t P_{t-1} - D_t \text{ or } \Delta P_t = \left(e^{r_t} - 1\right) P_{t-1} - D_t$$

**Problem 1. Simple Rate of Return**

**Problem 1**

After 73 days the price of a stock rose from PLN 100 do PLN 102.

1. Calculate simple rate of return ?
2. What is the annualized rate of return ?
3. What is the annualized return if the new price level is reached after 4 years ?

**Solution**

Ad 1.
Return is equal to: (102 : 100) -1 = 2%
Ad 2.
The annualized return is: (1 + 2,0%)^(365:73) -1 = 10,41%.
Ad 3.
The annualized return is equal to: (1 + 2,0%)^(365:1460) -1 = 0,50%.

## Problem 2. Arithmetic and Geometric Mean

**Problem 2**

Consider an investment with the following data

| *Period* | *Value* |
|---|---|
| 1 | 100 |
| 2 | 120 |
| 3 | 96 |
| 4 | 105,6 |
| 5 | 95,04 |

1. Calculate simple returns for each period.
2. Calculate arithmetic mean for the whole period.
3. Calculate geometric mean for the whole investment period.

**Solution**

Ad 1.

| Period | Return | Gross return |
|---|---|---|
| 2 | 20% | 120% |
| 3 | -20% | 80% |
| 4 | 10% | 110% |
| 5 | -10% | 90% |

Ad 2.

Arithmetic mean is equal to 0%.

Ad 3.

Geometric mean is equal to:

(120,0% * 80,0% * 110,0% * 90,0%) ^(1/4) - 1 = -1,3%.

## Problem 3. Portfolio Return

**Problem 3**

Begining (t=0) and ending (t=1) values of a portfolio which consists of three items are following:

| | Value | |
|---|---|---|
| Investment | t=0 | t=1 |
| 1 | 100 | 110 |
| 2 | 400 | 350 |
| 3 | 500 | 680 |
| | 1000 | 1140 |

1. Calculate simple returns for each investment and the whole portfolio.
2. Calculate continuously compounded returns for each investment and the whole portfolio.

**Solution**

Ad 1.

Return for the whole portfolio is: (1140 : 1000) - 1 = 14,0%.

This return may be also calculated as an average of simple returns for each item.

The weights are calculated for the moment t=0.

| | Value | | | | |
|---|---|---|---|---|---|
| Investment | t=0 | t=1 | w | R | w * R |
| 1 | 100 | 110 | 0,1 | 10% | 1% |
| 2 | 400 | 350 | 0,4 | -12,5% | -5% |
| 3 | 500 | 680 | 0,5 | 36% | 18% |
| | 1000 | 1140 | | | 14% |

Ad 2.

Logarithmic return for the whole portfolio is equal to: ln(1140:1000) = 13,1%.

This return may be also calculated using log returns for each portfolio using the formula:

$$r_P = \ln\left(\frac{P_1}{P_0}\right) = \ln\left(w_1 e^{r_1} + w_2 e^{r_2} + \cdots + w_n e^{r_n}\right)$$

| Investment | 1+R | r | w | $e^r$ =1+R | w * $e^r$ |
|---|---|---|---|---|---|
| 1 | 110,00% | 9,5% | 0,1 | 1,100 | 11% |
| 2 | 87,50% | -13,4% | 0,4 | 0,875 | 35% |
| 3 | 136,00% | 30,7% | 0,5 | 1,360 | 68% |
| | | | | Σ | 114% |
| | | | | $r_p$ = | 13,1% |

#### 1.1.1.3 Value

1.1.1.3.1 ***Market Value***

1.1.1.3.2 ***Economic Value***

$$(10) \quad PV = \sum_{t=1}^{n} \frac{CF_t}{(1+RRR)^t} + \frac{CV_n}{(1+RRR)^n}$$

### 1.1.2 Risk factors

- market risk
  - price risk
  - interest rate risk
  - foreign exchange rate risk
  - credit risk
- operational risk
- liquidity risk and marketability risk
- capital risk
- country/sovereign risk
- off-balance-sheet risk
- business risk
- technology risk
- environment
- war, revolution

### 1.1.3 Exposure

#### 1.1.3.1 Frank J. Fabozzi Classification

1. Traditional valuation,
2. Non arbitrage valuation,
3. Binomial Trees,
4. Simulation.

### 1.1.3.2 ZM Classification

1. Discrete models
    a. One-path (DCF models)
        i. Traditional – one discount rate
        ii. Non arbitrage – many discount rates (spot rates)
    b. Analytical methods
    c. Sensitivity and Scenario Analysis
    d. Simulation
    e. Binomial Models and Probabilistic Decision Trees
2. Continuous models (BSM)

#### 1.1.3.2.1 *Traditional Valuation:*

$$PV = \frac{CF_1}{(1+RRR)^1} + \frac{CF_2}{(1+RRR)^2} + ... + \frac{CF_n}{(1+RRR)^n} + \frac{CV_n}{(1+RRR)^n}$$

#### 1.1.3.2.2 *Non Arbitrage Valuation*

$$PV = \frac{CF_1}{(1+RRR_1)^1} + \frac{CF_2}{(1+RRR_2)^2} + ... + \frac{CF_n}{(1+RRR_n)^n} + \frac{CV_n}{(1+RRR_n)^n}$$

Differences between two approaches are shown in the following table (bond as an example):

| | Fixed rate | Floating rate |
|---|---|---|
| Traditional approach | $P = \frac{cB}{(1+YTM)^1} + \frac{cB}{(1+YTM)^2} + ... + \frac{cB+B}{(1+YTM)^T}$ | $P = \frac{z_1 B}{(1+YTM)^1} + \frac{{}_2f_1 B}{(1+YTM)^2} + ... + \frac{{}_Tf_{T-1} B+B}{(1+YTM)^T}$ |
| Arbitrage-free approach | $P = \frac{cB}{(1+z_1)^1} + \frac{cB}{(1+z_2)^2} + ... + \frac{cB+B}{(1+z_T)^T}$ | $P = \frac{z_1 B}{(1+z_1)^1} + \frac{{}_2f_1 B}{(1+z_2)^2} + ... + \frac{{}_Tf_{T-1} B+B}{(1+z_T)^T}$ |

P - price, c - coupon rate, B - face value, YTM - yield to maturity, z - spot rate, f - forward rate.

The traditional valuation methodology discounts every cash flow of an asset by the same discount rate. The arbitrage-free approach values an asset with each cash flow discounted at its unique discount rate (spot rate).

#### 1.1.3.2.3 *Analytical Methods*

Taylor expansion:

$$(11) \quad f(x) = \frac{f(x_0)}{0!} + \frac{f'(x_0)}{1!}(x - x_0) + \frac{f''(x_0)}{2!}(x - x_0)^2 + \ldots + \frac{f^n(x_0)}{n!}(x - x_0)^n + R_n$$

$$(12) \quad \Delta W \cong + \delta \Delta x$$

$$(13) \quad \Delta W \cong + \delta \Delta x + \frac{1}{2}\gamma \Delta x^2$$

$\Delta W = f(x) - f(x_0)$ – change in value

$\Delta x = x - x_0$ change in risk

#### 1.1.3.2.4 *Sensitivity and Scenario Analysis*

#### 1.1.3.2.5 *Simulation*

Simulation methods are used to value assets in assumed risky environment. The Monte Carlo simulation is used to value mortgage-backed securities and certain type of asset-backed securities in which the cash flows are based on interest rate path.

#### 1.1.3.2.6 *Option Pricing Models*

Option pricing (binomial and BSM) models are used to value assets with embedded options. Binomial model is used to value callable bonds, putable bonds, floating rate notes, and structured notes in which the cash flows are based on interest rate.

### 1.1.4 Real Assets, Financial Assets and Derivative Assets

Financial markets deal with financial assets and derivative assets.

Derivative assets (positions in forwards, futures, options and swaps) derive values from changes in real assets or financial assets, and sometimes changes of other specific indices, for example temperature index. Derivative assets are assets whose values are derived from some

primary assets. Derivatives are claims on primary assets: real or financial underlying assets. Derivative market is actually much greater than primary assets market.

Real assets tangible or physical (be it land, buildings, machinery, equipment, commodities or raw materials,) are primary assets.

Financial assets are claims on real assets. For derivatives financial instruments are also primary assets. Financial asset markets deal with treasury bills, bonds, stocks, loans, deposit and currencies. The owner of a primary asset has a direct claim on the benefits provided by an real asset.

Financial markets are places where borrowers (issuers of securities) requiring finance (deficit units) can meet with investors able to supply it (surplus units). The financial markets allow firms to realize their investment decisions and financial decisions (strategies). Investment decisions may be conservative (buying low return and low risk instruments) or active (buying high return and high risk instruments). Financial decisions may be conservative (low cost and low risk instruments) or active (for example issuing equity with high return and high risk).

### 1.1.5 Passive and Active Strategies

An optimum investment or borrowing portfolio is not simply a combination of individual assets that have desirable risk-return characteristics. You must consider correlation between returns on assets. Portfolios may be low return-low risk (passive strategy) or high return-high risk (active strategy).

#### 1.1.5.1 Passive Strategies

Passive strategies include: buy and hold and indexing. The last involves building a portfolio that will match the performance of a specified index. Matched-funding techniques (dedicated portfolios, horizon matching, immunizations) are also considered as conservative strategies. Dedication refers to construct a portfolio of assets with cash flows that will match the future liabilities.

These strategies use derivatives as an instrument to stabilize returns (cash flows and cost of capital and immunize the balance sheet.

#### 1.1.5.2 Active Strategies

These strategies rely on forecasts, valuation analysis, credit analysis, yield spread analysis, volatility analysis. Active management includes strategies that attempt to outperform a passive benchmark portfolio. These strategies use derivatives (especially futures and options) as an instrument to increase returns.

### 1.1.6 Spot markets and forward/futures markets

**Spot transactions** assume that delivery of an asset is realized instantly or within two or several days. For example, in currency spot transaction in the interbank market delivery date is usually exactly two working days after transaction.

**Forward/futures transactions** assume that delivery is at some future date, such as one month or six months into the future.

### 1.1.7 Types of Financial Derivatives

Types of derivatives:

- futures
- forward
- options
- swaps

#### 1.1.7.1 Forward Contracts

A forward contract obliges its purchaser to buy a given amount of a specified asset at some stated time in the future at the forward price. Similarly, the seller of the contract is obliged to deliver the asset at the forward price. Non-delivery forwards (NDF) are settled at maturity and no delivery of primary assets is assumed. NDF assumes only cash settlement at a future date.

Forward contracts are not traded on exchanges[1]. Forward contracts are widely used in foreign exchange markets. The global market for FX forward contracts is a network of financial institutions, mostly banks, that make market in these transactions.

#### 1.1.7.2 Futures Contracts

Futures contracts are created and traded on organized futures exchanges. Contracts are highly standardized in terms of the amount and type of the underlying asset involved and the available dates in which it can be delivered. The exchanges guarantee that contracts will be settled through clearinghouses. One of the primary roles of the clearinghouse is to be the opposite party to all investors. Buyers and sellers of future contracts do not deal directly with each other but with a clearinghouse.

There are four types of futures contracts:

- futures on interest bearing instruments (Eurodollar deposits, treasury bonds, notes and bills)
- futures on currencies,
- futures on stock indexes.
- futures on commodities (grains, metals, food),

#### 1.1.7.3 Options

Options are traded on exchanges and OTC market. An option is a derivative security that gives the buyer (holder) the right, but not the obligation, to buy or sell a specified quantity of a specified asset within a specified time period. or to make cash settlement. An option contract differs from the futures contract in that the option contract gives the buyer the right, but not the obligation, to purchase or sell a security at a later date at a specified price.

#### 1.1.7.4 Swaps

Swaps are considered to be interest rate risk management tools because they give an efficient means of adjusting the interest rate exposure of a company's assets and liabilities. It should be noted that other financial instruments, such as exchange-traded interest rate futures and

[1] Historically on some exchanges with a small number of participants such transactions were called forward contracts. During the last years energy exchanges sometimes involve only few participants and they have used the term "forward contract" to emphasize that most terms of a contract were negotiated between the two parties.

option contracts, are often capable of achieving the similar results. Swaps are long-term OTC instruments. A great flexibility in setting the terms of the swap agreement makes it a very effective instrument in interest rate risk management.

### 1.1.8 Interest Rate, Currency, Credit, Equity, and Commodity Derivatives

Derivatives can be divided

- interest rate derivatives
- currency derivatives
- credit derivatives
- equity derivatives
- commodity derivatives

#### 1.1.8.1 Interest Rate Derivatives

Interest rate derivatives are instruments whose value depend on interest rate of bills, bonds, deposits and other interest bearing instruments.

Interest rate derivatives are the most important derivative instruments in the world. These instruments enable to hedge against interest risk or speculate on the expected interest rate movement.

##### 1.1.8.1.1 *IRS*

**Interest Rate Swap (IRS)** is an agreement between two parties to exchange cash flows based on a specified amount of principal for a set length of time. IRS is a long term agreement. In Poland maturities reach 10 years (in the world up to 30 years).

The so called plain vanilla swap requires one of the participants to make its payments based on a fixed rate of interest that does not change throughout the life of the agreement. The other counterparty makes payments based on a floating interest rate that changes over time. The usual practice is to make net settlement payments on every settlement date. On each settlement date, the counterparty with the larger obligation to the other makes payment equal to the difference between the two amounts. In the world, several floating rate indexes are used, including London Interbank Offered Rate (LIBOR), commercial paper rates, Treasury bill rates, certificate of deposits rates, and the prime rate. The LIBOR is by far the most common variable-

rate index used. It is obvious that at any particular time there exists a term structure of swap spreads.

#### 1.1.8.1.2 *FRA*

**FRA (forward rate agreement)** is a transaction in which two counterparties agree to a single exchange of cash flows based on fixed and a floating rate.

#### 1.1.8.1.3 *IR Futures*

**Interest rate futures** contracts are traded on organized exchanges. In the world interest rate futures (eurodollar, T-bills, T-note, T-bond, municipal bond) contracts represent more than one-half of the entire futures market.

#### 1.1.8.1.4 *IR Options*

IR options are instruments which give the right to buy or sell interest rate sensitive instruments at a pre-determined interest rate. The price of the option is a premium paid on the second day after transaction.

### 1.1.8.2 Currency Derivatives

#### 1.1.8.2.1 *FX Forward*

**FX forward contracts** are nonstandardized transactions that call for the exchange of some quantity of a foreign currency at a future date. Sometimes it is called outright forward to emphasize that there is no corresponding spot transaction. Non-delivery forward (NDF) assumes only cash settlement at a future date. Maturities range from 1 week to 1 year. Transactions are mostly executed between banks. The share of non-residents in the turnover accounts for over 75 per cent.

#### 1.1.8.2.2 *FX Swap*

**FX swap** is a transaction in which one (foreign) bank makes a foreign currency deposit in a second (domestic) bank and simultaneously the second (domestic) bank makes a domestic currency deposit in the first (foreign) bank. The typical size of transaction is USD 10 million. Such transaction is a real financial transaction (just two real deposits). This transaction developed enormously from 1999 as it offered short-term zloty financing for foreign traders investing in Polish government bonds and T-bills offering extremely high real interest rates.

Most transactions (75%) have maturities less than 7 days. But in contrast to depo market, which is liquid for transactions with maturities up to one month, the FX swap market is liquid for maturities over one year. FX swap may be treated as a purchase of a currency (spot transaction) with simultaneous repurchase of this currency on a stated date (forward transaction). Without exchange of deposits and only settlements it is an NDF - non-delivery forward transaction. The exchange of deposits in different currencies (FX swap) is also the simplest form of a currency swap, which is considered as a derivative instrument.

#### 1.1.8.2.3 *CIRS*

**Cross-Currency Interest Rate Swap (CIRS)** is an agreement between two parties to exchange cash flows for a set length of time in different monetary units. Cash flows are based on floating or fixed interest rates in different currencies. Settlements are made every three or six months. The principal is PLN 0,5-1200 million. Maturities range from 1 to 10 years.

#### 1.1.8.2.4 *FX Futures*

**FX futures** are standardized exchange traded contracts calling for delivery of a specified quantity of a foreign currency at a fixed date in the future. Investors must post margin, which is marked to market daily. FX futures were introduced in September 1998 on Warsaw Stock Exchange. There were also traded on Warsaw Commodities Exchange and on the Polish Financial Exchange (actually does not exist). All FX futures contracts are settled in cash. A decline in FX futures trading in Poland was caused by the taxation of income FX futures are not securities (according to current law) and are not exempt from income tax).

### 1.1.8.3 Credit Derivatives

### 1.1.8.4 Equity Derivatives

#### 1.1.8.4.1 *Stock Index Futures*

**Stock index futures** specify an equity index as the underlying asset. Stock index futures can only be settled in cash.

#### 1.1.8.4.2 *Stock Futures*

**Stock futures** are futures contracts on individual stocks.

#### 1.1.8.4.3 *Securities Options*

Securities options give the buyer a right to buy or sell the underlying instrument (stock, debt security) at a pre-agreed price.

#### 1.1.8.5 Commodity Derivatives

### 1.1.9 Hedging, Speculation and Arbitrage

Derivative instruments are used to hedge, speculate or arbitrage. It is important to choose between hedging (conservative, passive) management and speculation (aggressive, active) management. There is also a wide range between these two extreme approaches.

#### 1.1.9.1 Hedging

**Conservative management** involves hedging cash flows and cost of capital against price risk, interest rate risk and, currency risk and credit risk. Hedging allows for stabilization of value of assets and equity. The simplest and historical way of hedging is **diversification**. It does not increase returns, but it lowers risk.

Financial markets and especially derivative markets offer participants the opportunity to reduce or eliminate risk through **hedging** which involves taking out counterbalancing contracts to offset existing risks (price risk, currency risk, interest rate risk, credit risk). Derivative instruments may be used to reduce the risk of the firm's cash flows and the risk of the cost of capital. Risk reduction is the main objective for **hedging**.

In hedging, an entity determines whether it has for future periods a short or long exposure. It then takes offsetting position in another asset (either primary or derivative) to reduce such an exposure. The resulting payoff pattern for the combined positions in the two assets is much less variable than before the hedge transaction. Hedging, in principle, is like buying insurance against adverse price movements.

Value of any asset may be defined as the present value of its expected cash flows discounted at the cost of capital (the required rate of return, *RRR*):

$$(2) \qquad V = \sum_{t=1}^{n} \frac{E(CF_t)}{(1+RRR)^t}$$

where $E(CF_t)$ represents the expected cash flows from the assets.

The firm's cash flows and cost of capital depend on commodity price, exchange rate and interest rate volatilities.

Hedging can stabilize the firm's value and hence shareholders' wealth. By managing risks, a firm can stabilize future cash flows and cost of capital and hence stabilize firm value. Reducing strategic risk (cash flow and cost of capital variability) can stabilize a company's:

1. revenues,
2. operating costs,
3. tax burden,
4. cost of debt,
5. market value of equity.

Passive strategies include: buy and hold and indexing. The last involves building a portfolio that will represent the performance of a specified index. Matched-funding techniques (dedicated portfolios, horizon matching, immunizations) are also considered as conservative strategies. Dedication refers to techniques that are used to construct a portfolio of assets with cash flows that will match the future liabilities.

#### 1.1.9.2 Speculation

**Active management** or **speculation** means a company has an open currency gap or interest rate gap and attempts to obtain higher returns in risky environment. It is possible to speculate on future trend or volatility of price movement. **Speculation** is aimed at taking above-average risk with the expectation of receiving substantial returns. Active management includes strategies that attempt to outperform a passive benchmark portfolio. These strategies use derivatives to increase returns. Active strategies rely on financial forecasts.

#### 1.1.9.3 Arbitrage

**Arbitrage** is defined as transaction of buying a security at a low price in one market and simultaneously selling in another market (or at the same market but in different time) at a higher price to make a profit. In efficient markets such opportunities cannot exist. For most of companies arbitrage opportunities do not exist. Arbitrage may be compared to money being left on the street (rare situation, usually small amounts, somebody may raise this money before you bend, even if you see this situation).