Aalto University
School of Science

# MS-E2114 Investment Science
# Lecture II: Fixed income securities

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# Overview

# This lecture

- **Fixed income securities** are debt instruments which provide (i) returns in the form of regular, or fixed, interest payments and (ii) repayments of the principal when the security reaches maturity
- Refers especially to bonds that pay a periodic, fixed, non-random coupon and other similar instruments
  - E.g., bonds issued by corporations, sovereign states, municipalities, etc.
- The term also encompasses instruments whose interest depends on a reference rate such as EURIBOR
- In this lecture, we derive valuation formulas for several types of fixed income securities

# Overview

Introduction

Annuities

Bonds

Duration

Immunization

Links

# Terminology

- **Financial instruments** are monetary contracts between parties
  - Cash, evidence of ownership, contract to receive cash or other financial instruments
- **Security** = A readily transferable financial instrument which is traded in a well-developed market
  - Governed by laws on public market securities (e.g. regarding insider information)
- **Fixed income instrument** = A financial instrument which provides a preagreed stream of cash flows
  - Interest rate may be fixed or depend on a possibly changing reference rate such as EURIBOR
  - Yet the issuer may **default** (e.g., bankruptcy)
- **Fixed income security** = A fixed income instrument which is a security, too

# Examples of fixed income instruments

- Money market instruments (securities)
  - Tradeable instruments that offer a guaranteed interest (possibly floating-rate) for a short period of time
  - Certificates of deposit offered by banks
  - Short term notes (1 yr or less) by corporations (= commercial paper)
- U.S. government securities
  - Treasury bills ("T-bills") < 1 year
  - Treasury notes 2-10 years
  - Treasury bonds > 10 years
- Other bonds (securities)
  - Municipal bonds (issued by e.g. by cities)
  - Corporate bonds

# Further examples (these are not usually securities)

- **Mortgages** are used by purchasers of real property to raise funds to buy real estate, or alternatively by existing property owners to raise funds for any purpose, while putting a lien on the property being mortgaged
  - **Reverse mortgages** allow owners of home equity to borrow against the value of their home
- **Annuities** provide a series of payments at equal intervals (e.g., regular deposits to a savings account, monthly insurance payments, and pension payment)

# Credit ratings

- Bonds offer a **fixed cash flow** *unless* the issuer defaults
- Ratings provided by credit rating agencies
  - The 'Big Three': Moody's, Standard & Poor's, Fitch
- U.S. Treasury securities have been considered the least risky historically
- Ratings are traditionally grouped into grades of *Investment Grade* (IG) and *High Yield* (HY)
  - Investment grade = Baa3 or better (Moody's), BBB- or better (S&P, Fitch)
  - High yield = Ba1 or worse (Moody's), BB+ or worse (S&P, Fitch)
  - High yield bonds are also known as *junk bonds*
  - `https://en.wikipedia.org/wiki/Credit_rating`

# Market for future cash

- Fixed income securities define the time value of money
- Markets for many types of these securities are extremely well-developed
- Market prices for these securities reflect
  1. Time value of money
  2. Fundamental risk premium (= compensation for the risk that the issuer defaults)
  3. Market price risk premium (= compensation for the risk that the value of the security goes down)
  4. Supply and demand

# Overview

# Perpetual annuity

- Receive $A$ € annually forever starting in a year's time
  - $r$ = interest rate
- The net present value of this cash flow stream is ($r > 0$)

$$P = \sum_{k=1}^{\infty} \frac{A}{(1+r)^k} = \frac{A}{1+r} + \frac{1}{1+r} \sum_{k=1}^{\infty} \frac{A}{(1+r)^k}$$

$$= \frac{A}{1+r} + \frac{P}{1+r}$$

$$\Rightarrow P = \frac{A}{r}$$

- If $A = 25000$ € and $r = 0.1 = 10\%$, then
  $P = 25\,000$ € /0.1= 250 000 €

# Cash flows of finite length

- Get $A$ € annually for the next $n$ years
  - Future cash flows discounted with interest rate $r$
- Present value can be computed from the perpetual annuity by substracting the cash flows that occur after the $n$-th year

$$
\begin{aligned}
P &= \sum_{k=1}^{n} \frac{A}{(1+r)^k} \\
&= \underbrace{\sum_{k=1}^{\infty} \frac{A}{(1+r)^k}}_{\frac{A}{r}} - \underbrace{\sum_{k=n+1}^{\infty} \frac{A}{(1+r)^k}}_{\frac{1}{(1+r)^n} \sum_{k=1}^{\infty} \frac{A}{(1+r)^k} = \frac{1}{(1+r)^n} \frac{A}{r}} \\
\Rightarrow P &= \frac{A}{r}\left(1 - \frac{1}{(1+r)^n}\right)
\end{aligned}
$$

# Examples of streams with finite life

- Get $A = 25\ 000$ € annually for 20 years
  - Interest rate $r = 0.1 = 10\%$

$$P = \frac{25\ 000\text{ €}}{0.1}\left(1 - \frac{1}{(1+0.1)^{20}}\right) = 213\ 000\text{ €}$$

  - PV "only" 37 000 € less than that of the corresponding perpetual annuity on slide 11
  - For high interest rates, the cash flows that occur in the more distant future do not matter that much

# Example: Consumer credit

- Loan $P = 10\,000$ €
  - Interest is paid monthly at the nominal rate of 12% p.a. $\Rightarrow r = 0.12/12 = 0.01$
  - Amortize (=pay back) in 3 years in **equal monthly payments** ($n = 36$)
- What are the monthly payments $A$?
  - Finite life stream with unknown $A$
- Solving the pricing equation on slide 11 for $A$ gives

$$A = \frac{r(1+r)^n P}{(1+r)^n - 1} = \frac{0.01(1+0.01)^{36} 10\,000 \text{ €}}{(1+0.01)^{36} - 1} \approx 332.14\text{€}$$

- Sum of payments $36 \times 332.14$ € $= 11\,957.04$ €
- Amortization table
  - (Loan at $n+1$) = (Loan at $n$) – (Amortization at $n$)

# Example: Consumer credit

| n | Loan capital | Interest | Amort. | Payment | n | Loan ca. | Inter. | Amort. | Paym. |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 10000.0 | 100.0 | 232.1 | 332.1 | | | | | |
| 1 | 9767.9 | 97.7 | 234.5 | 332.1 | 19 | 5169.0 | 51.7 | 280.5 | 332.1 |
| 2 | 9533.4 | 95.3 | 236.8 | 332.1 | 20 | 4888.5 | 48.9 | 283.3 | 332.1 |
| 3 | 9296.6 | 93.0 | 239.2 | 332.1 | 21 | 4605.3 | 46.1 | 286.1 | 332.1 |
| 4 | 9057.4 | 90.6 | 241.6 | 332.1 | 22 | 4319.2 | 43.2 | 289.0 | 332.1 |
| 5 | 8815.9 | 88.2 | 244.0 | 332.1 | 23 | 4030.2 | 40.3 | 291.8 | 332.1 |
| 6 | 8571.9 | 85.7 | 246.4 | 332.1 | 24 | 3738.4 | 37.4 | 294.8 | 332.1 |
| 7 | 8325.5 | 83.3 | 248.9 | 332.1 | 25 | 3443.6 | 34.4 | 297.7 | 332.1 |
| 8 | 8076.6 | 80.8 | 251.4 | 332.1 | 26 | 3145.9 | 31.5 | 300.7 | 332.1 |
| 9 | 7825.2 | 78.3 | 253.9 | 332.1 | 27 | 2845.2 | 28.5 | 303.7 | 332.1 |
| 10 | 7571.3 | 75.7 | 256.4 | 332.1 | 28 | 2541.6 | 25.4 | 306.7 | 332.1 |
| 11 | 7314.9 | 73.2 | 259.0 | 332.1 | 29 | 2234.8 | 22.4 | 309.8 | 332.1 |
| 12 | 7055.9 | 70.6 | 261.6 | 332.1 | 30 | 1925.0 | 19.3 | 312.9 | 332.1 |
| 13 | 6794.3 | 67.9 | 264.2 | 332.1 | 31 | 1612.2 | 16.1 | 316.0 | 332.1 |
| 14 | 6530.1 | 65.3 | 266.8 | 332.1 | 32 | 1296.1 | 13.0 | 319.2 | 332.1 |
| 15 | 6263.3 | 62.6 | 269.5 | 332.1 | 33 | 977.0 | 9.8 | 322.4 | 332.1 |
| 16 | 5993.8 | 59.9 | 272.2 | 332.1 | 34 | 654.6 | 6.6 | 325.6 | 332.1 |
| 17 | 5721.6 | 57.2 | 274.9 | 332.1 | 35 | 329.0 | 3.3 | 328.9 | 332.1 |
| 18 | 5446.6 | 54.5 | 277.7 | 332.1 | 36 | 0.1 | | | |

$\approx 0$

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# Bonds as examples of fixed income securities

- A bond pays its **principal** (also known as **face value** or **par value**) on its **maturity date**
  - E.g. pay a face value of 1000 € on 1.1.2029
- Most bonds pay periodic interest payments (also known as **coupon payments**)
  - **Coupon rate** defined as a percentage of face value
    - E.g., coupon rate 9 % p.a. ⇒ receive 90 € on every 1st of January until 1.1.2029
  - Coupon rate of a par bond (issue price = face value) is close to the prevailing interest rate when the bond is issued
  - If the bond is issued at a discount (issue price is less than face value), then the coupon rate can be less
    - Price appreciation to maturity generates further return to the investor
  - Originally, actual coupons were attached to printed bond certificates

# Bond yield

- **Yield (To Maturity)(YTM)** = Internal rate of return (IRR) of a bond per annum (p.a.) at its current price
  (i) Face value $F$
  (ii) $m$ coupon payments p.a., each payment $C/m$
  (iii) $n$ periods (payments) left to maturity
- If the current price is $P \Rightarrow$, then YTM is the rate $\lambda$ such that

$$P = \frac{F}{[1+(\lambda/m)]^n} + \underbrace{\sum_{k=1}^{n} \frac{C/m}{[1+(\lambda/m)]^k}}_{\text{Finite life stream}}$$

$$\Rightarrow P = \frac{F}{[1+(\lambda/m)]^n} + \frac{C}{\lambda}\left(1 - \frac{1}{[1+(\lambda/m)]^n}\right)$$

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The formula is best understood if you substitute $r = \lambda/m$ as the periodic (e.g. monthly) IRR, and then obtain an annualized rate (= YTM) by linear annualization $\lambda = rm$.

# Bond yield

- As with IRR in general, YTM ($\lambda$) is computed numerically
- **Accrued interest** (AI) tells how much interest the bond has accrued since the last coupon payment
  - Linear interpolation:

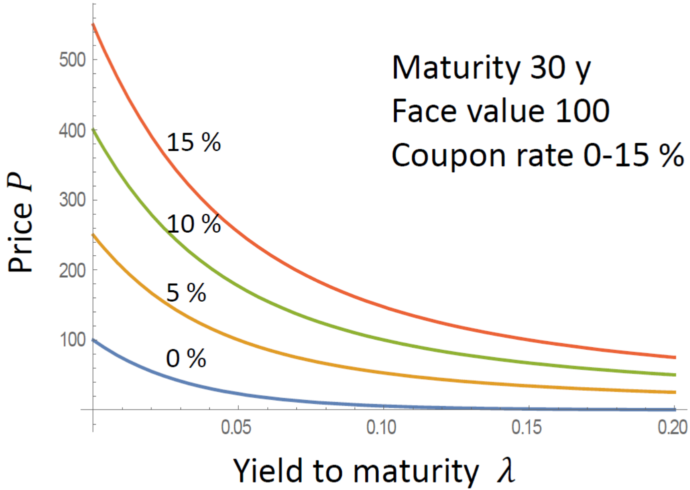
$$AI = \frac{\text{Days since last coupon}}{\text{Days in period}} \times \text{Coupon payment}$$

  - Consider a bond which has face value 1 000€, coupon rate 9 % with coupon payments every Feb 15 and Aug 15.
  - If this bond is bought on May 5, there are 83 days since last coupon payment and 99 days until next payment
  - $AI = \frac{83}{83+99} \times \frac{9\%}{2} \times 1\ 000€ = 20.52€$

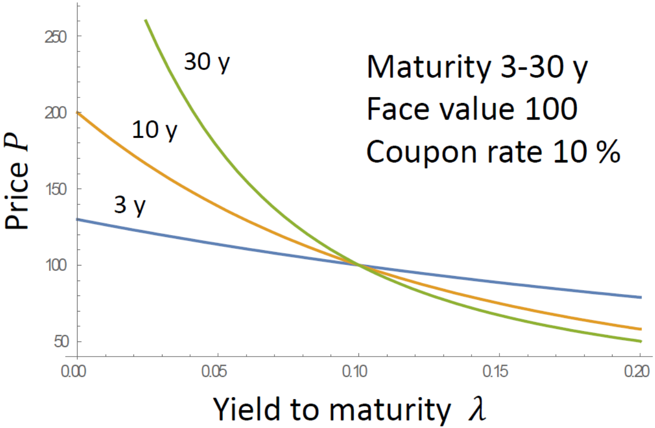
# Example of bond quotes

| U.S. Treasury Quotes Wednesday, January 13, 2016 | | | | | |
|---|---|---|---|---|---|
| Treasury Notes & Bonds | | | | | |
| **Maturity** | **Coupon** | **Bid** | **Asked** | **Chg** | **Asked yield** |
| 1/31/2020 | 1.250 | 99.45 | 99.47 | 0.0469 | 1.385 |
| 1/31/2020 | 1.375 | 99.93 | 99.95 | 0.0234 | 1.389 |
| 2/15/2020 | 3.625 | 108.82 | 108.84 | 0.0391 | 1.393 |
| 2/15/2020 | 8.500 | 128.23 | 128.25 | 0.0547 | 1.369 |
| 2/29/2020 | 1.250 | 99.38 | 99.39 | 0.0703 | 1.402 |
| 2/29/2020 | 1.375 | 99.91 | 99.93 | 0.0938 | 1.393 |
| 3/31/2020 | 1.125 | 98.84 | 98.85 | 0.1250 | 1.407 |
| 3/31/2020 | 1.375 | 99.82 | 99.84 | 0.0859 | 1.415 |
| 4/30/2020 | 1.125 | 98.80 | 98.81 | 0.1094 | 1.411 |
| 4/30/2020 | 1.375 | 99.76 | 99.77 | 0.0703 | 1.429 |
| 5/15/2020 | 3.500 | 108.56 | 108.58 | 0.0703 | 1.451 |
| 5/15/2020 | 8.750 | 130.61 | 130.63 | 0.1094 | 1.437 |
| 5/31/2020 | 1.375 | 99.66 | 99.68 | 0.1172 | 1.451 |
| Coupon: Annual rate (%) | | | | | |
| Ask and bid prices: % of face value | | | | | |
| Chg: Daily change in asked price | | | | | |
| Asked yield: yield to maturity at asked price | | | | | |

# Price-yield curve



# Price-yield curve



# Price-yield curve

- Yield $\lambda = 0$ if and only if the price equals the total cash flow, that is, $P = F + nC/m$
- Yield $\lambda$ equals the coupon rate if and only if price $P$ = face value $F$
- If the yield $\lambda$ increases, the price $P$ of bonds with small coupon rates decline more than the price of bonds with high coupon rates
  - The bigger early coupon payments are less affected by the rising interest rates
- For bonds of longer maturity, the price-yield curve is steeper
  - Steeper curve $\iff$ bond prices are more sensitive to the interest rate

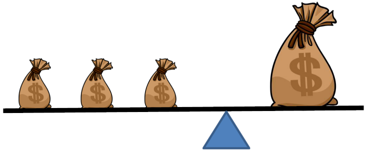
# Overview

# Duration

- Consider the cash flow stream $(c_0, c_1, \ldots, c_n)$ which gives $c_i$ at time $t_i, i = 0, \ldots, n$
- The **duration** of this cash flow stream is

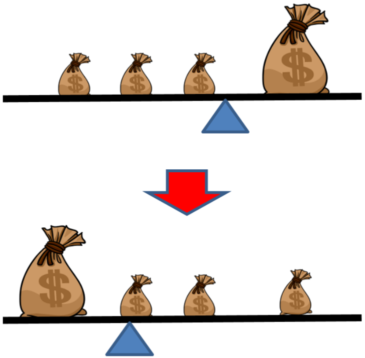
$$D = \frac{PV(t_0)t_0 + PV(t_1)t_1 + \cdots + PV(t_n)t_n}{PV},$$

  where $PV(t_i), i = 0, 1, \ldots, n$ is the present value of $c_i$ and $PV = PV(t_0) + \cdots + PV(t_n)$
- This is the PV weighted average of the payment times $t_0, t_1, \ldots, t_n$ of the cash flow stream $(c_0, c_1, \ldots, c_n)$
  - $i$-th weight = share of the $PV(t_i)$ out of the total $PV$
  - By definition, these weights add up to one



# Duration

- Duration is a measure of the bond's 'average' maturity
  - If there are no coupons, then duration = maturity
  - If there are coupons, then duration < maturity
  - For two bonds with the same total cash flow (i.e., coupons + face value), the duration is shorter for the one with higher coupon rate



# Macaulay duration

- What interest rate $r$ should one use when computing duration?
- Macaulay duration: $r$ = YTM

$$\Rightarrow \quad D = \frac{\sum_{k=1}^{n} \frac{k}{m} \frac{c_k}{(1+\frac{\lambda}{m})^k}}{PV}, \text{ where}$$

$$PV = \sum_{k=1}^{n} \frac{c_k}{(1+\frac{\lambda}{m})^k}$$

- For bonds (derived in exercises)

$$D = \frac{1+y}{my} - \frac{1+y+n(c-y)}{mc[(1+y)^n - 1] + my}, \text{ where}$$

$m$ = periods per year $\quad$ $n$ = nr of periods left

$y = \lambda/m$ = yield per period $\quad$ $c$ = coupon rate

# Modified duration

- The present value of cash flow $c_k$ is

$$PV_k = \frac{c_k}{[1 + (\lambda/m)]^k}$$
$$\Rightarrow \frac{dPV_k}{d\lambda} = -\frac{(k/m)c_k}{[1 + (\lambda/m)]^{k+1}} = -\frac{(k/m)PV_k}{1 + (\lambda/m)}$$

- The price sensitivity of a bond is

$$P = \sum_{k=1}^{n} PV_k$$
$$\Rightarrow \frac{dP}{d\lambda} = \sum_{k=1}^{n} -\frac{(k/m)PV_k}{1 + (\lambda/m)} = -\frac{1}{1 + (\lambda/m)} \frac{\sum_{k=1}^{n}(k/m)PV_k}{P} P$$
$$\Rightarrow \frac{dP}{d\lambda} = -\frac{1}{1 + (\lambda/m)} DP = -D_M P,$$

where $D_M$ is the **modified duration** $D_M = D/[1 + (\lambda/m)]$

# Applying modified duration

- Consider a bond such that
  - Maturity 30 y, no coupons (i.e., coupon rate 0 %)
- Assume that interest rates rise from 10 % to 11%

$$\lambda \to \lambda + \Delta\lambda, \quad \lambda = 0.1, \Delta\lambda = 0.01$$

- No coupons $\Rightarrow D =$ Maturity $\Rightarrow D_M = 30/[1 + 0.1] \approx 27.27$
- Linear approximation:

$$\Delta P \approx -D_M P \Delta\lambda$$
$$\Rightarrow \frac{\Delta P}{P} \approx -D_M \Delta\lambda = -27.27 \times 0.01 = -27.27\%$$

  - Price approx. sinks by 27 % if the interest rate rises by 1%

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The actual price drop when yield changes from 10% to 11% is 23.78%. For smaller changes the approximation is more accurate: For 0.1% change, the drop is 2.689% and for 0.01% change, 0.2723%.

# Application of modified duration

- Consider another bond with
  - Maturity 30 y, coupon rate 10 %, 2 coupons per year
  - Price = face value, i.e., YTM is 10 %
- Macaulay duration
  $D = 9.938 \Rightarrow D_M = 9.938/[1 + (0.1/2)] \approx 9.47$
- Price change

$$\frac{\Delta P}{P} \approx -D_M \Delta\lambda = -9.47 \times 0.01 = -9.47\%$$

  - The relatively decline in price is now much less because of the coupon payments

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The actual price drop when yield changes from 10% to 11% is 8.72%. For smaller changes the approximation is more accurate: For 0.1% change, the drop is 0.9386% and for 0.01% change, 0.09457%.

# Duration of a portfolio

- **Portfolio** of bonds = a collection consisting of a set of $m$ bonds
- Price $P = P_1 + P_2 + \cdots P_m$
  - $P_i$ = price of bond $i = 1, 2, \ldots, m$

Theorem

*(**Duration of a portfolio**) Suppose there are m fixed-income securities with prices and durations of $P_i$ and $D_i$, respectively, $i = 1, 2, \ldots, m$, all computed using the same yield. Then the price P and duration D of the portfolio consisting of the aggregate of these securities are*

$$P = P_1 + P_2 + \cdots + P_m$$
$$D = w_1 D_1 + w_2 D_2 + \cdots + w_m D_m,$$

*where* $w_i = P_i / P, i = 1, 2, \ldots, m$

# Duration of a portfolio

- **Proof.** Outline for the case of two securities $A$ and $B$:

$$D^{A+B} = \sum_{k=0}^{n} \frac{PV_k^{A+B} t_k}{P^{A+B}}$$

$$D^{A} = \sum_{k=0}^{n} \frac{PV_k^{A} t_k}{P^{A}}$$

$$D^{B} = \sum_{k=0}^{n} \frac{PV_k^{B} t_k}{P^{B}}$$

$$\Rightarrow P^A D^A + P^B D^B = \sum_{k=0}^{n} t_k \left( PV_k^A + PV_k^B \right)$$

# Duration of a portfolio

- Divide both sides of equation by $P = P^{A+B} = P^A + P^B$

$$\Rightarrow \frac{P^A D^A + P^B D^B}{P} = \frac{\sum_{k=0}^{n} t_k \left(PV_k^A + PV_k^B\right)}{P} = D$$

$$\Rightarrow D = \frac{P^A}{P} D^A + \frac{P^B}{P} D^B$$

- By definition, duration of a portfolio of A and B is

$$D^{A+B} = \sum_{k=0}^{n} \frac{t_k PV_k^{A+B}}{P^{A+B}} = \sum_{k=0}^{n} \frac{t_k PV_k^{A+B}}{P}$$

- Thus, $PV_k^{A+B} = PV_k^A + PV_k^B$ implies $D^{A+B} = D$
  - Holds when payments from A and B are discounted with the same rate for each period $k$, assuming the same yield
  - This assumption of identical interest rates does not hold for Macaulay duration which uses YTM for each bond

# Overview

# Immunization

- **Immunization** is the development of an investment strategy when:
  - An investor has a liability stream (a cash flow stream the investor has to pay) that is sensitive to interest rates
  - He or she wants to construct an investment portfolio to match this liability stream both in terms of
    - present value and
    - interest rate sensitivity
- The combination of the portfolio and the liability stream is insensitive (immune) to (small) interest rate changes
- If an investor wants to immunize a bond portfolio, then he or she may have to short other bonds, which may be difficult or expensive in practice

# Immunization

- **Principle**: Buy a portfolio of equal NPV whose interest rate sensitivity is the same as that of the liability stream being immunized
- If there are zero coupon bonds with many enough maturities, then perfect matching of cash flows is possible
  - Would match interest rate sensitivities exactly
  - This is difficult, however, because zero coupon bonds are rare and there may be no bonds whose maturities coincide with those of the cash flows of the portfolio
- The other method is to use **duration**
  - First-order (i.e., first derivative) approximation of interest rate sensitivity

# Immunization

- **Task**: Immunize a liability stream with duration $D$ and price $P$
- Bonds $A$ and $B$ available for immunization
- Buy $A$ and $B$ for total amount $V_A$ and $V_B$ (unit price times units bought) such that

$$P = V_A + V_B$$
$$D = w_A D_A + w_B D_B, \text{ where}$$
$$w_i = \frac{V_i}{P}, i = A, B$$

- In practice, more than two bonds would used
  - Helps diversify risk (of default)
  - Leads to more variables than equations $\Rightarrow$ there can be many solutions

# Example: Immunization

- A company is liable to pay 1 million € in 10 years
  - No coupons ⇒ Duration 10 y
- Immunize using the following three bonds whose face value is 100 € and which pay two coupons per year

| Bond | Coupon rate | Maturity (y) | Price (€) | YTM | Duration (y) |
|---|---|---|---|---|---|
| 1 | 6% | 30 | 69 | 9% | 11.44 |
| 2 | 11% | 10 | 113 | 9% | 6.54 |
| 3 | 9% | 20 | 100 | 9% | 9.61 |

- The PV of the liability at the prevailing rate is

$$P = \frac{1\,000\,000€}{[1 + (0.09/2)]^{20}} \approx 414\,634€$$

# Example: Immunization

- If we use bonds 1 & 2

$$\begin{cases} P &= V_1 + V_2 \\ D &= \frac{V_1}{P} D_1 + \frac{V_2}{P} D_2 = 10 \end{cases}$$

$$\Rightarrow \begin{cases} V_1 &= P \frac{D - D_1}{D_1 - D_2} \approx 292\ 788 \\ V_2 &= P \frac{D_1 - D}{D_1 - D_2} \approx 121\ 854 \end{cases}$$

$$\Rightarrow \begin{cases} \frac{V_1}{P_1} &= \frac{292\ 788}{69} = \textbf{4241 units of bond \# 1} \\ \frac{V_2}{P_2} &= \frac{121\ 854}{113} = \textbf{1078 units of bond \# 2} \end{cases}$$

# Example: Immunization

- If we use bonds 2 & 3
  - No solution with positive amounts of bonds (weighted average of $D_2 = 6.54$ and $D_3 = 9.61$ less than $D = 10$ with all positive weights)

$$\begin{cases} V_2 & = P\frac{D_3 - D}{D_3 - D_2} \approx -52\ 575 \\ V_3 & = P - V_2 \approx 467\ 317 \end{cases}$$

$$\Rightarrow \begin{cases} \frac{V_2}{P_2} & = -\frac{52\ 575}{113} = \textbf{sell short 465 units of bond \# 2} \\ \frac{V_3}{P_3} & = \frac{467\ 317}{100} = \textbf{purchase 4673 units of bond \# 3} \end{cases}$$

# Example: Immunization

| | | Percent yield | | |
|---|---|---|---|---|
| | | 9.0 | 8.0 | 10.0 |
| Bond 1 | Price | 69.04 | 77.38 | 62.14 |
| | Shares | 4241.00 | 4241.00 | 4241.00 |
| | Value | 292798.64 | 328168.58 | 263535.74 |
| Bond 2 | Price | 113.01 | 120.39 | 106.23 |
| | Shares | 1078.00 | 1078.00 | 1078.00 |
| | Value | 121824.78 | 129780.42 | 114515.94 |
| Obligation | Value | 414642.86 | 456386.95 | 376889.48 |
| Surplus | | -19.44 | 1562.05 | 1162.20 |

# Overview

# Links

- Bloomberg bond rates
- Statistics on the Finnish central government debt
- Information on credit ratings
- Credit ratings of Finland
- Euro area yield curves
- Russia government bonds
- 10-year government bond spreads
- Debt structure of Stora Enso
- S&P credit rating of Stora Enso
- List of sovereign debt crises
- List of stock market crashes and bear markets

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