F210 Programación Aplicada a Finanzas

Instrumentos de Renta Fija

Instrucciones: Se le pide que desarrolle una clase de objetos o un conjunto de funciones que permita abordar de manera integral los problemas que se presentan a continuación. En otras palabras, los scripts asociados a los problemas deben contener la menor cantidad de código explícito posible, debiendo ser resueltos por las funciones generales de bonos o por los métodos de la clase.

1. On 04/12/2001, consider a fixed-coupon bond whose features are the following:

   • face value: $1,000

   • coupon rate: 8%

   • coupon frequency: semiannual

   • maturity: 05/06/04

   • issue date: 05/12/1998

   • type: bullet

   • day count convention: actual/actual

   • settlement: trade +2business days

   • if settlement date corresponds to a non-business day, settlement takes place the next business day.

   1. What are the future cash flows delivered by this bond? *(the method/function should print the corresponding dates and payments in different columns, discriminating between interest payments and amortization)*

   2. Compute the accrued interest to that date. Answer the same question if we are now on 06/09/2002. *(The method should return the accrued interest and have a printout specifying the last payment date, the next payment date, the number of days elapsed in the current period, the total number of days in the period, and the corresponding accrued interest. You have to design all the functions that compute the day counting between the two dates, for the four different day-count bases: Actual/Actual, Actual/365, Actual/360 and 30/360)*

      This exercise may be of help in computing the distance between two dates in the actual convention.

      "Is It a Leap Year?

      Most years have 365 days. However, the time required for the Earth to orbit the Sun is actually slightly more than that. As a result, an extra day, February 29, is included in some years to correct for this difference. Such years are referred to as leap years.

The rules for determining whether or not a year is a leap year follow:

- Any year that is divisible by 400 is a leap year.
- Of the remaining years, any year that is divisible by 100 is **not** a leap year.
- Of the remaining years, any year that is divisible by 4 is a leap year.
- All other years are **not** leap years.

Write a program that reads a year from the user and displays a message indicating whether or not it is a leap year."

3. Back on 04/12/2001, the **dirty price** of the bond is 107.457% of its par value. Determine the bond`s yield to maturity and the bond clean price. *(You are expected to build a method that computes the bond ytm from a dirty price, a current date and the bond specs, and another that returns the bond's clean price. All methods should have printouts specifying the current date, the current dirty price, last and next coupon payment dates and amounts, day count convention, accrued interest, yield to maturity and current clean price)*

4. Repeat question 3 if 107.457% is the bond's **clean price** instead of the dirty price. Assume that the day count convention this time is 30/360 instead of actual/ actual.

5. The DV01 or Dollar Value of 1 basis point, is a measure of the interest rate sensitivity / risk of a bond in response to change in yield by a single basis point (100 basis points correspond to a 1percentage point in yield). It is computed in the following way: $DV01 = abs\left(\frac{BP(y+h)-BP(y)}{h}\right)$, where BP(y) is the dirty price of a bond for a given yield to maturity *y*, and *h* = 1bp. The units of measurement for DV01 are USD/bp. Build a method/ function associated to our bond class and compute the DV01 on 04/12/2001 for the bond in this problem, for a clean price of 107.457% of par value under the 30/360 convention rule. (*If you think that the DV01 measure looks pretty similar to a forward derivative, you are exactly right. It is just a forward derivative of the bond price with respect to its ytm, in absolute value*)

2. Some bonds have **irregular first coupons** (grace period) and are handled differently according to their prospects' specs. Here are some examples:

   • ***A <u>long first coupon</u>*** **is paid on the second payment date of the bond and starts accruing on the issue date**. So, the first coupon value is greater than the normal coupon rate. After, that, all other coupons pay the normal coupon rate

• ***A long first coupon with regular value*** **is paid on the second payment date of the bond and starts accruing on the first payment date**. So, all coupon payments are equal to the normal coupon rate.

• **A *short first coupon* is paid on the first payment date of the bond and starts accruing on the issue date**. The first coupon value is smaller than the normal coupon rate.

• **A *short first coupon with regular value* is paid on the first payment date of the bond and has a value equal to the normal coupon rate.**

Consider the four following bonds with nominal value equal to 1 million usd and annual coupon frequency:

• Bond 1: issue date 21/05/96, coupon 5%, maturity date 21/05/02, long first coupon, redemption value 100%;

• Bond 2: issue date 21/02/96, coupon 5%, maturity date 21/02/02, long first coupon with regular value, redemption value 99%;

• Bond 3: issue date 21/11/95, coupon 3%, maturity date 3 years and 2 months, short first coupon, redemption value 100%;

• Bond 4: issue date 21/08/95, coupon 4.5%, maturity date 21/08/00, short first coupon with regular value, redemption value 100%.

1. Compute the cash flows of each of these bonds.
2. Compute the clean price, accrued interest and yield to maturity of each bond if they all trade at par value on 14/08/1997 (assume a day counting convention Actual/Actual and a settlement date equal to trade date)

3. We consider the following zero-coupon curve:

Maturity (years)	Zero-Coupon Rate (%)
1	4.00
2	4.50
3	4.75
4	4.90
5	5.00

a. What is the arbitrage free price of a 5-year bond with a $100 face value, which delivers a 5% annual coupon rate on issuance date? (In your pricing function/method, you should have as parameters:
   i. If the valuation method is arbitrage free or traditional,
   ii. if the price is clean or dirty
   iii. if you are providing a ytm, a yield curve or a zero coupon curve for valuation purposes
   iv. a set of values for such ytm, yield curve or zero coupon curve

v. all bond specs (cash flows, dates, amortization scheme, day counting rule, settlement rule, type of irregular first coupon type if applicable, etc. This is not necessary if you are using objects as such characteristics are usually included in the *self* attributes)

b. What is the yield to maturity of this bond?
c. Compute again the bond price but this time using the traditional approach and the ytm found in item b.
d. We suppose that the zero-coupon curve increases instantaneously and uniformly by 0.5% (50bps). What is the new price and the new yield to maturity of the bond obtained using the arbitrage free method? Compare with the results that you would get by simply changing the ytm of point b.
e. Compare the price changes obtained in point d to the one that results from making $\Delta P = -DV01 * \Delta ytm$, with Δytm expressed in bps.

4. In a certain country, we have the following information about on-the run Treasury bonds with the following features

Bond	Maturity (years)	Annual Coupon	Price
Bond 1	1	10	106.56
Bond 2	2	8	106.20
Bond 3	3	8	106.45

Also, the overnight (1 day) annualized interest rate for interbank lending in this economy is set by the Fed at 0.5%. Assume we are at time t=0. All bonds pay semiannual coupon rates, are of type bullet and have FV=100. There is also a fourth Treasury bond traded in the market with the following characteristics:

Bond	Maturity	Annual Coupon	Price
Bond 4	3 years	9	109.01

You are asked to determine if such bond is well priced or not, and if not to suggest an arbitrage strategy. In order to do so, you decide to do the following:

a) Develop a function that constructs the **yield curve,** using the yield to maturity of bonds 1-3 and the information on the overnight interbank rate, assuming **linear interpolation** for all intermediate points for which you do not have market data.
b) Based on the yield curve, construct the **Annual par yield curve**
c) For the Annual par yield curve obtained in point b, construct the **zero coupon curve** from bootstrapping
d) Introduce the zero coupon curve in the pricing function previously developed to determine the arbitrage free price of bond 4.
e) Determine if bond 4 is well priced or not and how would you take advantage of that potential mispricing in the coupon strips market.