MSc Financial Mathematics
MSc Mathematical Finance & Trading
MSc Quantitative Finance
SMM269 FIXED INCOME
Group Coursework
Gianluca Fusai
Academic Year 2024-25

Contents

General Rules

Read Carefully this part. No exceptions will be made. Penalties will occurr if these rules are not strictly fulfilled

RULES

Rules as follow.

1. This is a group coursework. Rules as follow.

2. Group size: group coursework.

3. Groupwork composition: as agreed with the course officer.

4. Deadline: **Please Submit your Group Coursework by the date set by the course officer**. Late deliveries will not be considered. Upload your coursework on the Moodle system.

5. You are solely responsible for managing group dynamics, as well as addressing any potential problems that may arise. No extensions will be granted for issues of this nature.

6. You have the flexibility to implement the project using Matlab, R, Python, VBA, Excel, the swap manager in Bloomberg, or Refinitiv. The latest versions of Matlab offer convenient functions that you are free to utilize for your project (please acknowledge their use). For instance, refer to the following link for useful functions: `http://it.mathworks.com/help/fininst/examples/fitting-interest-rate-curve-functions.html`. The use of Excel dynamic array functionalities as well as the use of Lambda functions in Excel will also be appreciated. In Python you can use the Quantlib package. It also provides an Excel addin.

7. Feel free to utilize the Excel sheets and lambda functions introduced in class, while acknowledging and highlighting any enhancements or improvements you have made to them.

8. Whatever software you are going to use you have to disclose what is your own work and what is not.

9. The submission for this project should consist of a zipped folder containing all relevant files, along with a PDF report. In the report, provide a comprehensive description of your data, assumptions, methodology, and outcomes, excluding proofs of material covered in class.

10. Please submit the project as a zipped file via the web-learning system. The zipped file should be named with the surnames of the group members. Note that projects sent via email will not be considered. Ensure that the Excel file, the PDF report, and the Matlab folder are all named with the surnames of the group members.

11. Ensure that your written report is in .pdf format, as no other format will be accepted.

12. Ensure that both the Excel/Matlab files and your report are designed to be easily understandable for a non-expert reader.

13. In the report, provide a clear outline of the contributions made by each group member, specifying the tasks undertaken by each individual.

14. University rules regarding plagiarism will be enforced.

15. Any questions related to the coursework should be raised at the beginning of each lecture, once the lecture concludes. Inquiries sent via email will receive a public response on the Moodle system. I will not respond to e-mails or personal enquiries regarding the coursework.

16. Data arE available via Moodle.

17. In your report, please adhere to the following structure, providing explicit details on your assumptions, data analysis, results, and references:

    (a) **1. Introduction** Clearly state the general problem under consideration.

    (b) **Product Description and Market Data**
    - Describe the financial product being priced.
    - Explain the chosen market data and justify the decision-making process.
    - Include details on methodologies such as bootstrapping procedures and interpolation methods.

    (c) **Pricing Procedures and Model Justification**
    - Outline the procedures adopted for pricing.
    - Provide a rationale for the chosen pricing models.

    (d) **Implementation of Pricing Procedure**
    - Explain how the pricing procedure was implemented.
    - Justify the chosen approach.

    (e) **Results and Discussion**
    - Present the results obtained.
    - Discuss any issues encountered during the analysis.

    (f) **Conclusions** Summarize the key findings and conclusions drawn from the analysis.

(g) **Bibliography** Include a bibliography with relevant references used in your coursework.

You may refer to a standard academic paper for style guidance.

18. The report is limited to a maximum of 15 pages, inclusive of tables and figures. Please adhere to A4 format, single spacing, and an 11-point font size. While I highly recommend using LaTeX and Overleaf for composing the report, it is not mandatory.

19. *Ensure proper labeling of all figures and tables, accompanied by a caption containing a concise description of their content. When incorporating a figure or table, it is crucial to elaborate on its content and emphasize its significance within the main text.*

20. All computations performed in your spreadsheet or scripts must be transparently disclosed and replicable. If you are using data obtained from Bloomberg, please specify the steps taken with Bloomberg data to ensure clarity and transparency in your analysis.

21. Please note that all the material you submit can be freely utilized by the course teacher thereafter.

Things To Do

QUESTION: PRICING A STRUCTURED PRODUCT

You are required to price a structured bond and implement a hedging strategy.

The bond description is as given in the accompanying pdf file BNNPParibas. The trade Date is assumed to be **November 24th, 2024** (Spot Lag: 2 days).

You have to answer to the following questions:

1. Provide a general overview of the bond's characteristics, supported by a chart illustrating the coupon behavior. Specifically, explain how to replicate the coupon payoff using basic interest rate securities (e.g., floating rate notes (FRN), coupon bonds, caps/floors, digital options, etc.).

2. Create a table summarizing the historical coupons paid to date. Utilize the reference rates available on the Suomen Pankki website `https://www.suomenpankki.fi/en/Statistics/interest-rates/charts/korot_kuviot/euriborkorot_pv_chrt_en/`. For each coupon, include:

   - Reset date
   - Start date of the coupon period
   - End date of the coupon period (adjusted for weekends using the Business Day Convention and End-of-Month (EOM) rule)
   - Reference rate on the reset date
   - Coupon rate
   - Coupon amount

   Comment on the results and include relevant observations.

3. Bootstrap the term structure of interest rates using EURIBOR and interest rate swaps (IRS).

4. Analyze the best and worst-case scenarios for the bondholder and compute the corresponding market values. Provide a detailed explanation of these scenarios.

5. Based on the decomposition described in Item 1, price the option components using an interest rate model of your choice. Justify your selection and calibrate the model using caplet volatilities derived from 6-month EURIBOR cap quotes.

6. Explain the process of adjusting the risk-free value of the bond by incorporating Credit Valuation Adjustment (CVA). Compute the CVA considering the issuer's potential early default. Use the survival probability approximation:

$$Q(t,T) = \frac{e^{-CDS(t,T)(T-t)} - R}{1 - R}$$

Assume a CDS level from [Investing.com] `https://www.investing.com/rates-bonds/bnp-paribas-cds-5-year-eur`) and a recovery rate of 40

7. Clearly state the assumptions used in your calculations.

8. Present a table detailing the value of each coupon component, along with the bond's gross and clean prices.

9. Generate a chart illustrating the bond's expected cash flows (excluding notional) and provide commentary on the results.

10. Compare your estimated fair value with the bond's clean price as quoted on EuroTLX (Close price: 98.43, Date: 11/18/2024). Calculate the market-implied CDS and discuss the methodology used. Provide insights based on your findings.

11. Discuss the calculation and implementation of sensitivities of the bond's estimated fair market value to shifts (level, slope, and curvature) in the term structure. Analyze and interpret the results.

12. Evaluate a hedging strategy for your portfolio against anticipated changes in the term structure using quoted plain vanilla swaps. Explain the criteria for selecting the swaps' characteristics and the methodology for determining the required quantities.

13. Implement the proposed hedging strategy and discuss its potential limitations.

14. Measure the bond's exposure to changes in CDS levels.

15. Describe how CDS contracts can be utilized to mitigate the bond's credit risk exposure. Detail the practical implementation of this hedging strategy.

16. Assume that changes in the bond's gross price are modeled by the factor equation:

$$\Delta GP(t, T_i) = \beta_{l,i}\Delta l(t) + \beta_{s,i}\Delta s(t) + \beta_{c,i}\Delta c(t) + \beta_{cds,i}\Delta cds(t) + \varepsilon(t)$$

where the changes in the factors are uncorrelated and follow a normal distribution with zero mean and the variances:

$\text{Var}(\Delta l(t)) = 0.022$, $\text{Var}(\Delta s(t)) = 0.003$, $\text{Var}(\Delta c(t)) = 0.001$, $\text{Var}(\Delta cds(t)) = 0.002$

and the residual disturbance term can be omitted. Use Monte Carlo simulation to model the factor changes and bond value variations. Construct the profit and loss distribution, and compute the Value at Risk (VaR) and Expected Shortfall (ES) at a 99% confidence level.

17. Compare the Monte Carlo results with the exact formula for the VaR and ES, utilizing the linear relationship between the bond value change and risk factors changes.

18. Decompose the bond's Value at Risk (VaR) into marginal and component risk contributions from each factor.

19. Compile a table summarizing the fair values and sensitivities of each component of the structured bond. Provide a comparable table for the selected hedging instruments.

20. Conclude with recommendations for a potential investor based on your findings and analysis. Additionally, discuss the limitations of your analysis and suggest areas for further investigation.

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PART III

Market Data

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Deposit rates, IRS and cap volatilities can be found in the excel sheet MarketData.xlsx

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PART IV

Useful things

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LATEX EDITOR

I strongly recommend (but it is not required) to use for your report LATEXor similar word-processing (an easy to use is Overleaf `www.overleaf.org` or TeXStudio). The final document turns out to be much better looking than the one produced in Word. In addition inserting mathematical formulas and Tables is much easier. Useful links are:

`http://www.youtube.com/watch?v=pSb6Lf5U0qk`
`https://hackr.io/tutorials/learn-latex?sort=upvotes&type_tags%5B%5D=1`

Relevant readings on term structure bootstrapping and interpolation for your assignment are provided. It's at your discretion whether to consider them or not.

PART V

BNPP VARIABLE RATE CAP & FLOOR in EURO with a 5-Year Term

BOND DESCRIPTION

This bond, issued by BNP Paribas, offers a variable annual coupon rate linked to the 3m Euribor rate. On each Floating Coupon Payment Date, an amount equal to the Nominal Value multiplied by the Reference Rate observed on the corresponding Floating Coupon Observation Date, on a 30/360 basis. The Reference Rate cannot be lower than the Minimum Rate (Floor) or higher than the Maximum Rate (Cap). The nominal value of each bond is €1000, and the bond will be redeemed at par at maturity. The bond is listed on EuroTLX `https://www.borsaitaliana.it/borsa/obbligazioni/eurotlx/scheda/XS2392609181.html?lang=en`.

KEY FACTS

Characteristic	Details
Issuer	BNP Paribas (example)
Bond Name	Variable Rate Bond 2033
ISIN	XS2392609181
Currency	EUR
Nominal Value	€1000 per bond
Issue Date	July 29, 2022
Issue Price	€1000 per bond
Maturity Date	July 29, 2027
Coupon Rate	3m Euribor
Floor	1.60% p.a.
Cap	3.70% p.a.
Coupon Frequency	Quarterly

Interest Payment Dates	29 January, 29 April, 29 July and 29 October in each year from and including 29 October 2022 to and including 29 July 2027
Reset Date	Second TARGET Settlement Day prior to the first day of each Interest Period
Business Day Convention for Interest Payment Date	Modified Following
Business Day Convention for Maturity Date	Modified Following
Day Count Convention	30/360
Redemption Type	At par
Credit Rating	AA (example)

Listing	`https://www.borsaitaliana.it/borsa/obbligazioni/`
	`eurotlx/listino-ufficiale.html?isin=XS2392609181&`
	`lang=en`

Key Information

Prospect
  `https://investimenti.bnpparibas.it/product-details/XS2392609181/FT.pdf`
Key Facts
  `https://kid.bnpparibas.com/XS2392609181_IT.pdf`
CDS
  `https://uk.investing.com/rates-bonds/bnp-paribas-cds-5-year-eur`
Ratings
  `https://www.bnpparibasfortis.com/investors/banking-entities-ratings`

Key Dates

- **Issue Date:** 29 July 2022

- **First Coupon Payment:** 31 October 2022

- **Maturity Date:** July 29, 2027

Risk Factors

- **Interest Rate Risk:** The bond is subject to interest rate fluctuations which may affect its market price.

- **Credit Risk:** Although rated AA, the issuer's ability to meet obligations may change due to economic conditions.

- **Liquidity Risk:** The bond's tradability depends on market conditions and demand.

DISCLAIMER

This document is for informational purposes only and does not constitute an offer to sell or a solicitation of an offer to buy any securities. Please consult with a financial advisor for investment decisions.