Fixed Income Derivatives
Final Exam - 2010

Introduction

The exam questions are accompanied by a spreadsheet with data that can be downloaded from the course website. Also, you need to download the latest version of `fidAnalytics.xla`. Make sure to read all the questions as well as the data spreadsheet carefully. The purpose of the exam is to test your ability to price and risk manage derivatives. In order to receive the grade 12, you must demonstrate the ability to implement and use the models and methodologies covered in the course. The exam is structured as a rotation between some of the functions in a financial institution. At each department you will use the skills acquired in the course.

GOOD LUCK!

Formalities

There is no physical hand-in of your solutions, instead you shall upload your solution as a pdf file on Absalon (there is a link on the course page). The file should be called "ExamNumber.pdf" e.g. 12345.pdf and nothing else. Do NOT include your name or any other personal details. The deadline for uploading your solution is Sunday, May 9th at 16.00. Late solutions will not be accepted.

If you believe that you have found any errors or unclarities in the assignment, the lecturer can be reached via e-mail at martin.linderstroem@gmail.com. You are not allowed to discuss the exam with anyone other than the lecturer.

Excel/VBA settings

In order to avoid any differences in results stemming from numerical issue alone, you should set your Excel `SOLVER` to have the following settings:

- Max Time=300
- Iterations=500
- Precision=0.000001
- Tolerance=5%
- Convergence=0.0001
- Automatic Scaling=Yes

1 The Swap Curve

In the section below you will be acting as the swap trader for a large investment bank. The bank looks on IRSs, CCSs and FX Forwards as being related products, therefore you will be handling the pricing and risk management of all of these.

1.1 Estimating the swap curve

Using the market data found in the spreadsheet, estimate the forward and discounting zero coupon curves for both the EUR and the USD market using hermite interpolation. You should estimate the curves under the assumption that you are representing a bank that can fund itself at 3M USD LIBOR flat. This means that the the forward and discount curves are identical for the USD market. You should use the knot points listed in the Data sheet.

Report your estimated knot point rates with 4 digits (e.g. 4.0000%). Plot the continuously compounded Act/365 zero coupon (forward and discounting) rates as well all 3M forward xIBOR rates (Act/360, MF) in 3M spacings out to 30Y. For the EUR curve, you should also calculate the forward 3M CCS breaks (Act/360, MF).

Hint: Calibrate the USD and EUR curve separately to speed up the calibration. You should roll out the dates corresponding to the 3M spacings by adding multiples of 3 months to the anchor date and adjusting these according to the MF convention.

1.2 Terminating interest rate swaps

One of the trades on your book has the details listed in the data sheet. The client that is the counter part to this trade is interested in terminating it against a cash payment. Calculate the mid-market value (i.e. the PV) of the trade on the calibrated curve.

Hearing your termination price, the client is somewhat surprised since her own pricing system shows a significantly different price. During your discussion with the client you quickly establish that you are agreeing on the par swap levels, however you also learn that the client's system is a "classical" pricing system with just a single curve used to calculate both forward rates and discount factors. Explain why a single curve system based on the observed EUR par IRS quotes will result in a different termination price.

1.3 Pricing a fixed-for-fixed cross currency swap

An important task for a swap trading desk is to quote and hedge customized swaps. One such swap is a fixed-for-fixed forward starting cross currency swap. Using the calibrated EUR and USD curves, calculate which fixed EUR (annual, 30/360) rate will cause the swap with the below details to have zero NPV:

- Both legs have 1M forward start and matures 6Y later
- Both legs are rolled according to the MF convention
- USD leg notional=140,000,000
- EUR leg notional=100,000,000
- USD leg fixed rate (Semi-annual, 30/360)=3.34%

- Initial and final exchange of notional on both legs

Explain why this fixed rate will differ from the plain vanilla EUR IRS par swap rate.

Finally, describe which instruments you would need to use to hedge the above swap.

1.4 Pricing long FX forwards

In trading operations, cross currency swap traders are often responsible for quoting long-dated FX forwards. Calculate the implied FX forward exchange rates from you calibrated EUR and USD curves for the maturities 1Y, 2Y, 5Y, 10Y and 30Y. The quotes should be presented in both forward exchange rates and pips with 4 digits (i.e as 1.3400 for exchange rates and pips rounded to whole pips). The maturity dates for the forwards are found by adding the relevant tenor to the anchor date (adjusted according to the MF convention).

2 A leveraged CMS note

In the question below you are now acting as a so-called *structurer*. It is your responsibility to structure customized derivatives to investors. In particular, you are being asked to pitch in on the marketing of a structured note. A structured note is a bond-like instrument which is the combination of a zero coupon bond (that repays the notional) and an exotic coupon stream. In order to price such a note, it is customary to price the individual components.

2.1 Pricing a structured note

The structured note in question is a so called leveraged CMS spread note. The coupon paid in the note is written as Coupon = Gearing $\cdot$ ($\text{CMS}_{10Y} - \text{CMS}_{2Y}$). This coupon is paid quarterly (fix-in-advance, pay-in-arrears using Act/360 accrual, adjusted MF), note that such a coupon can become negative if the swap curve inverts.

The structured note starts accrual after 2B, has a maturity of 5Y and a notional of EUR 10,000,000. Assuming that you want to sell the note to investors at a price of par (i.e. receive EUR 10,000,000 at $t = 0$), which gearing can you offer them at mid-market prices? Explain how you arrive at this result.

If you want to charge a structuring fee of 0.50% of the notional paid upfront (again at $t = 0$), what will the gearing then be?

Hint: You should price the components (CMS floating rate payment stream + zero coupon) individually. Use the curve data and SABR model parameters found in the data sheet. You should interpolate linearly between these SABR parameters to find the relevant values for each CMS swaplet.

2.2 Risk managing a structured note

As a part of the marketing effort of the structured note, you should qualitatively describe the risks of the product. How would you describe the sensitivity of the structured note towards:

- Parallel shifts in the forward and discounting curve?
- A steepening/flattening of the forward and discounting curve?

- Changes in (ATM) implied swaption volatility. Which swaptions in the swaption matrix are the product sensitive to?

To document your qualitative description, you should report a table with the net (forward + discount) delta vector as well a parallel shift in the σ_0 parameters. This should be done for the structured note that includes the structuring fee.

It is often customary for investment banks to let a third party issue the note, meaning that the third party guarantees both the notional repayment and the coupons. Explain in words how you could quantify the credit risk that investor will be exposed to.

Hint: For the parallel shifts and the deltavector, you should just calculate net figures for both the forward and discounting curve. For the vega risk, calculate how much you should bump each σ_0 in order to induce a 1% increase in the ATM Black'76 volatility using `fidBlackToSabr`. Applying these shifts provides you with a vega risk measure. Calculating the deltavector for such a dual CMS linked product takes time — so be patient with you PC.

3 Single Name Credit Risk

In the below, you should — as the junior fixed income analyst — demonstrate your skills in comparing different assets. In particular, you should use your knowledge of asset swaps and credit default swaps to compare different bonds. The EUR curve that is provided has been calibrated relative to 3M USD Libor flat.

3.1 Building an ASW VBA function

Since you will be looking at multiple bonds below, you should build a VBA function `fidAswSpread` that can calculate par-par asset swap spreads. Since the asset swap is a customized interest rate swap, `fidAswSpread` will require all the same inputs as `fidSwapRate`. In addition to these, the function should take an input called `BondDirtyPrice` (the dirty price for a bond notional of 100), `Coupon` (entered as 0.04 for a 4% coupon) and `PrevCouponDate` (the previous coupon date, this input should be a date).

Report your VBA code and explain with comments in the code what you are doing in the different steps.

Hint: Remember that a par-par asset swap has "full first" coupon on the fixed leg. The fixed leg should thus be priced as if the coupon accrual started on the previous coupon date. The floating legs starts when the bond purchase settles, i.e. 3B for EUR denominated bonds. Use the same day rule for both legs.

3.2 Estimating an ASW curve

Using the function developed above, you should calculate the par-par asset swap levels for the curve inputs and bonds listed in the data sheet (calculate the spreads "by hand" if you cannot get the function to work). Plot these spreads as a function of time to maturity.

How would you characterize the the credit quality of these bonds relative to the swap curve?

3.3 Foreign currency funding

The bonds listed above are all EUR denominated bonds. Suppose now that the issuer of these bonds are approached with the idea of issuing USD denominated bonds in order to diversify his funding base. It is believed that the investor can issue 4Y bonds in USD at prices that are consistent with an ASW spread of 3M USD LIBOR flat. Is this an attractive funding level relative to the spreads found above?

Describe how the issuer could use the derivatives market to convert USD denominated bonds into EUR funding.

3.4 Calibrating a CDS curve

Use the CDS quotes and knot points listed in the data sheet to calibrate an intensity curve. Report your calibrated intensities with 4 digits (e.g. 1.0000%).

Price (i.e. find the par spread of) a CDS that matches the maturity of the 4% 16 December 2016 bond. If this CDS was traded with a fixed coupon of 100 bps, what should the upfront payment be on a notional of EUR 50m for the protection buyer?

3.5 The cash-CDS basis

Comparing the CDS- and ASW spread for the 4% 16 December 2016 bond, you note that they are not identical. Some of your colleagues argue that this represents an arbitrage opportunity, what do you think and why?

4 Risk management

The final part of your rotation brings you to the risk management department. The department is responsible for determining and monitoring the overall risk appetite of the institution.

4.1 Calculating VaR and ES on a bond position

As you arrive, you are being asked to weigh in on the decision to take on a asset swapped bond position. When asset swapping a bond, you effectively have a position in the ASW spread. Remembering, that this risk can be quantified by the annuity PV it is obvious that that long dated bonds are more sensitive towards changes in the ASW spread. Suppose the spread risk (i.e. the PV of 1 bps paid in the asset swap) is EUR 18,000/bps for a 2Y bond and EUR 88,000/bps for a 10Y bond, both on a EUR 100m notional. You can use this spread risk to estimate the potential profit-and-loss distribution by holding the bond (you gain if the spread tightens and loose if it widens).

Use the time series of historical ASW spreads for 2Y and 10Y Greek Government Bonds to estimate the 1-day Value-at-Risk and Expected Shortfall at a safety level of 95% on a EUR 100m long position in either bond. Report your findings in a table.

Which position would you characterize as being more risky?