# TEACHING AN OLD DOG NEW TRICKS

## OUR FAIR PRICE ENGINE

ILARIA PICCIRILLI

DYALOG USER MEETING 2018

SimCorp

# MY FAB TEAM AND ME

- **6 Programmers**: 4 based in Milan, 1 in Pistoia, 1 in Trieste
- 3 graduated in Mathematics, 2 in Physics, 1 Actuary
- Pair Programming
- Work Alone
- Shared Analysis

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# MAGIC TEAM

# SOFIA

# SimCorp Sofia

- **Integrated System for Institutional Investors**
- **Position Keeping**
- **Risk Management**

# PRICING


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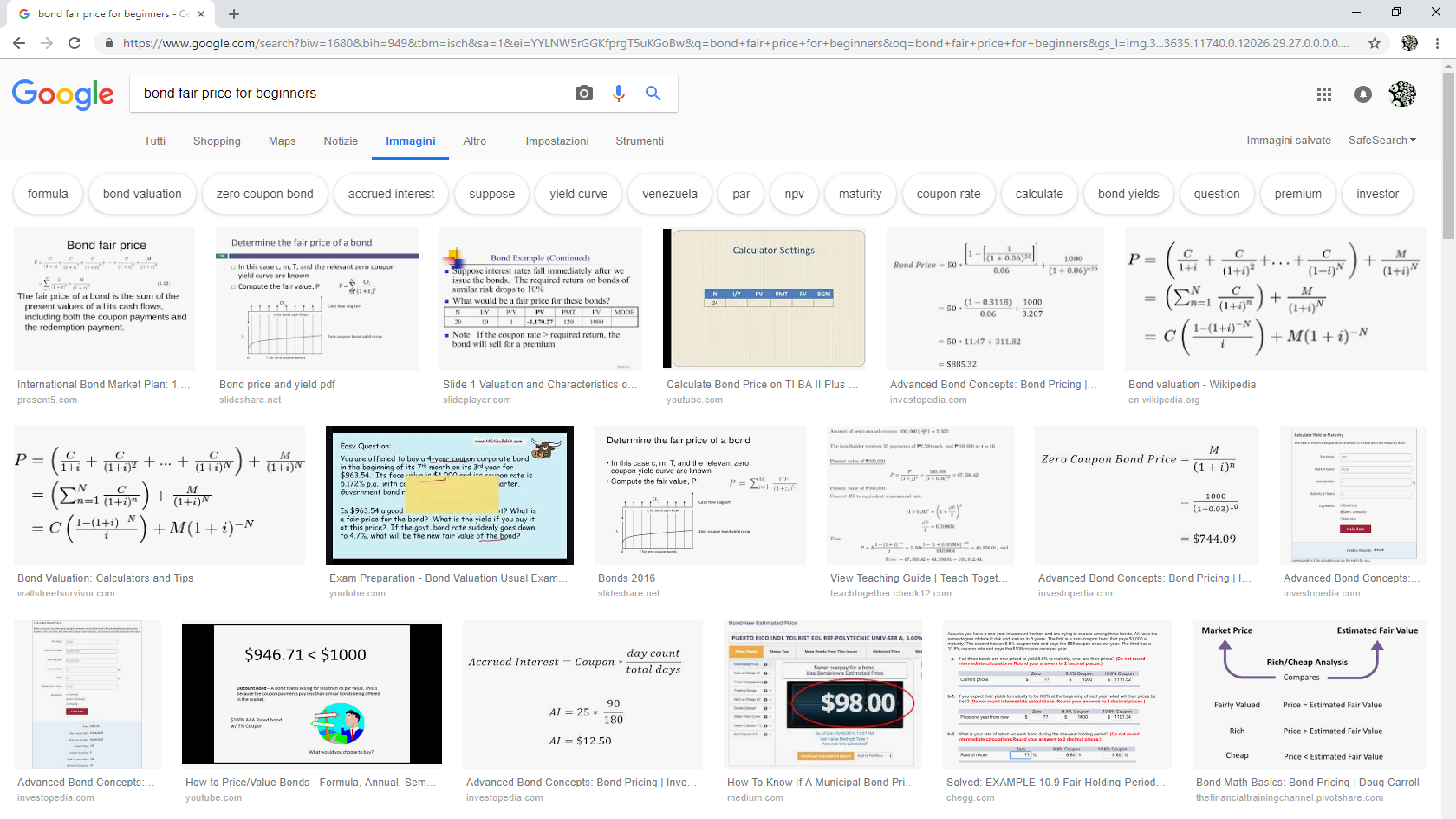
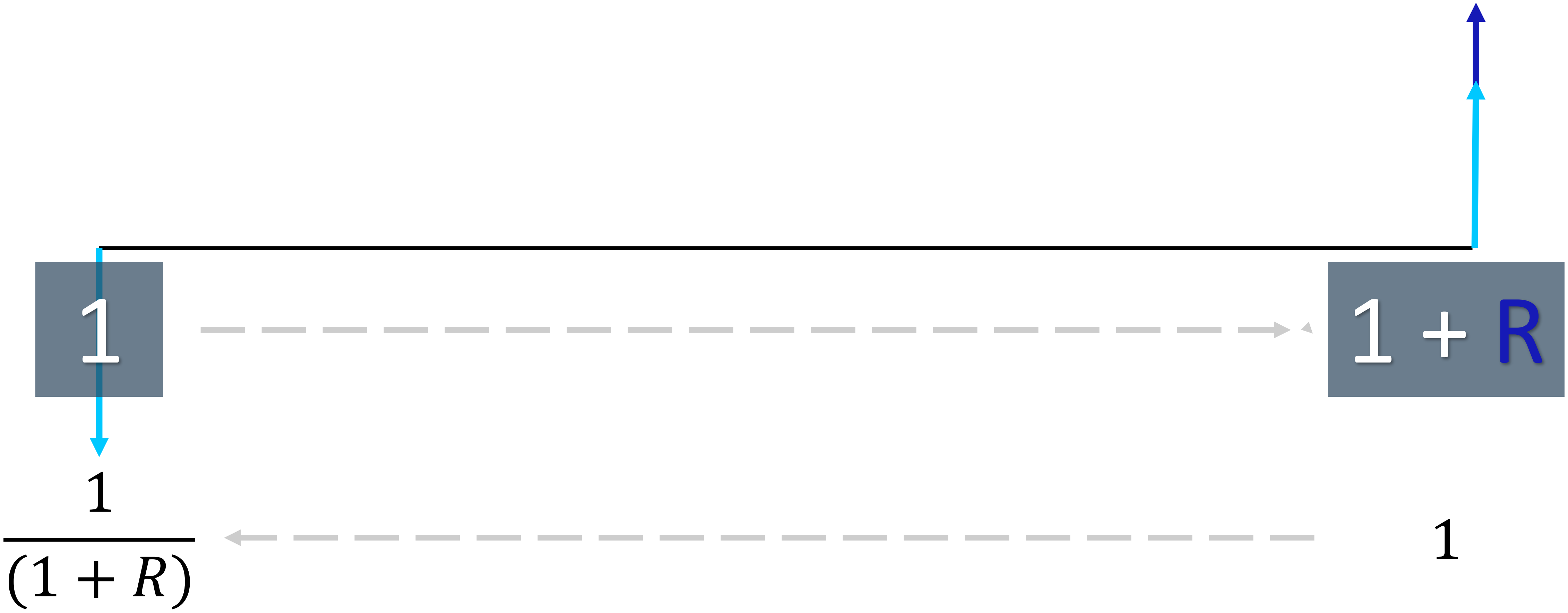
# BOND

THREE PER CENT LOAN OF 1898.
1898 1918
The United States of America
ARE INDEBTED UNTO THE BEARER IN THE SUM OF
20 TWENTY DOLLARS 20 TWENTY DOLLARS 20
This bond is issued under authority of an Act of Congress entitled "An Act to provide ways and means to meet war expenditures" approved June thirteenth eighteen hundred and ninety eight, and is redeemable at the pleasure of the United States after the first day of August 1908, and payable August 1, 1918 in coin, with interest at the rate of three per centum per annum payable quarterly in coin on the first day of November, February, May and August in each year. The principal and interest are exempt from all taxes or duties of the United States as well as from taxation in any form by, or under State, municipal or local authority.
Washington D.C. August 1, 1898.
Entered
Recorded
Act of June 13 1898.
Register of the Treasury
○34597○
○34597○
UNITED STATES OF AMERICA
AUG. 1918
MAY 1918
FEBY 1918
NOVR 1917
AUG. 1917
15 CTS.



bond fair price for beginners - Co
https://www.google.com/search?biw=1680&bih=949&tbm=isch&sa=1&ei=YYLNW5rGGKfprgT5uKGoBw&q=bond+fair+price+for+beginners&oq=bond+fair+price+for+beginners&gs_l=img.3...3635.11740.0.12026.29.27.0.0.0.0....
Google
bond fair price for beginners
Tutti
Shopping
Maps
Notizie
Immagini
Altro
Impostazioni
Strumenti
Immagini salvate
SafeSearch
formula
bond valuation
zero coupon bond
accrued interest
suppose
yield curve
venezuela
par
npv
maturity
coupon rate
calculate
bond yields
question
premium
investor
Bond fair price
The fair price of a bond is the sum of the present values of all its cash flows, including both the coupon payments and the redemption payment.
International Bond Market Plan: 1....
present5.com
Determine the fair price of a bond
Bond price and yield pdf
slideshare.net
Bond Example (Continued)
Slide 1 Valuation and Characteristics o...
slideplayer.com
Calculator Settings
Calculate Bond Price on TI BA II Plus ...
youtube.com
= $885.32
Advanced Bond Concepts: Bond Pricing |...
investopedia.com
Bond valuation - Wikipedia
en.wikipedia.org
Bond Valuation: Calculators and Tips
wallstreetsurvivor.com
Easy Question:
Exam Preparation - Bond Valuation Usual Exam...
youtube.com
Determine the fair price of a bond
Bonds 2016
slideshare.net
View Teaching Guide | Teach Toget...
teachtogether.chedk12.com
Zero Coupon Bond Price
= $744.09
Advanced Bond Concepts: Bond Pricing | I...
investopedia.com
Advanced Bond Concepts:...
investopedia.com
Advanced Bond Concepts:...
investopedia.com
$946.71 < $1000
How to Price/Value Bonds - Formula, Annual, Sem...
youtube.com
Accrued Interest = Coupon * day count / total days
AI = 25 * 90/180
AI = $12.50
Advanced Bond Concepts: Bond Pricing | Inve...
investopedia.com
Bondview Estimated Price
$98.00
How To Know If A Municipal Bond Pri...
medium.com
Solved: EXAMPLE 10.9 Fair Holding-Period...
chegg.com
Market Price
Estimated Fair Value
Rich/Cheap Analysis
Compares
Fairly Valued
Price = Estimated Fair Value
Rich
Price > Estimated Fair Value
Cheap
Price < Estimated Fair Value
Bond Math Basics: Bond Pricing | Doug Carroll
thefinancialtrainingchannel.pivotshare.com

# ZERO COUPON BOND





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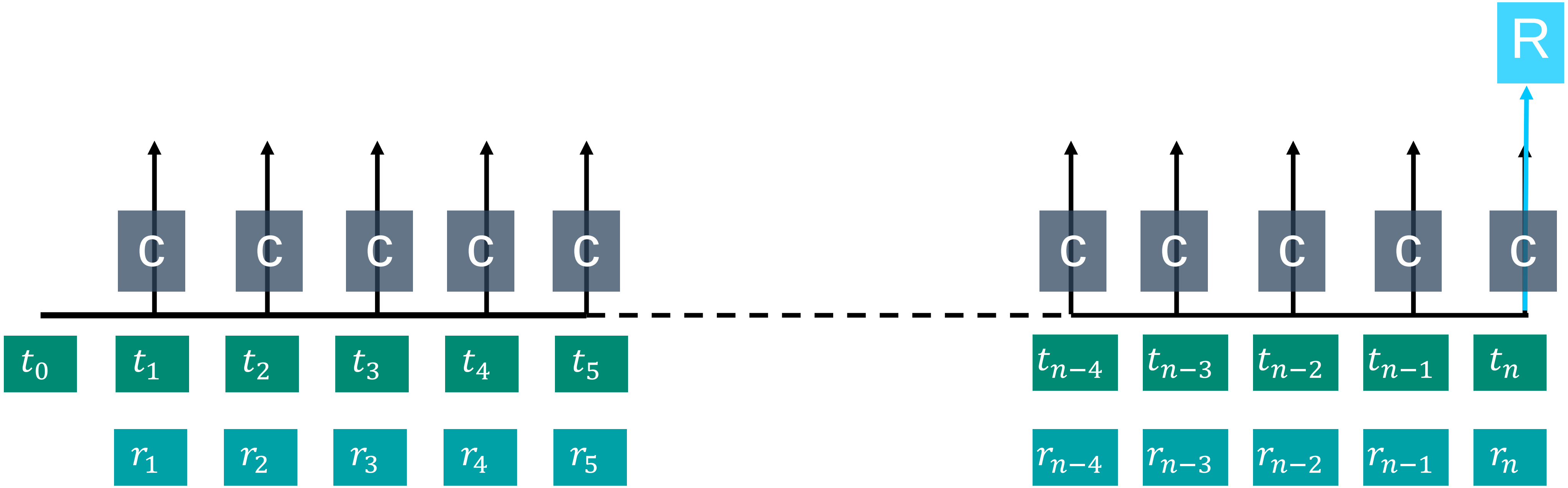
# FIXED COUPON BOND




$$P=\sum_{i=0}^{n}\frac{c}{(1+r_i+s)^{t_i}}+\frac{R}{(1+r_n+s)^{t_n}}$$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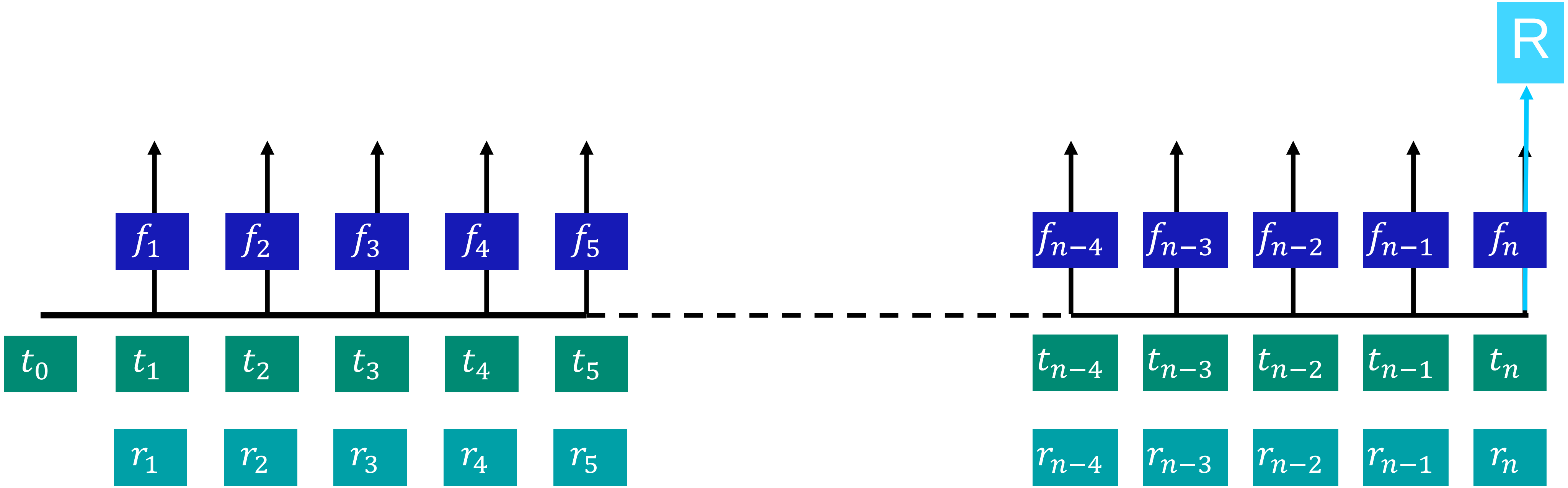
# FLOATER COUPON BOND




$$P = \sum_{i=0}^{n} \frac{f_i}{(1+r_i+s)^{t_i}} + \frac{R}{(1+r_n+s)^{t_n}}$$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In the beginning was the Pricing

and the Pricing was with the Engine

and the Pricing was the Engine

# BOND FAIR PRICE CALCULATION

**SECURITY INFORMATION**

**CREDIT SPREAD**

**TERM STRUCTURE OF INTEREST RATES**

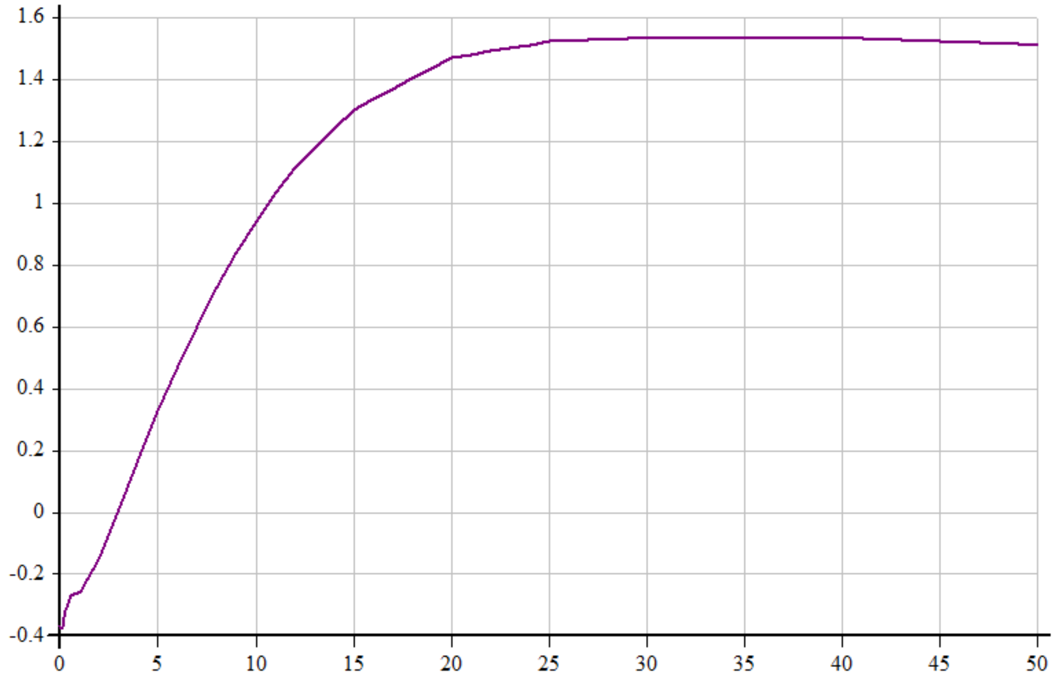
**GETSpr**

**GETCurve**

**No holding information is needed, we need just the security specifications**

$$P = \sum_{i=0}^{n} \frac{f_i}{(1+r_i+s)^{t_i}} + \frac{R}{(1+r_n+s)^{t_n}}$$

**FAIR PRICE**

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# THE ENGINE BIRTH

## STEP 1: STRESS TEST- MANAGING TWO CURVES

The 30/12/2005 Italian regulator asked the Insurance Companies to analyse the behaviour of the portfolio under market shocks as:

- Interest rates
- FX rates
- Credit Spread
- Equity Indices

### STRESS TEST MODULE

It's based on a full repricing approach and It allows to define market scenarios taking into account changes in interest rates, credit spread, equity indices, fx rates


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# FAIR PRICE ENGINE



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# STRESS TEST MODULE

## STEP 1: STRESS TEST- MANAGING TWO CURVES

**SECURITY INFORMATION**

**2 Spread:**
- Mkt spread
- Stressed spread

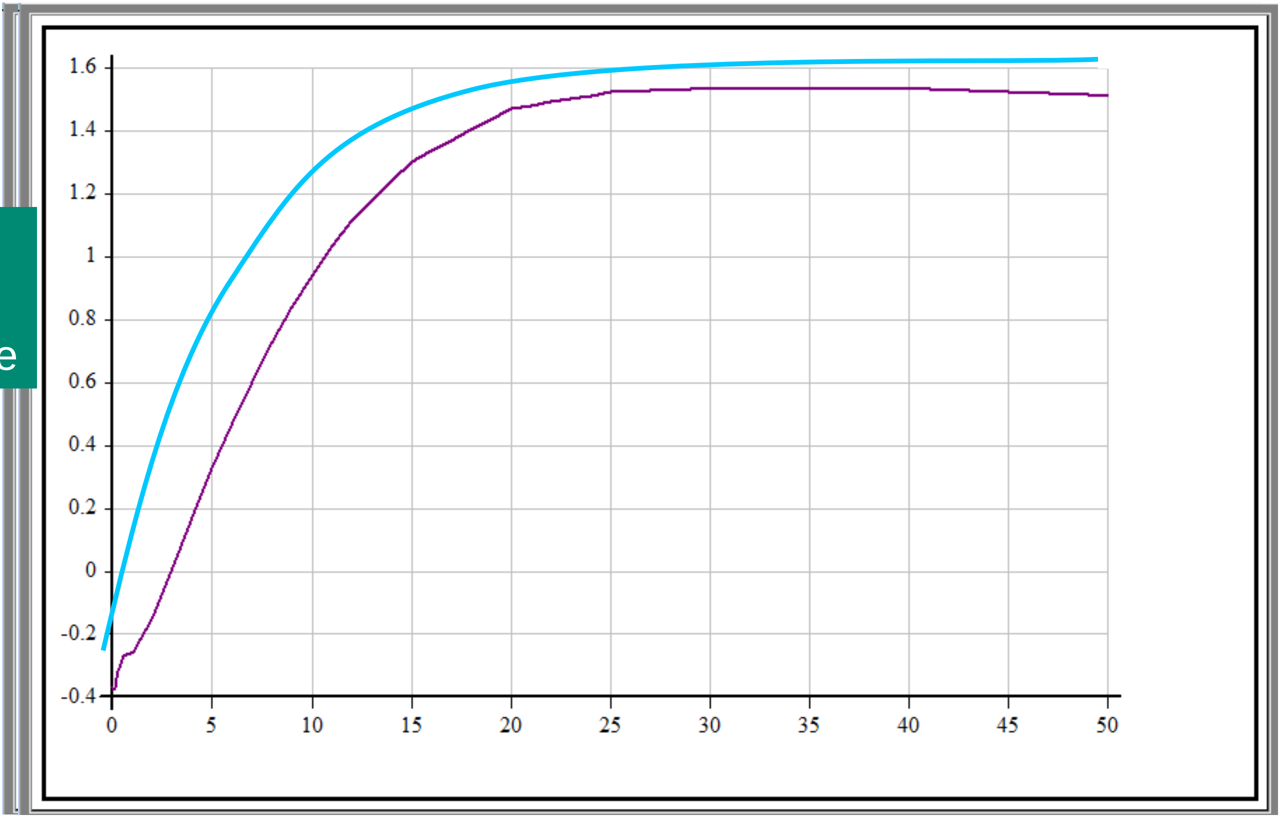
**GETSpr**

**GETCurve**

**2 CURVES:**
- Mkt curve
- Stressed curve

**STRESSED PRICE**

**No holding information is needed, we need just the security specifications**





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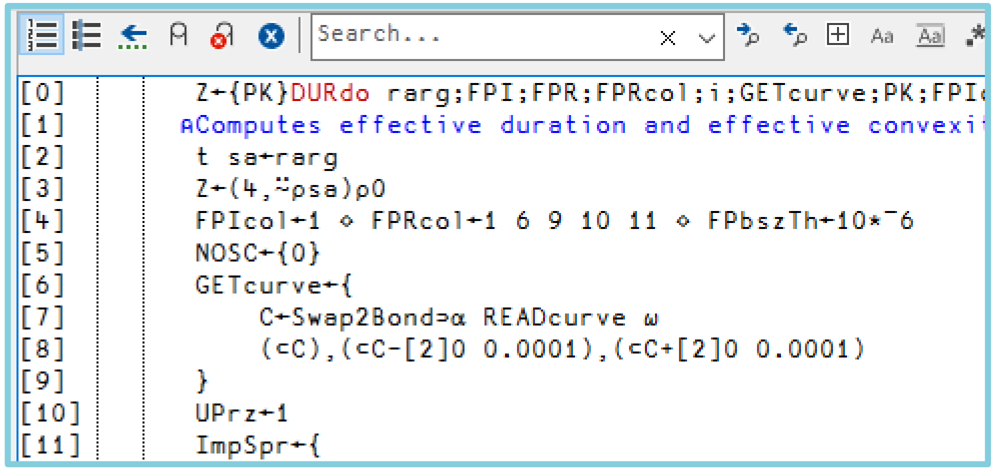
Tilted Curve
2,5
2
1,5
1
0,5
0
-0,5
-1
0,00
100,00
200,00
300,00
400,00
500,00
600,00
700,00

# SIDE EFFECT

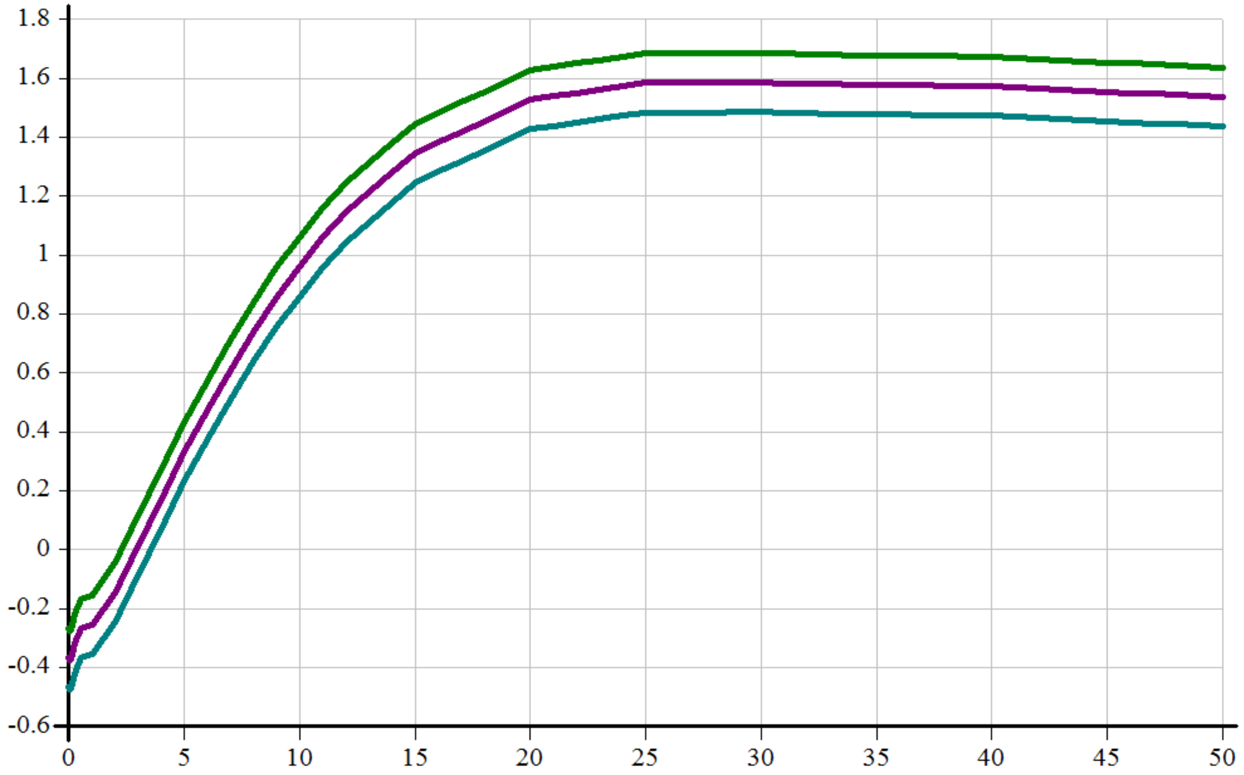
## BORN JUNE 2006

- Effective Duration
- Spread Duration

$$D = \frac{P_{-} - P_{+}}{2Ph}$$



```
Z←{PK}DURdo rarg;FPI;FPR;FPRcol;i;GETcurve;PK;FPI
⍝Computes effective duration and effective convexi
t sa←rarg
Z←(4,⍨⍴sa)⍴0
FPIcol←1 ⋄ FPRcol←1 6 9 10 11 ⋄ FPbszTh←10*¯6
NOSC←{0}
GETcurve←{
    C←Swap2Bond⊃⍺ READcurve ⍵
    (⊂C),(⊂C-[2]0 0.0001),(⊂C+[2]0 0.0001)
}
UPrz←1
ImpSpr←{
```





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# THE ENGINE EVOLUTION

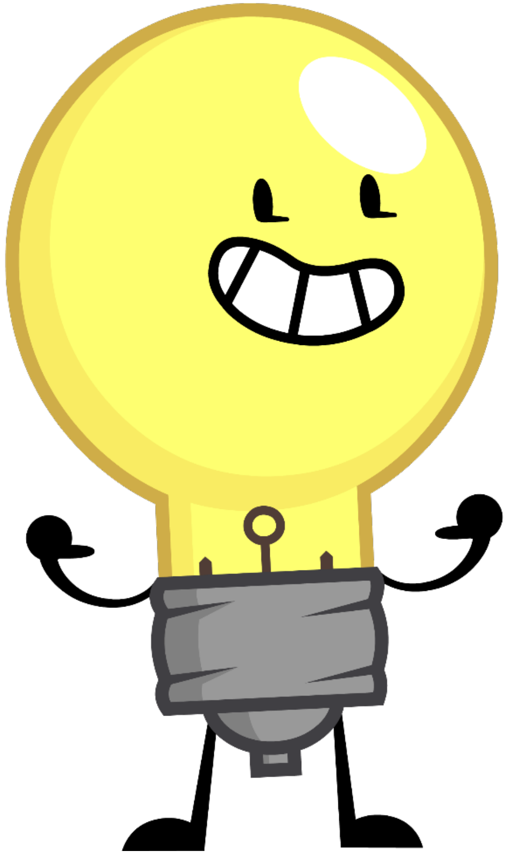
## INTEGRATE THE CALCULATION CORE WITH THE ALM MODULE

**Fair Price:**

- 1 Curve
- Credit Spread

**Stress Test: 2 Curves**

- 2 curves
- 2 spreads: implied Stressed spread



**Asset Liabilities Management:**

- Many curves: a Forward Curve for every end of month for at least 5 years
- 2 spreads: Mkt spread and user defined spread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# ASSETS LIABILITIES MANAGEMENT

- Projection of portfolio future value and expected cash flows for both assets and liabilities
- Time horizon of many years → multiple forward dates

## ASSETS:

- Interest rate risk and liquidity risk
- Credit risk rescaling scenarios
- Prices (including embedded options prices), flows, accruals, callable bonds moneyness, durations
- Future buys and sells

## LIABILITIES:

- Clustering of policies into model points
- Projection of future deaths, surrenders, etc… and corresponding cash flows


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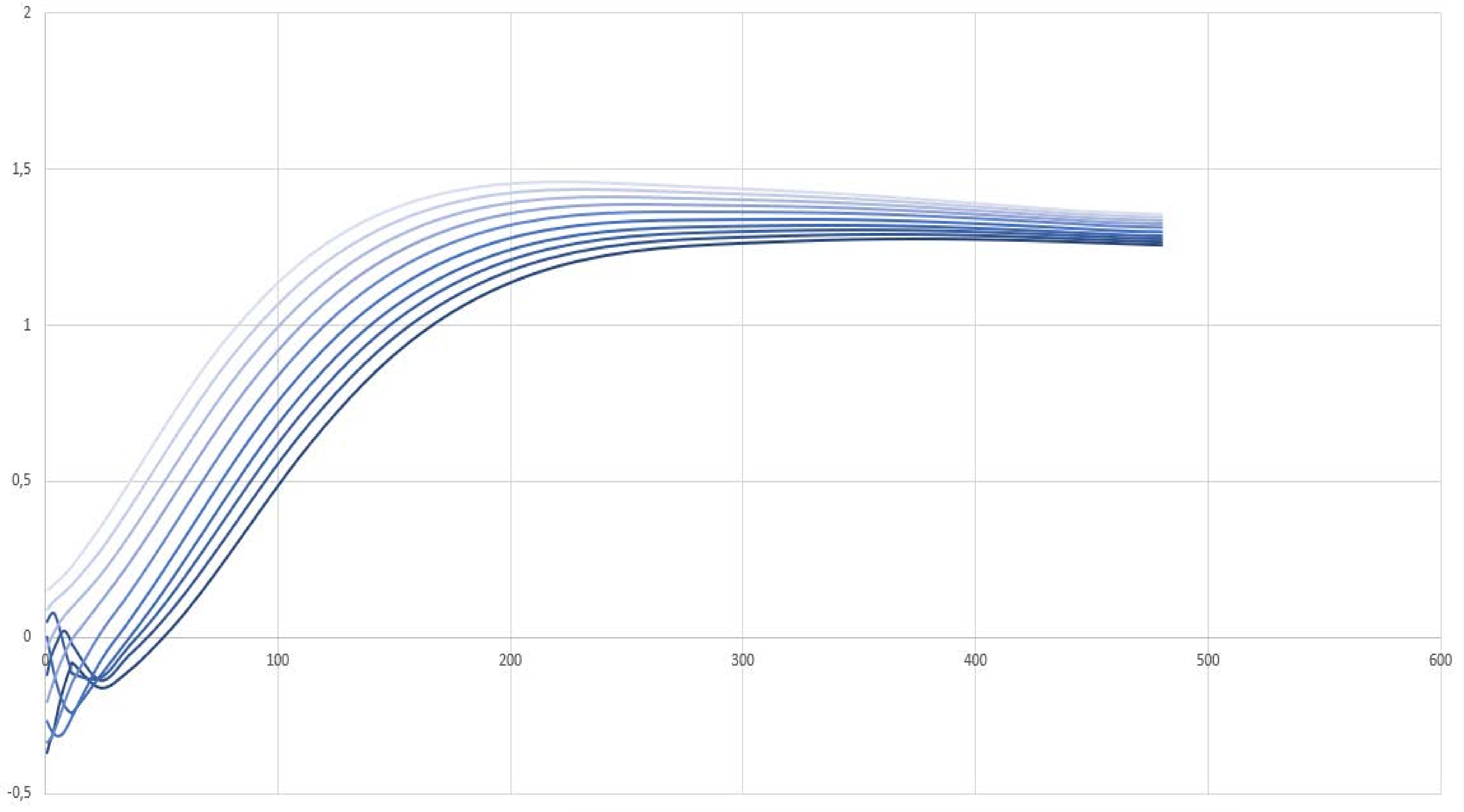
2
1,5
1
0,5
0
-0,5
0
100
200
300
400
500
600

# ALM MODULE

## STEP 2: MANAGING A FAMILY OF FORWARD CURVES

**SECURITY INFORMATION**

**Spread:**
- Implied spread
- User Defined

**GETSpr**

**GETCurve**

**A CURVE FAMILY**
- Mkt curve
- Fwd curve

**FWD CASHFLOWS**
**&**
**FWD PRICES**

**No holding information is needed, we need just the security specifications**

- Buy and sell Fictitious Assets in the forecast.
- Rebalancing calculation mechanism: Simulation of buys and sells, calculation of new holdings values

```
Z←t GETcurve sela
⍝
Z←t READcurve sela
⍝∘ (c)APLIT b NFP mbl 02/03/2006 14:16
```

```
Z←{PK}ALMdo rarg;FPI;FPR;FPRcol;i;GETcurve;PK;FPIcol;SA;D;L2;FLD;R;ex
uGSTK',bNFP,bSTR'
OPENsmt'sprval'
_←#.CLOSEsmt uDefer'sprval'
NOftz←{ω×ω≤ρd235}
alm←1 ⋄ t sa ftz←rarg ⋄ NOboot←1
FPdt←∪t,{ω[⍋ω]}(t≤DTC)/DTC
Nc←ρFPdt ⋄ MD C F IRR CNVX CPN ACCR ICALL←⊂0ρ⍨Nc,⍨ρsa,ftz
Nc+←1 ⋄ P←(Nc,⍨ρsa,ftz)ρ0 ⋄FLOWS←0 11ρ0 ⋄ C1lITM←0 5ρ0 ⋄ AllCRV←0 3ρ0
FPIcol←2 ⋄ FPRcol←1 9,⊃PRRpar[30]⌽(6 10 11 18 19 20)(18 21 22)
GetCRVrule←GetAlmCRVrule
:If PRRpar[40 88]∧.≠0
    uGSTK',bEIO,beio,bltg'
    :Select PRRpar[88]
    :Case ¯1
        GETcurve←GetALMsimCrv
    :Case 1                                   ⍝ eiopa 2011
        STns←qis5
        GETcurve←GetALMeiopaCrv
    :Case 2                                   ⍝ ltga 2013
        ⎕SHADOW'GetFSpr'
        STns←ltga
        GETcurve←GetALMltgaCrv
        Sscen←1⌈⊃⌽5↑100⊃PRRpar
        FSpr←0 2ρ0
        :If Sscen>1
            FSpr←⊃Sscen FSpr ALMarchFSpr'G' ⋄ :EndIf
        GetFSpr←{0,(¯1+ρFPdt)/(FSpr⍪0)[FSpr[;1]⍳ω;2]}
    :EndSelect
:ElseIf PRRpar[68]
    GETcurve←ALMxlsCurve
:Else
    GETcurve←GetALMcurve ⋄ :EndIf
GetInfCrv←GetALMinfCrv
```

```
C←t GetALMcurve sac;b;C1;D;d;d1;iota12;DF;df;spr
t b←2↑t,1        ⍝ se non passo PRRpar[27] il default è 1 (pe
:If ~sac ANg 3034
    ⎕SHADOW'Swap2Bond'
    Swap2Bond←{ω} ⋄ :EndIf
:If 0∊ρC1←⊃datac READcurve sac
    C←(≢FPdt)ρ⊂0 2ρ0
    :Return ⋄ :EndIf
:If PRRpar[40]
    C←('CRVrule'uQV GetAlmCRVrule sac)AlmStressCrv C1
:Else
    C←C1 ⋄ :EndIf
:If PRRpar[12] ⍝ curva spot anche a date fwd (per ora ad us
    C←(⊂C1),(¯1+≢FPdt)ρ⊂C
:Else
    D←(÷360)×30 dCVD FPdt,[1.1]t
    d←(÷12)×(⍳11),12×⍳⌈⊃⊖C
    d1←(÷12)×⍳12×(⊃⌽D)+⊃⊖C
    iota12←{⌊0.5+12×ω}{(αα α)⍳αα ω}
    C C1←d1∘{
        c←0 SPLI1 ω
        0 Swap2Bond α,[1.1]c SPLIVAL α}¨C C1
    d(⊣(/⍨)≤)←⊃⊖C
    DF←C[;,1],(1+C[;2])*-C[;1]
    DF←d1{
        c←0 SPLI1 ω
        α,[1.1]c SPLIVAL α}DF
    df←DF[;2],⌈⊃⊖⌽DF
    df←df[d1 iota12 d∘.+1↓D]÷[2]df[d1 iota12 1↓D]
    C←C[C[;1]iota12 d;2],¯1+df*[1]-÷d
    C←(⊂C1),1↓(⊂d),[1.1]¨↓[1]C ⋄ :EndIf
:If b∧PRRpar[10]
    spr←(CUspr⍪0)[CUspr[;1]⍳sac;2]
    (1↓C)←0 spr∘(+[2])¨1↓C ⋄ :EndIf
:If ~16 uBIT PRRpar[104]
    C←(⌈/Θ)0∘(⌈[2])¨C ⋄ :EndIf
⍝∘ (c)APLIT b ALM gar 22/11/2017 16:35          28217
```

```
:If ∨/14 15 16 uBIT PRRpar[38]
    FPrescale←{1}
:ElseIf PRRpar[40]
    FPrescale←{mkt←(MKT⍪0)[MKT[;1]⍳sa;2] ⋄ ⍵[1;1]{⍺ q ⍺ uDV ⍵}(×mkt)×mkt-ioptr[1;1]}
:Else
    FPrescale←{mkt←(MKT⍪0)[MKT[;1]⍳sa;2] ⋄ n←⊃⍴fpr ⋄ n⍴(⍵[1;1]{⍺ q ⍺ uDV ⍵}(×mkt)×mkt-ioptr[1;1])} ⋄ :EndIf
:If PRRpar[40]
    :If 1=PRRpar[88]
        SPRtab←PRRpar[89]GETeiopaSpr sa
        SprCorp←{0,(¯1+⍴FPdt)/(SPRtab⍪0)[SPRtab[;1]⍳sa;2]}
    :ElseIf 0≠PRRpar[67]
        SPRtab←ALMclfSpr sa
        SprCorp←{
            s←(0⍪tSprCls)[1+(SPRtab⍪0)[SPRtab[;1]⍳⍵;2];]
            b1←tSprDt∊⍨{⍵[⍋⍵]}tSprDt∪FPdt
            b2←FPdt∊⍨{⍵[⍋⍵]}tSprDt∪FPdt
            s←b2/b1\s ⋄ s[1]←0
            0.0001×uDVSc s}
    :Else
        Corporate←SELcorp ArchivioSel'LA'
        SprCorp←{0,(¯1+⍴Curva)⍴×/0.0001,(sa∊Corporate),PRRpar[48]} ⋄ :EndIf ⋄ :EndIf
:If PRRpar[99]
    ALMdur←1 ⋄ :EndIf
ImpSpr←{
    (2 3∊⍨ANG 223)∧0=MKT[MKT[;1]⍳sa;2]:(PMR⍪PMR[1;])[(PMI[;3]×PMI[;2]=1)uINDX t;3]
    0=MKT[MKT[;1]⍳sa;2]:0
    (0 1)FPbond ⍵
}
:If PRRpar[22]                              ⍝ indicizza pay off
    PO2IC←1 ⋄ :EndIf
:If 0≠⎕NC'PK'
    ∆nomi←∆pnames PK
    ⎕SHADOW ∆nomi
    ∆pdef PK ⋄ :EndIf
PK←∆pack'GETcurve FPIcol FPRcol UPrz ImpSpr FPbszTh FPdt CURind FPflows FPrescale FPrsk SprCorp',,' ','∆nomi'uQV''
SA←t FPexpand sa ⋄ sa,←ftz
SA/⍨←(t,⊃⌽FPdt)HasFP SA
OPTsa⌿⍨←~(t≥OPTsa[;2]ANg 219)∨(OPTsa[;2]ANg 3159)∊8 9
ISPR←(0=GetCmp SA)/SA ⋄ ISPR,[1.1]←0⌈⊃smt'LAST/DATA'∆Fdur'SPR'ISPR(⌽40 20 dCV t-0,⍳5)
FPRAT←FPdt GETrateo SA
FPrat←SA,FPRAT[;2+6×¯1+⍳⍴FPdt]
FPpar←∆Mkt[14 10],(1+1=≡∆Mkt)⊃RenDT,20 40 dCV 2⊃∆Mkt
FPI FPR←PK FPdo t(SA,ftz)
:If 0∊⍴FPI
    P F C MD IRR CNVX CPN ACCR ICALL←⊂0⍴⍨ml1.∊⍴¨sa FPdt
    P,←0 ⋄ FPdur←0⍴⍨0,1+⍴FPdt
    FLOWS←'FLOWS'uQV 0 11⍴0 ⋄ FLOWS[;11]←1
    Z←P FLOWS C F FPdt FPrat C11ITM HWci HWcr FPdur MD IRR CNVX CPN ACCR ICALL AllCRV
    uGSTK 0
    :Return ⋄ :EndIf
:If PRRpar[99]                              ⍝ calcolo duration 'destra'
    FPRplus⌿⍨←FPRplus[;1]∊FPI[;1]            ⍝ pleonastico?
```

# SPPI BENCHMARK TEST - SOLELY PAYMENTS OF PRINCIPAL AND INTEREST

## IRFS9 INTERNATIONAL FINANCIAL REPORTING STANDARD

- As a result of the financial crisis of 2008, the Financial Accounting Standards Board (FASB), decided to revise their accounting standard introducing this test:
- The Benchmark Test is performed on all bonds whose coupon rate is indexed to a interest rate whose frequency doesn't match the coupon frequency. The test involves the comparison of two cahsflows.


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# THE FAIR PRICE ENGINE

Using the engine in so many different contexts implies that it must be able to receive the input data in many different forms:

INTEREST CURVES

- **1** curve for FP
- **2** curves for Stress Test
- **Many fwd** curves for ALM

CREDIT SPREAD

- Market spread for fair price
- Implied spread or **user defined** spread elsewhere

CREDIT RISK
rescaling scenarios



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# THE FAIR PRICE ENGINE

In each context the output requested may be very different:

Just prices, for example for
VaR
Stress test

Just flows for
SPPI benchmark test

Prices (embedded options prices), flows, accruals, callable bonds moneyness, durations for ALM


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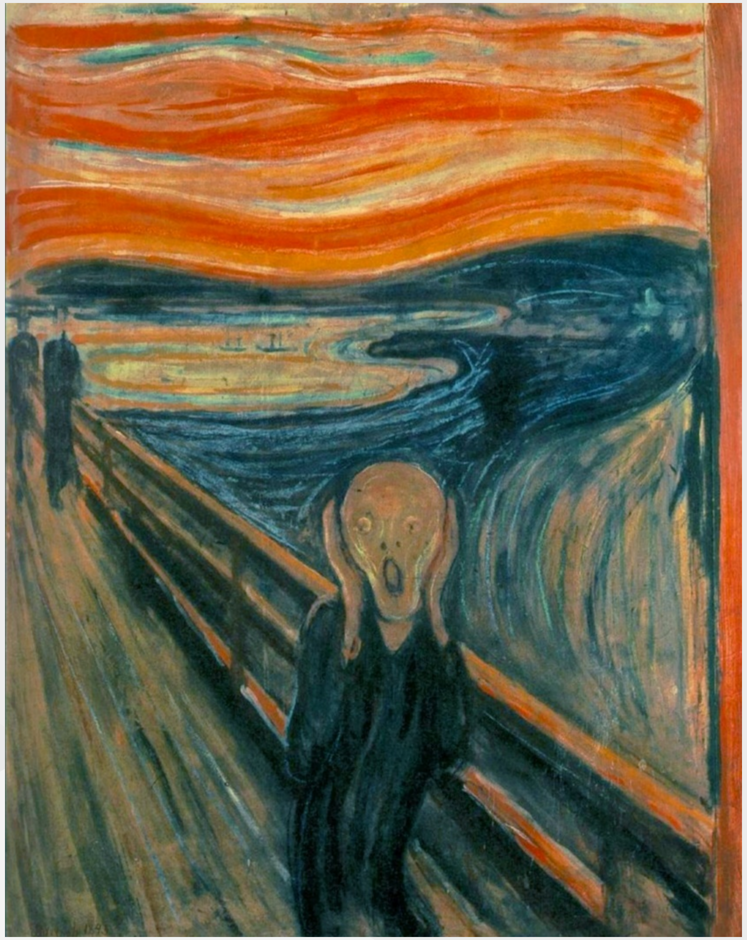
# THEN THE (ALMOST) IMPOSSIBLE BECAME REALITY

- On 11 June 2014 the ECB introduced the negative interest rates
- Black models stopped working
- Change model
- In fact we have two different Fair price engines: one is based on closed formulas the other is a Monte Carlo based on Hull-White model.



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# HWcalc

Monte Carlo based on
Hull-White model

# FPcalc

Closed formulas


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# AT THE END WAS THE ENGINE

FAIR PRICE

ALM

STRESS TEST

SCR

EFFECTIVE AND SPREAD DURATION

VAR

SPPI BENCHMARK TEST

PROFIT AND LOSS ATTRIBUTION

# THANKS TO



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