1. INTEREST RATE RISK. Term Structure of Interest Rates. Conversions

Investment philosophy and investment strategy
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 (for example issuing equity with high return and high risk) or active (low return and low risk instruments).
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).

Interest rate risk – definitions.

Money markets are the markets for short term and highly liquid debt securities issued by government (treasury bills), national bank (NBP bills), banks (deposits) or corporations (commercial papers).
Treasury bills
NBP money market bills
Interbank deposit market (depo market)
Repurchase agreement (repo, RP) and SBB (sell-buy-back)
Certificates of deposit
Bank short term deposits
Commercial papers
Commercial short term loans
Short term consumer loans

Capital markets are the markets for long-term and less liquid debt securities and stocks.
Treasury bonds
NBP bonds
Local government bonds (municipal bonds).
Bank time deposits
Mortgage bonds
Corporate bonds
Financial lease
Commercial term loans
Mortgage loans
Subscription warrants
Common stock
Consumer term loans

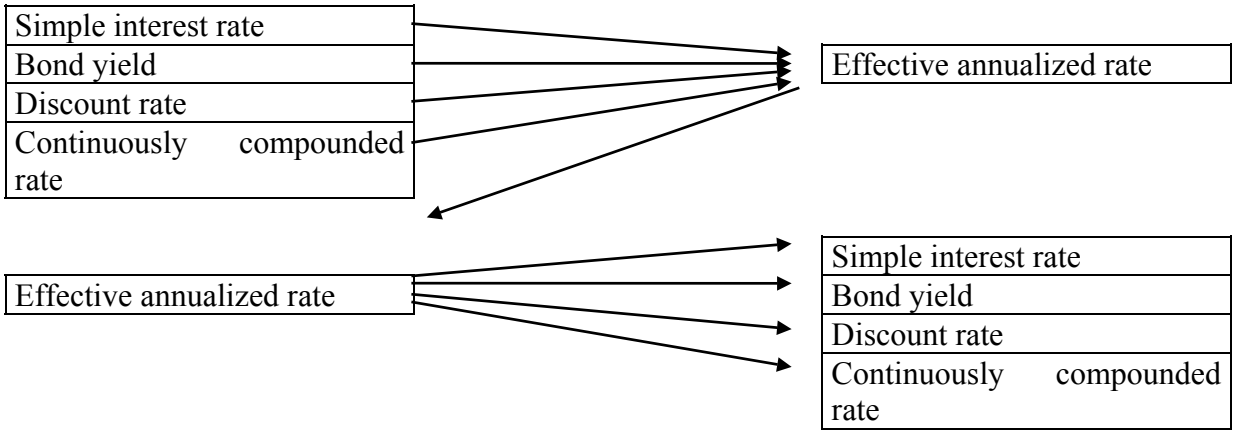
Interest rate derivatives
Interest rate futures
FRA (forward rate agreement)
IR options
Interest Rate Swap (IRS)
Other derivatives include index futures, stock futures, warrants, commodity swaps.

Monetary Policy Council establishes short-term interest rates: **reference rate** (14 days), **lombard rate** (1 day) and **deposit rate** (1 day) and also required obligatory reserves ratio.

NBP policy	Expansionary policy	Restrictive policy
Open market operations	Purchase securities	Sell securities
Reserve requirements	Reduce reserve requirements	Raise reserve requirements
Interest rates	Lower interest rates	Raise interest rates

An Eurodollar deposit. US dollar deposited with a bank outside the USA. This could be a foreign bank or an overseas branch of a US bank.
Foreign bond. A bond sold by a foreign issuer but denominated in the currency of the country in which it is sold.
Eurobond. A bond denominated in a currency other than the national currency of the issuer.

Rate of interest is just rate of return for an investor or in the same time cost of capital for a borrower.



Picture 1. Interest rates conversions

Tabela 1. Effective rates

	Efektywna stopa roczna	Stopa równoważna
Simple interest rate	$i = \left(1 + \frac{rt}{360}\right)^{\frac{365}{t}} - 1$	$r = \frac{360}{t}\left[(1+i)^{\frac{t}{365}} - 1\right]$
Bond yield	$i = \left(1 + \frac{y}{2}\right)^{2} - 1$	$y = 2\left[(1+i)^{\frac{1}{2}} - 1\right]$
Discount rate	$i = \left(\frac{1}{1 - \frac{dt}{360}}\right)^{\frac{365}{t}} - 1$	$d = \frac{360}{t}\left[1 - \frac{1}{(1+i)^{\frac{t}{365}}}\right]$ lub $d = \frac{r}{1 + \frac{rt}{360}}$
Continuously compounded rate	$i = e^{c} - 1$	$c = \ln(1+i)$

Money market yield

A simple interest or money market yield is used for most deposits, loans and many other instruments. The simple rate is

$$y_t = R_t \frac{365}{t} = \frac{\Delta P_t}{P_{t-1}} \frac{365}{t} = \frac{\text{interest}}{\text{principal}} \frac{365}{t}$$

But y_t is not an effective annual rate. The effective annualized rate is

$$i = \left(1 + y_t \frac{t}{365}\right)^{\frac{365}{t}} - 1$$

Problem 1. Money market yield

If you deposit $100 in the bank today and it earns interest at a rate of 10% compounded monthly.
(a) How much will be in the account 12 months from today if you calculate interest on a a/365 basis ?"
What is the effective annualized interest rate ?
(b) What is the effective annualized interest rate on a 30/360 basis ?
(c) What is the equivalent continuously compounded rate ?

Solution

(a)

Month	No of days	Balance	Effective rate
1	31	100,849315	10,470434%
2	28	101,622954	10,474925%
3	31	102,486053	10,470434%
4	30	103,328404	10,471930%
5	31	104,205988	10,470434%
6	30	105,062475	10,471930%
7	31	105,954787	10,470434%
8	31	106,854676	10,470434%
9	30	107,732934	10,471930%
10	31	108,647926	10,470434%
11	30	109,540923	10,471930%
12	31	110,471270	10,470434%

The effective rate for the whole year is equal 10,471270%

(b)

On a 30/360 basis, the effective rate is (1+10%/12)^12= 10,471307%

(c)

The equivalent continuously compounded rate is equal to ln(1+10,47%) = 9,96%.

Discount rate

Some money market instruments (Treasury bills, NBP bills) are quoted on discount rate basis. The discount rate is calculated as the discount divided by the face value of the bill multiplied by the number of periods of length t in a 360-day year:

$$d_t = \frac{\text{discount}}{\text{face value}} \frac{360}{t}$$

Actually in Poland the appropriate yield for bills is calculated (spot rate) on a a/360 days basis.

$$z_t = \frac{\text{discount}}{\text{face value - discount}} \frac{360}{t} = \left(\frac{\text{face value}}{\text{face value - discount}} - 1 \right) \frac{360}{t}$$

It can be shown that two rates are interrelated:

$$d_t = \frac{z_t}{1 + z_t \frac{t}{360}} \quad \text{and} \quad z_t = \frac{d_t}{1 - d_t \frac{t}{360}}$$

Because yield for bills is calculated on a/360 basis, we can calculate the equivalent money market yield:

$$y_t = z_t \frac{365}{360}$$

All the above stated three rates are not annualized returns. The effective annualized rate is

$$i = \left(1 + y_t \frac{t}{365} \right)^{\frac{365}{t}} - 1 \quad \text{or} \quad i = \left(1 + z_t \frac{t}{360} \right)^{\frac{365}{t}} - 1$$

Problem 2. Discount rate and effective rate

The face value of a Treasury bill is 10000 zł. Maturity is 65 days. The yield is 4,50%.
(a) What is the present value of one bill ?
(b) Calculate discount, discount rate, spot rate (a/365) and effective annualized rate.
(c) What is your net income after tax (tax rate is 20 per cent).

Solution

(a)

Price 9919,40

Yield (10000/9919,40 - 1)* 360/65=4,500%

(b)

Discount	80,60 zł
Discount rate	4,464%
Spot rate a/360 (z_t)	4,500%
Spot rate a/365 (y_t)	4,562%
Effective rate (i)	4,649%

$$i = \left(1 + y_t \frac{t}{365} \right)^{\frac{365}{t}} - 1$$

(c)

Interest after tax is equal to 80,60 x 0,8 =64,48.

Problem 3. Discount rate and effective rate

Treasury bills auction on October 2, 2003

Value date	03-10-03
Type of bill	10 tyg.
ISIN	PL0000000790
Maturity	12-12-03
Supply	3500,00 mln zł
Demand	6243,20 mln zł
Accepted offers	3500,00 mln zł
Minimum price	9 899,01 zł
Average price	9 899,77 zł
Maximum price	9 903,71 zł
Maximum yield	5,247%
Average yield	5,207%
Minimum yield	5,000%

(a) Show calculations of maximum, minimum and yield.

(b) Calculate, discount, discounting, rate and effective annualized rate.

Solution

(a)

Number of days to maturity 70

Maximum yield (10000/9899,01 - 1)* 360/70=5,247%

Average yield (10000/9899,77 - 1)* 360/70=5,207%

Minimum yield (10000/9903,71 - 1)* 360/70=5,000%

(b)

Discount	Discount rate	Spot rate	Effective rate
100,99 zł	5,194%	5,247%	5,359%
100,23 zł	5,155%	5,207%	5,318%
96,29 zł	4,952%	5,000%	5,102%

Factors influencing interest rates

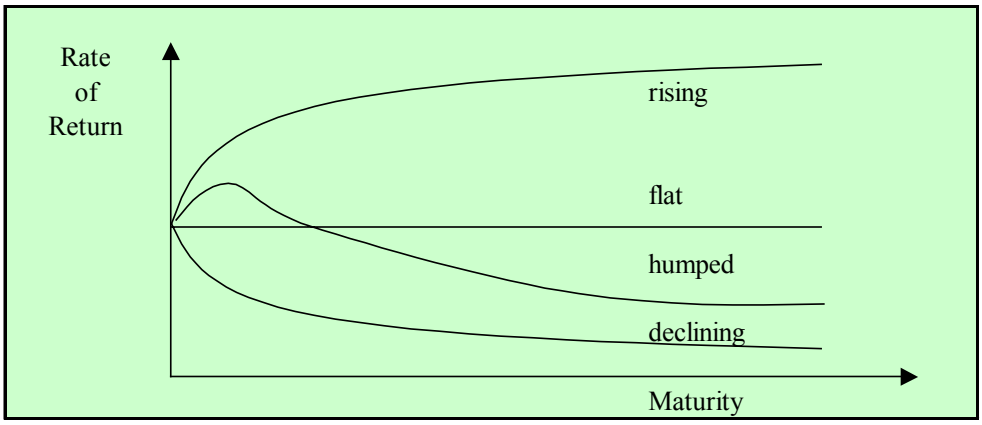
- Maturity (duration)
- Credit risk
- Size of the loan or deposit

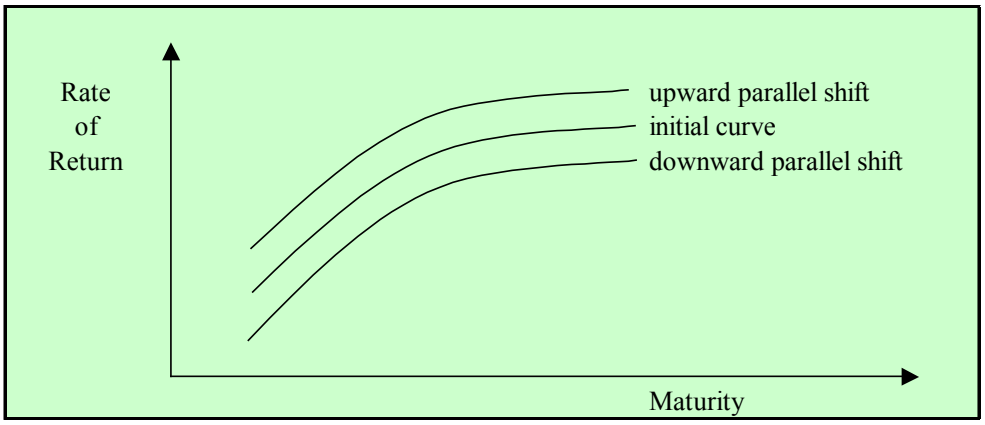
Yield curves

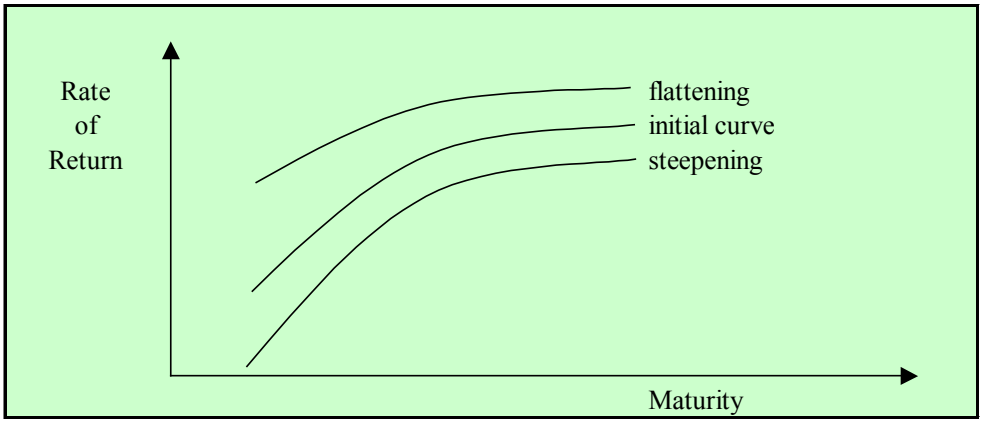
The **term structure of interest rates** is a function that relates the term to maturity to annualized interest rates.

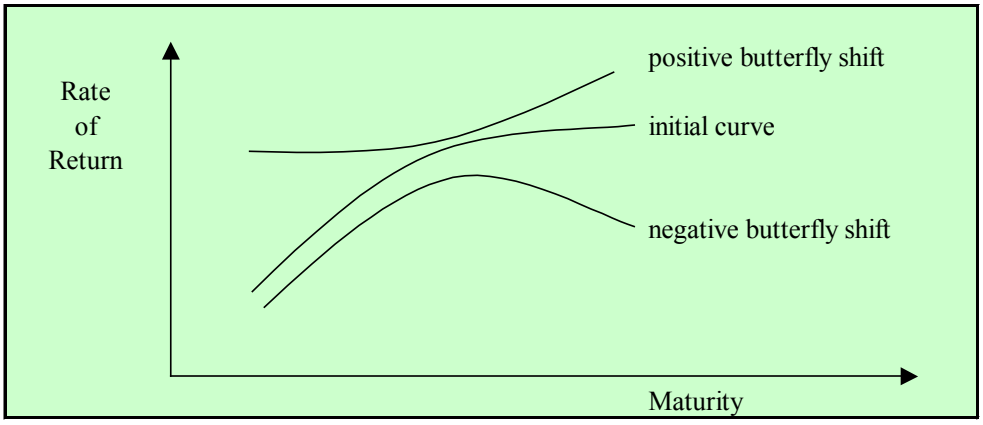
The shape of yield curve is explained by number of theories. The most popular theories are:

- expectations theory,
- liquidity preference theory,
- market segmentation theory.


Rate
of
Return
rising
flat
humped
declining
Maturity


Rate
of
Return
upward parallel shift
initial curve
downward parallel shift
Maturity


Rate
of
Return
flattening
initial curve
steepening
Maturity


Rate
of
Return
positive butterfly shift
initial curve
negative butterfly shift
Maturity