Certified International Investment Analyst

EXAMINATION II:

Fixed Income Valuation and Analysis

Derivatives Valuation and Analysis

Portfolio Management

Questions

Final Examination

March 2019

Question 1: Fixed Income / Derivative Valuation and Analysis (69 points)

In your role as a financial analyst, you are called to analyze a bond swapping strategy based on yield spreads for securities of two European companies active in the industrial components sector. The companies operate exclusively in Europe and are present on the bond market with a series of senior unsecured issues which are all included in the benchmark. They have the following ratings: BB+ for Company Alpha; BBB- for Company Beta.

The following are the main balance sheet metrics for the current FY (financial year) and the estimates for the next FY:

Table 1 - Main balance sheet metrics for the current FY and next FY

Main balance sheet metrics	Company Alpha		Company Beta	
	Current FY	Next FY	Current FY	Next FY
Revenues (EUR)	800,000,000	900,000,000	1,450,000,000	1,500,000,000
EBITDA (EUR)	240,000,000	315,000,000	507,500,000	495,000,000
Net financial position (EUR) *	-150,000,000	-50,000,000	-250,000,000	-300,000,000
Net leverage (Net debt/EBITDA)	2.8x	2.3x	2.0x	2.2x
Interest coverage ratio (EBIT/Interest expense)	5.5x	6.5x	6.2x	6.0x

Note:
* Net financial position is defined as cash and cash equivalents plus readily monetizable financial instruments, less borrowings.

Table 2 - Bonds selected for the bond swapping strategy

Description	Bond Company Alpha	Bond Company Beta
Expiry date	5yrs	5yrs
Coupon rate	3.50%	2.50%
Coupon payment	Annual	Annual
Rating	BB+	BBB-
Capital redemption type “bullet"	Yes	Yes
Modified duration	4.61	4.68
Price*	103.932	103.561
YTM	2.65%	1.75%

Note:
* Accrued interest is zero, because coupons have just been paid.

a) With the above information, answer the following questions:

a1) Explain how each of the 5 balance sheet metrics of the two companies shown in Table 1 changes between the current and the next FY, with a particular focus on the metrics of fundamental credit analysis, and determine that the financial position of each company improves or worsens. (6 points)

a2) All else being equal and assuming that in the estimates of the next FY of the Alpha company a potential contract of significant weight of the annual revenues with an EBITDA margin above the company average is not yet incorporated, explain the impact of this assumption on the rating and the yield to maturity of the securities of the Alpha company. (5 points)

a3) Explain the meaning of "bond swapping strategy based on yield spreads", and give the main 2 sources from which the yield spreads can emerge. (7 points)

a4) Mention what are the four determinants of the Macaulay duration formula, and indicate how these elements affect it (positive and/or negative). Calculate the price duration of the two securities in Table 2. (7 points)

a5) In order to profit from the estimated evolution of the economic and financial metrics of the two companies, you are asked to carry out a bond swapping strategy. Explain in detail the sign (purchase or sale) of the transactions to be carried out on the two securities in Table 2, assuming that it is also possible to carry out "short selling" sales on both securities.
[Hint: Short selling means the possibility of selling a bond by borrowing from a broker.]
(4 points)

a6) Calculate the nominal amount and the corresponding counter-value of the bond Company Alpha 3.50% 5yrs in order to implement the strategy described in question a5), assuming that the nominal value of the bond Company Beta 2.50% 5yrs to be traded is EUR 5 million. The strategy has to be "modified duration neutral." Show the relevant calculations.
[Note: Round up the nominal amount to a multiple of 1,000 EUR.]
(4 points)

a7) Let's assume that immediately after you have implemented the strategy in question a6), the securities are traded on the secondary market at the following YTM:

YTM of Bond Company Alpha 3.50% 5yrs = 2.50%

YTM of Bond Company Beta 2.50% 5yrs = 1.90%

Calculate the Profit & Loss of the strategy in monetary terms using only the modified duration method. Show the relevant calculations.
Day-count convention 30/360, with annual compounding.
(8 points)

b) Considering an expected increase in inflation rate led by the widespread recovery of the main world economies in general and in Europe in particular, you decide to suggest to your customers the investment in a bond instrument indexed to the European inflation index, the "Expected" European Harmonised Annual Index of Consumer Prices.

Table 3 - Expected Increase of the European Harmonised Annual Index of Consumer Prices

Period	Expected Increase of the European Harmonised Annual Index of Consumer Prices*
For year 1	1.200%
For year 2	1.500%
For year 3	1.750%
For year 4	1.900%
For year 5	2.000%

Note:
*"Expected increase": rate on annual basis.

b1) Describe the basic features of capital indexed inflation-linked bond and coupon indexed inflation-linked bond. (4 points)

b2) Let us assume you make an investment in a capital indexed inflation-linked bond with the following features:

- real coupon: 2.00% (paid on annual basis)
- expiry 5yrs
- bullet redemption
- market price (clean): 100.00
- minimum redemption price: 100.00 (Deflation floor)

Using the data contained in Table 3, fill the table below and show your calculations for:

(i) the annual indexed capital (intended as the redemption price of the security).

(ii) the annual indexed coupons up to the 5^{th} year.

(iii) the expected total cash flows of the inflation-linked bond up to the 5th year.

	(i) Indexed Capital	(ii) Indexed Coupons	(iii) Annual Cash flows
Year 1			
Year 2			
Year 3			
Year 4			
Year 5			

(9 points)

b3) Calculate the break-even inflation implied in the bond purchased at t = 0, using as nominal bond a generic benchmark senior bond of the same issuer, expiry 5yrs, coupon 2.5% (paid on annual basis), market price 100.00. (3 points)

b4) Let us assume that the "Expected" European Harmonised Annual Index of Consumer Prices for the next years shown in Table 3 will be realized. Show your calculations to verify if the realized inflation-linked yield obtained by purchasing the bond today at 100.00 matches one of the following levels:

3.255% vs 3.695%

[Notes: The inflation-linked bond has no interest rate accrual as it is traded on the ex-coupon day. If you didn't calculate the expected cash flows of the inflation-linked bond from year 1 to year 5 use the following data: 1yr 2.00%; 2yrs 2.05%; 3yrs 2.10%; 4yrs 2.15%; 5yrs 111.00%. Verify among the following yields: 3.25% vs 3.73%.]

(6 points)

b5) You are planning to invest in an inflation-linked bond identical to the one of question b2), which however does not provide the deflation floor on the capital. Explain:

(i) if the deflation floor can be considered as a call or a put option.

(ii) if the investor is long or short the option when investing in an inflation-linked bond with deflation floor.

(iii) if and how the absence of this contractual clause, all else being equal, changes the value of the security in terms of credit spread. No calculations are necessary.

[Hints:

- Deflation floor means the guarantee according to which the redemption value of the security can never be lower than the nominal value, as in question b2) the minimum redemption value of the security will be 100.00;
- Credit spread of the security means in this case the number of basis points with respect to the Euribor calculated considering all the items of the security.]

(6 points)

Question 2: Derivative Valuation and Analysis **(35 points)**

The Market Stock Average (MSA) index currently (t=0) stands at 14,328. The Index dividend yield is zero. Table 1 shows the prices of European call and put options written on MSA with a maturity of 3 months. The risk-free rate is 5% per annum (continuously compounded). The option contract size is 1,000 (this means that if P is the option price, the cost of purchasing 1 option contract is 1,000·P). Round off your answers to the first decimal place.
[Note: S_T in the tables shows the MSA index value at maturity.]

Table 1: Option prices (in CU)

Strike price: K	Call price: C(K)	Put price: P(K)
14,125	770	365
14,250	690	415
14,375	615	500

a) Enter the formulae for the payoff at maturity in the table below, assuming that you sell one contract each of the call and put options with strike price 14,250 in Table 1.

Table 2: Payoff at maturity

	$S_T < 14{,}250$	$S_T \geqq 14{,}250$
Sell Call		
Sell Put		
Total		

(6 points)

b) Calculate the theoretical price of a call with strike 14,250, assuming that the theoretical price of the put option with the same strike price is given in Table 1. (5 points)

c) Since the price of the call option with strike 14,250 is higher than its theoretical price, there is an arbitrage opportunity. Assuming that you trade 1 call option contract, enter the formulae for the arbitrage payoffs in the table below. Describe the arbitrage opportunity and calculate the arbitrage profit.

Position	Cash flow at t = 0	Payoff at maturity	
		$S_T < 14{,}250$	$S_T \geqq 14{,}250$
Total	Arbitrage profit:		

(12 points)

d) You purchase one contract of the call with strike 14,125, sell two contracts of the call with strike 14,250, and purchase one contract of the call with strike 14,375. Draw the payoff of this position at maturity in the graph below. Plot the relevant values on the two axes. Explain what an investor taking this position expects for the MSA index in the future.

(8 points)

e) What position should an investor take if the investor expects a highly volatile market in the next three months, when it is unclear whether the MSA index will gain or lose? Describe two strategies with different payoffs. Explain their positions, assuming that you can purchase a maximum of two option contracts for each strategy. No calculation required.

(4 points)

Question 3: Derivatives in PM and Portfolio Management (76 points)

You are a financial advisor, and your job is to provide advice on asset management to individual investors.

a) One of your customers, Mr. A, is currently 30 years old and works as a public employee, which means that he can look forward to a stable income until retirement. He has a wife and two children who are dependent on him. To prepare for life after retirement, Mr. A is considering saving 10% of his annual income for the next 35 years and is looking at investments in stock ETFs (exchange traded fund) and bond ETFs because of the low management costs (investment trust management fees). You want to explain to Mr. A about appropriate investment in light of the "human capital" concept and lifecycle investing.

   a1) Explain what human capital is, and describe the current level and risk of Mr. A's human capital. (4 points)

   a2) Explain and justify how the appropriate risk level for Mr. A's financial assets will change over the next 35 years. (4 points)

   a3) Mr. A is considering enrollment in life insurance to provide for his dependent family members should he be incapacitated or die before retirement. Explain and justify how the appropriate life insurance coverage will change over the next 35 years. (3 points)

   a4) After 10 years of investing, the market value of accumulated financial assets turned out to be significantly lower than what Mr. A had expected due to fall in market prices. What should he do if he wants to maintain the post-retirement living standards he initially envisioned? Describe and explain two approaches. (4 points)

b) Your customer Mr. B is 66 years old and began to receive a pension last year. In addition to pension benefits, he also has income from financial assets to supplement his post-retirement life. You recommended the policy portfolio found in Table 1 to Mr. B last year based on his investment goals and preferences. Mr. B decided to invest in the portfolio, but you are concerned that the actual weights in his financial asset portfolio are significantly different from the policy portfolio weights.

Table 1: Mr. B's policy portfolio and actual portfolio

	Expected return	Risk (standard deviation)	Policy portfolio weight	Actual portfolio weight
Global bonds (foreign exchange fully hedged)	2.0%	4.0%	80%	60%
Domestic equity	6.0%	20.0%	20%	40%

[Note: The correlation coefficient between the return on domestic equity and the return on global bonds (foreign exchange fully hedged) is 0.20.]

   b1) Calculate the expected return and risk (standard deviation) of Mr. B's policy portfolio based on the information in Table 1. (5 points)

b2) Calculate the expected active return and active risk for Mr. B's actual portfolio against the policy portfolio (tracking error) based on the information in Table 1. (5 points)

b3) The reason the foreign exchange exposure of Mr. B's global bonds is fully hedged is because Mr. B does not want to take any foreign exchange risk. Mr. B believes that the uncovered interest parity (UIP) relationship holds for foreign exchange markets. Explain what UIP is. (3 points)

b4) Even if the UIP relationship holds, it may be reasonable for risk-averse investors to partially leave open (not hedged) their foreign exchange exposure of global bonds rather than fully hedging them. Explain with any reason. (4 points)

c) Your customer Mr. C is a 55-year-old public employee. Mr. C's father recently died and he inherited stocks of a listed company (X Corporation) founded by his father. The father's will prevents Mr. C from selling his stocks of X Corporation for 10 years after inheritance, but he is planning to sell all of the stocks after 10 years in order to provide for living expenses in his retirement years and he is worried about the risk of a fall in the share price while he is waiting. Table 2 contains the market value of the X Corporation stock inherited by Mr. C, and the return/risk profiles of X Corporation and the domestic stock market index.

Table 2: Market value of inherited X Corporation stock and its return/risk profiles

	Market value	Expected return	Risk (standard deviation)
Inherited X Corporation stock **	EUR 1,000	4.0%	30.0%
Domestic stock market index	–	4.0%	20.0%

Note:
** X Corporation stock has a beta of 1.0 against the domestic stock market index.

c1) Calculate the correlation coefficient between the return on X Corporation stock and the return on the domestic stock market index by using the information in Table 2.

(4 points)

c2) Assuming the returns on X Corporation stock follow normal distribution, even if the market value of the stock were to fall from the current level of EUR 1,000 after 1 year, what is the amount of 95% Value at Risk after 1 year for the inherited X Corporation stock? (For example, when the 95% Value at Risk is EUR -500, this means that there is a 5% chance that the loss is larger than EUR 500.) In your calculation, take the expected return of X Corporation into consideration. [Hint: Use the standard normal distribution table in the formulae booklet.] (4 points)

c3) If you were to sell EUR 1,000 in notional principal of domestic stock market index futures maturing in 1 year to hedge the risk of the decline in the market value of X Corporation stock, what will be the amount of 95% Value at Risk for 1 year after hedging? As in c2), take the expected return into consideration. Assume that interest, dividends on the domestic stock market index, and basis risks for the domestic stock market index and futures can be ignored. [Hint: Use the standard normal distribution table in the Formulae booklet.] (5 points)

c4) Mr. C has decided to pursue a full hedge strategy with domestic stock market index futures as described in c3). However, if the inherited X Corporation stock accounts for the majority of Mr. C's financial assets at the current point in time, there are significant difficulties associated with implementing the full hedge strategy using futures described in c3). Explain some of these difficulties. (5 points)

c5) Instead of selling domestic stock market index futures, you consider purchasing EUR 1,000 in notional principal of at-the-money put options on the market index maturing in 1 year. Give one main advantage and one main disadvantage of this hedging strategy versus the one which uses futures. (4 points)

c6) Instead of purchasing put options on the domestic stock market index, you want to achieve the same effect as purchasing put options by dynamically trading futures on the index with "dynamic hedge (delta hedge)" strategy. However, there are situations in which the dynamic hedge strategy leads to less desirable outcomes than purchasing put options. Explain two demerits to the strategy in comparison to purchasing put options. (4 points)

d) Your customer Ms. D is currently 26 years old and works in a private company. She has started making investments only one year ago (at the beginning of the year). She has invested USD 1,000 per month into Fund Y which has generated a total of 20% return at the end of the year. However, her wealth at the end of the year is actually USD 11,787 which is less than the total amount she has invested (USD 12,000). You want to explain to her about the concepts of "money weighted" and “time weighted” rates of returns and their impact in evaluating the performance of her investment. The investment and fund net asset value (NAV) during the past year is as follows:

Table 3: Investment and NAV of Fund Y

	Amount invested (in USD)	NAV of Fund Y
Beginning of the year	1000	100
At end of month 1	1000	112
At end of month 2	1000	120
At end of month 3	1000	160
At end of month 4	1000	175
At end of month 5	1000	135
At end of month 6	1000	130
At end of month 7	1000	110
At end of month 8	1000	110
At end of month 9	1000	115
At end of month 10	1000	117
At end of month 11	1000	118
At end of month 12	-	120

d1) Explain how the timing of cash flows affect the measurement of investment performance. Discuss the concept of money weighted rate of return (MWR) and that of time weighted rate of return (TWR) and mention which one needs to be used to evaluate (i) the Fund Y's performance and (ii) Ms. D's investment performance. (6 points)

d2) Internal rate of return (IRR) is known as the true MWR. Describe briefly how the IRR is calculated, mentioning the assumptions behind the calculation method. (4 points)

d3) Explain the Dietz method for calculating the performance of an investor. Use the original Dietz method to calculate the investment performance of Ms. D. (4 points)

d4) What is the true TWR? Calculate the true TWR using the data provided in Table 3. (4 points)

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Question 1: Fixed Income / Derivative Valuation and Analysis (69 points)

a)

a1)

The analysis of the proposed budget metrics shows a divergent trend between the two companies:

- Revenues: both companies see an increase in turnover (revenues) estimates for the following year, even though for Company Beta the expected increase is less than proportional to that expected for Company Alpha;
- EBITDA: while for Company Alpha the EBITDA is expected to increase both in absolute value and in terms of EBITDA margin (EBITDA / Revenues from 30% to 35%), Company Beta is expected to reduce the EBITDA both in absolute terms and in terms of EBITDA margin (from 35% to 33%);
- Net financial position: while for Company Alpha it is expected to improve for the next year, for Company Beta a worsening of 50 million is expected (from -250 million to -300 million);
- Net debt/EBITDA: also for this parameter the situation of Company Alpha is expected to improve with a reduction of the ratio of 0.5x (from 2.8x to 2.3x). For Company Beta the ratio is expected to worsen by 0.2x (from 2.0x to 2.2x), also due to the reduction in EBITDA;
- Interest coverage ratio: the coverage of financial charges is expected to improve for Company Alpha by 1.0x (from 5.5x to 6.5x), while it is expected to worsen for Company Beta by 0.2x (from 6.2x to 6.0x).

It is therefore possible to argue that both from an income point of view and from the financial perspective, the estimates for the two companies are divergent: a good improvement for Company Alpha and a small deterioration for Company Beta.

a2)

Based on the balance sheet metrics provided and on the possible order for Company Alpha not yet incorporated in the estimates, it is possible to forecast an upgrade or a positive review of the outlook by rating agencies. All else being equal, with a sizable contract with better EBITDA margin, the company should improve its "Net leverage" and its "Interest coverage ratio". The improvement of income and financial metrics will also determine for the securities issued by Company Alpha a probable tightening of the yield to maturity requested by market participants according to the improvement of the credit risk profile.

a3)

Yield spread and bond swapping strategy:

Yield spread strategies are based on the positioning of portfolio components in order to gain from movements in yield spreads between the various segments of the bond market. The bond swapping in particular means exchanging an overvalued bond in the portfolio for another bond that the portfolio manager believes is undervalued by the market. In both cases the undervaluation and the overvaluation are measured in terms of the spread: in the case of the former (undervaluation) the spread is too wide, and in the case of the latter (overvaluation) the spread is said to be too narrow. Once the yield spread between the two bonds gets realigned (the yield of the bond that has been sold increases and the yield on the purchased bond decreases), the manager capitalizes on the difference, by reversing the bond swap.

Yield spreads can emerge from different sources:

1. the credit spread: this is by far the main source. It takes advantage of bonds of lower quality that trade at a spread with respect to higher quality ones (and ultimately to the relevant benchmark government bond). The spread between low and high quality bonds tends to widen when the economy is going to face a recession and narrows during boom phases (lower quality issuers face more difficulties in servicing their debt when the general level of economic activity is low and thus their income from operations also tends to decrease). Knowing that, the portfolio manager can swap low quality bonds for high quality ones when the level of economic activity is approaching the peak (the so called flight to quality) and do the opposite when the recession is approaching its trough.
2. the call provision: the probability that the issuer will exercise the call option is closely related to the level of interest rates (the probability of exercising is increasing if interest rates decrease) and to their volatility (like any option, the value of the call provision increases with the volatility of the underlying security – in this case the interest rate). Thus, when the portfolio manager expects a **decrease** in the level of interest rates he can swap from callable to non-callable bonds, since the spread of callable bonds is likely to increase and the price of callable bonds is likely to decrease. Why? Because the issuer is more likely to exercise the option as interest rates decrease, so the option value increase. As the investor is short the call option, bond price of the call option is going down and spread up).

a4)
Determinants of Macaulay Duration:

- Time to maturity: all being equal, longer maturity of the bond $\Rightarrow$ longer the duration
- Coupon rate of interest: all being equal, higher the coupon $\Rightarrow$ shorter the duration.
- Accumulation of the accrued interest $\Rightarrow$ all being equal, bond's duration naturally increases on coupon payment date, as the accrued interest drops off. These effects are especially pronounced for high coupon issues and for long maturity bonds.
- General level of interest rates (YTM level): all being equal, higher the YTM of the bond $\Rightarrow$ shorter the duration.

The price duration of the two securities are calculated as below:

Bond Company Alpha 3.50% 5yrs: $\text{Price duration} = \frac{4.61 \cdot 103.932}{100} \approx 4.79$

Bond Company Beta 2.50% 5yrs: $\text{Price duration} = \frac{4.68 \cdot 103.561}{100} \approx 4.85$

a5)
Considering the expected reduction in the credit risk profile for Company Beta compared to an increase for Company Alpha, the transactions to be carried out on the two securities indicated in order to better exploit the different effect on the yield to maturity of the two issuers, and assuming it is possible to make "short selling" on both titles, are as follows:

- Selling the Beta Company Bond 2.50% 5yrs ⇒ as it is possible that the security will undergo an increase in the yield to maturity on the secondary market;
- Purchase the Bond Company Alpha 3.50% 5yrs ⇒ as it is possible that the security will show a reduction in the yield to maturity on the secondary market.

a6)
Bond swapping strategy:

Bond Company Alpha 3.50% 5yrs nominal value N to be purchased:

$$\left(5,000,000 \cdot 103.561 \cdot 4.68\right) = \left(\mathrm{N} \cdot 103.932 \cdot 4.61\right)$$

$$\mathrm{N} \cong \text{EUR } 5{,}058{,}000$$

Bond Company Alpha 3.50% 5yrs counter-value B to be purchased:

$$\mathrm{B}=\mathrm{N} \cdot \frac{\mathrm{P}}{100} = 5{,}058{,}000 \cdot \frac{103.932}{100} = \text{EUR } 5{,}256{,}881$$

a7)
Bond swapping P&L strategy (calculated through ΔPrice/Price with coupon accrual):

(i) Long position on Bond Company Alpha 3.50% 5yrs $\Rightarrow \Delta\mathrm{Y} = 2.50\% - 2.65\% = -0.15\%$

$$\frac{\Delta\text{Price}}{\text{Price}} = -\,\text{Dmod} \cdot \Delta\text{y} = -4.61 \cdot \left(-0.15\%\right) = 0.6915\%$$

$$\text{Profit} = \Delta\mathrm{B} = \mathrm{B} \cdot \frac{\Delta\mathrm{B}}{B} = \mathrm{B} \cdot \frac{\Delta\mathrm{P}}{P} = 5{,}256{,}881 \cdot 0.6915\% = \text{EUR } 36{,}351$$

(ii) Short position on Bond Company Beta 2.50% 5yrs $\Rightarrow \Delta\mathrm{Y} = 1.90\% - 1.75\% = +0.15\%$

$$\frac{\Delta\text{Price}}{\text{Price}} = -\,\text{Dmod} \cdot \Delta\text{y} = -4.68 \cdot \left(+0.15\%\right) = -0.7020\%$$

$$\text{Profit} = \Delta\mathrm{B} = \mathrm{B} \cdot \frac{\Delta\mathrm{B}}{B} = \mathrm{B} \cdot \frac{\Delta\mathrm{P}}{P} = -\left(5{,}000{,}000 \cdot \frac{103.561}{100}\right) \cdot \left(-0.7020\%\right) = \text{EUR } 36{,}350$$

(iii) $\text{Net Profit} = 36'351 + 36'350 = \text{EUR } 72'701$

b)
b1)

- Capital Indexed inflation-linked bond: both principal and coupon payments are not fixed, they change following movements of the reference inflation index used. In particular, the principal is continually indexed to realized inflation and the coupons are set as a fixed percentage of this value.
- Coupon Indexed inflation-linked bond: only the coupons are indexed, while the principal redemption value remains constant. The coupons are a variable percentage of the constant principal. Thus, the indexed coupon interest rates are calculated simply by adding the inflation rate of the period to the coupon rate of the bond.

b2)
As it is a capital indexed inflation-linked bond, only the principal is indexed to inflation. Real coupons stay unchanged at 2.00%.

Annual indexed capital, annual indexed coupons and expected cash flows of the inflation-linked bond from year 1 to year 5 calculation:

	(i) Indexed principal	(ii) Indexed coupons	(iii) Annual cash flows
Year 1	$100 \cdot (1+1.2\%) = 101.2$	$101.2 \cdot (2\%) = 2.024$	2.024
Year 2	$101.2 \cdot (1+1.5\%) = 102.72$	$102.72 \cdot (2\%) = 2.054$	2.054
Year 3	$102.72 \cdot (1+1.75\%) = 104.52$	$104.52 \cdot (2\%) = 2.090$	2.090
Year 4	$104.52 \cdot (1+1.9\%) = 106.50$	$106.5 \cdot (2\%) = 2.130$	2.130
Year 5	$106.50 \cdot (1+2.0\%) = 108.63$	$108.63 \cdot (2\%) = 2.173$	108.63+2.173=110.803

b3)
Break even inflation calculation:
Implied Break-even inflation (at t = 0) $\Rightarrow 2.5\% - 2.0\% = 0.5\%$
$\left[\text{YTM of Nominal 5yrs senior benchmark} - \text{Real yield Inflation linked bond}\right]$

Alternative calculation method:
Implied Break-even inflation (at t = 0) $\Rightarrow \frac{1+2.5\%}{1+2.0\%} - 1 = 0.4902\%$
$\left[\frac{(1+\text{YTM of Nominal 5yrs senior benchmark})}{(1+\text{Real yield Inflation linked bond})} - 1\right]$

b4)
Realized inflation-linked yield calculation:

Using calculated cash-flows:

$$100 = \frac{2.024\%}{(1+3.695\%)} + \frac{2.054\%}{(1+3.695\%)^2} + \frac{2.090\%}{(1+3.695\%)^3} + \frac{2.130\%}{(1+3.695\%)^4} + \frac{2.173\%+108.63\%}{(1+3.695\%)^5}$$

$$100 \neq \frac{2.024\%}{(1+3.255\%)} + \frac{2.054\%}{(1+3.255\%)^2} + \frac{2.090\%}{(1+3.255\%)^3} + \frac{2.130\%}{(1+3.255\%)^4} + \frac{2.173\%+108.63\%}{(1+3.255\%)^5}$$

The realized inflation-linked yield equals 3.695%.

Using given cash-flows:

$$100 = \frac{2.00\%}{(1+3.73\%)} + \frac{2.05\%}{(1+3.73\%)^2} + \frac{2.10\%}{(1+3.73\%)^3} + \frac{2.15\%}{(1+3.73\%)^4} + \frac{111.00\%}{(1+3.73\%)^5}$$

$$100 \neq \frac{2.00\%}{(1+3.25\%)} + \frac{2.05\%}{(1+3.25\%)^2} + \frac{2.10\%}{(1+3.25\%)^3} + \frac{2.15\%}{(1+3.25\%)^4} + \frac{111.00\%}{(1+3.25\%)^5}$$

The realized inflation-linked yield equals 3.73%.

b5)

$$\text{Principal repayment at maturity} = \text{Max}\left(100\%; \text{Indexed principal at maturity}\right)$$

The deflation floor can therefore be considered as a put option embedded in the bond structure. The investor is long a put option: he has the right to sell the bond at 100.00. This determines in term of price that:

$$\text{Bond}_{\text{ with floor}} = \text{Bond}_{\text{ without floor}} + P_{floor=100\%}$$

Where $P_{floor=100\%}$ is the price of the put option with strike 100.00.

Therefore the bond <u>without</u> deflation floor has a lower price because it is riskier, the risk being to be repaid below 100.00 after 5 years if inflation is negative on the period. With a lower price, the spread over Euribor will be higher.

Hence the bond <u>without</u> deflation floor has a higher credit spread compared to the corresponding bond with the deflation floor.

Question 2: Derivative Valuation and Analysis (35 points)

a)
You sell one unit each of a call and a put with strike 14,250. Therefore:

	$S_T < 14{,}250$	$S_T \geqq 14{,}250$
Sell Call	0	$-(S_T - 14{,}250)\cdot 1{,}000$
Sell Put	$-(14{,}250 - S_T)\cdot 1{,}000$	0
Total	$(S_T - 14{,}250)\cdot 1{,}000$	$(14{,}250 - S_T)\cdot 1{,}000$

b)
By using put-call parity: $P_E + S_0 = C_E + Ke^{-r\tau}$
where

τ	time until expiry of the option
K	strike or exercise price of the option
r	continuously compounded risk-free rate of interest
S_0	spot price of the underlying
C_E	value of European call option
P_E	value of European put option

Hence,
$C_E = P_E + S_0 - Ke^{-r\tau} = 415 + 14{,}328 - 14{,}250\cdot e^{-(5\%\cdot 0.25)} = 14{,}743 - 14{,}073 = CU\ 670$

c)
The market price of the call is higher than its theoretical price, so you sell one unit of the call, borrow the present value of the strike price at the risk-free rate $14{,}250\cdot e^{-(5\%\cdot 0.25)}\cdot 1{,}000 = CU\ 14{,}073\cdot 1{,}000$, purchase 1 unit of the put, and purchase 1 unit of the MSA index.

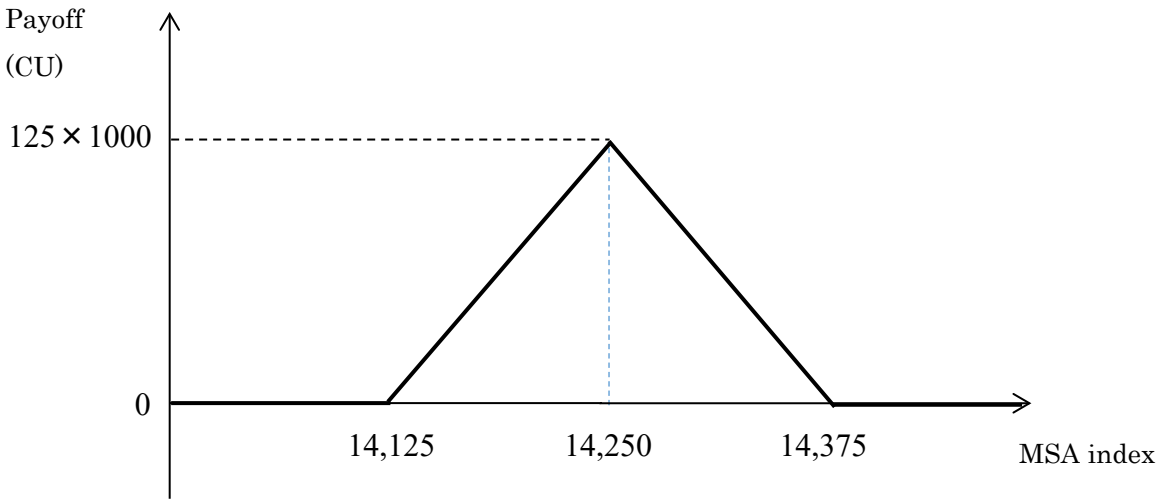
Position	Cash flow at present (t=0)	Payoff at maturity		
		$S_T < 14{,}250$	$S_T \geqq 14{,}250$	
Sell Call	$690\cdot 1000$	0	$-(S_T - 14{,}250)\cdot 1{,}000$	
Borrow risk-free asset	$14{,}250\cdot e^{-(5\%\cdot 0.25)}\cdot 1{,}000 = 14{,}073\cdot 1{,}000$	$-14{,}250\cdot 1{,}000$	$-14{,}250\cdot 1{,}000$	
Buy Put	$-415\cdot 1{,}000$	$(14{,}250 - S_T)\cdot 1{,}000$	0	
Buy the MSA index	$-14{,}328\cdot 1{,}000$	$S_T\cdot 1{,}000$	$S_T\cdot 1{,}000$	
Total	Arbitrage profit:	0	0	

	$20 \cdot 1,000 = 20,000$			

Therefore, you will surely receive CU 20,000 (if not rounded, CU 19,984) now for a zero payoff at maturity. Hence, by this trade you will earn an arbitrage profit of CU 20,000.

d)
You purchase one unit of the call with strike 14,125, purchase one unit of the call with strike 14,375, and sell two units of the call with strike 14,250. Therefore:

Position	$S_T < 14,125$	$14,125 \leqq S_T < 14,250$	$14,250 \leqq S_T < 14,375$	$S_T \geqq 14,375$
C(14,125)	0	$(S_T - 14,125) \cdot 1,000$	$(S_T - 14,125) \cdot 1,000$	$(S_T - 14,125) \cdot 1,000$
C(14,375)	0	0	0	$(S_T - 14,375) \cdot 1,000$
-2C(14,250)	0	0	$-2 \cdot (S_T - 14,250) \cdot 1,000$	$-2 \cdot (S_T - 14,250) \cdot 1,000$
Total	0	$(S_T - 14,125) \cdot 1,000$	$(14,375 - S_T) \cdot 1,000$	0



Investors taking this position do not believe there will be much movement of the MSA index at maturity from 14,250. So, from today's level of 14,328, they expect a slight correction of around -0.5% (≈14,250/14,328 – 1).

e)

- A straddle strategy purchasing one unit each of the at-the-money call and the at-the-money put, both with the same strike price.
- A strangle strategy purchasing one unit each of the out-of-the-money call and the out-of-the-money put.

Question 3: Derivatives in PM and Portfolio Management (76 points)

a)

a1)

"Human capital" is interpreted as the discounted present value of labour income that a person will produce in the future. Mr. A is relatively young at 30 and his human capital is high. As a public employee, there is relatively little uncertainty in his labour income, and he therefore has low human capital risk.

a2)

Mr. A is young being 30 years old and at the beginning can only invest part of the money he will put aside over the next 35 years in financial assets. It is therefore appropriate for him to invest in high-risk/high-return assets, mostly stock. In other words, if Mr. A's total assets are considered to be the total of human capital and financial assets, while he is young his financial assets will account for only a low percentage of total assets. As a public employee, Mr. A's human capital has low risk, and it is therefore appropriate for him to invest in high-risk/high-return financial assets.

However, as he ages, he will accumulate more financial assets and his human capital will decline, which means that as he ages he will have less tolerance for a decline in the value of his financial assets. In other words, over the next 35 years, the risks that should be taken in financial assets will decline as age increases.

a3)

If he dies before retirement, Mr. A's human capital will become zero. Life insurance is to hedge that risk. Mr. A's human capital will decline with age, which will reduce the human capital to be hedged and therefore reduce the amount of life insurance coverage required.

a4)

- It is possible to increase the annual funding ratio (10% of annual income) from what was initially planned. This is essentially reducing pre-retirement living standards below what was initially planned to provide for post-retirement funds. One key point to be borne in mind, therefore, is this reduction in living standards prior to retirement.
- Another conceivable strategy is to increase human capital. Mr. A could transfer to a better paid job, or his wife could work as well. Either would increase the total human capital of the household and increase annual savings without reducing initially planned pre-retirement living standards. Key points to hold in mind are the increased risk to Mr. A's human capital resulting from a job change, and the change in lifestyles were Mr. A's wife to work.
- Another conceivable strategy is to increase the risk exposure of financial assets from initially planned levels in search of higher returns. The key point to note is that this will also increase the downside risk on financial assets, which means there will be a greater risk of decline in post-retirement living standards.

b)
b1)

The expected return on Mr. B's policy portfolio μ_{bmk} can be calculated from the expected returns of global bonds and domestic equities (μ_b and μ_s), and their basic portfolio weights: ($w_{bmk,b}$ and $w_{bmk,s}$):

$$\mu_{bmk} = w_{bmk,b} \cdot \mu_b + w_{bmk,s} \cdot \mu_s$$
$$= 0.8 \cdot 2\% + 0.2 \cdot 6\% = 2.8\%$$

Similarly, the risk (standard deviation) of Mr. B's policy portfolio σ_{bmk} can be calculated from the risks of global bonds and domestic equities (σ_b and σ_s), their correlation coefficient ρ, and their basic portfolio weights ($w_{bmk,b}$ and $w_{bmk,s}$), as shown below:

$$\sigma_{bmk} = \sqrt{w_{bmk,b}^2 \cdot \sigma_b^2 + 2 \cdot w_{bmk,b} \cdot w_{bmk,s} \cdot \rho \cdot \sigma_b \cdot \sigma_s + w_{bmk,s}^2 \cdot \sigma_s^2}$$
$$= \sqrt{(0.8 \cdot 4.0\%)^2 + 2 \cdot 0.8 \cdot 0.2 \cdot 0.2 \cdot 4.0\% \cdot 20.0\% + (0.2 \cdot 20.0\%)^2}$$
$$= \sqrt{0.003136} \approx 5.6\%$$

b2)

The active weight of Mr. B's actual portfolio against the policy portfolio ($w_{act,b}$ and $w_{act,s}$) is:

$$w_{act,b} = 60\% - 80\% = -20\%$$
$$w_{act,s} = 40\% - 20\% = 20\%$$

Therefore, the expected active return of Mr. B's portfolio against the policy portfolio μ_{act} can be calculated from the expected returns of global bonds and domestic equities (μ_b and μ_s), and their active weights ($w_{act,b}$ and $w_{act,s}$):

$$\mu_{act} = w_{act,b} \cdot \mu_b + w_{act,s} \cdot \mu_s$$
$$= -0.2 \cdot 2\% + 0.2 \cdot 6\% = 0.8\%$$

[Alternative answer:
We can calculate the actual expected return: (0.6 · 2%) + (0.4 · 6%) = 3.6%, which is 0.8% higher than the recommended policy portfolio of 2.8% → expected active return = 0.8%.]

Similarly, the active risk (estimated tracking error: standard deviation) of Mr. B's portfolio against the policy portfolio σ_{act} can be calculated from the risks of global bonds and domestic equities (σ_b and σ_s), their correlation coefficient ρ, and their active weights against the policy portfolio ($w_{act,b}$ and $w_{act,s}$), as shown below:

$$\sigma_{act} = \sqrt{w_{act,b}^2 \cdot \sigma_b^2 + 2 \cdot w_{act,b} \cdot w_{act,s} \cdot \rho \cdot \sigma_b \cdot \sigma_s + w_{act,s}^2 \cdot \sigma_s^2}$$
$$= \sqrt{(-0.2 \cdot 4.0\%)^2 + 2 \cdot (-0.2) \cdot 0.2 \cdot 0.2 \cdot 4.0\% \cdot 20.0\% + (0.2 \cdot 20.0\%)^2}$$
$$= \sqrt{0.001536} \approx 3.9\%$$

b3)
Uncovered interest parity (UIP) refers to a situation in which the expected rate of return of the foreign exchange is equal to the difference between domestic interest rate and foreign interest rate.

b4)
Returns on foreign exchange are not fully linked to the returns of global bonds (foreign exchange fully hedged), domestic equities, and other assets. The diversification effect therefore could reduce the portfolio's risk. For example, if there is a negative correlation between global bonds (foreign exchange fully hedged) and foreign exchange returns, leaving the foreign exchange exposure on global bonds partially open (not fully hedged) could reduce the overall risk for the portfolio. This makes it rational for even risk-averse investors not to fully hedge foreign exchange rates.

c)
c1)
X Corporation stock's β_x against the domestic stock market index can be expressed using X Corporation stock's risk σ_X, the domestic stock market index's risk σ_M, and their correlation coefficient ρ.

$$\beta_x = \rho \cdot \frac{\sigma_X}{\sigma_M}$$

Therefore,

$$\rho = \beta_x \cdot \frac{\sigma_M}{\sigma_X} = 1.0 \cdot \frac{20\%}{30\%} = 0.67$$

c2)
From the standard normal distribution table, there is a 95% probability of a value smaller than 1.65 standard deviations, so if returns are assumed to follow normal distribution, X Corporation stock's 1 year 95% value at risk VaR(95%) can be calculated from X Corporation stock's market value V_0, its stock expected return μ_X, and its stock risk (standard deviation) σ_X, as shown below:

$$\text{VaR}(95\%) = V_0 \cdot (\mu_X - 1.65 \cdot \sigma_X)$$
$$= 1000 \cdot (4\% - 1.65 \cdot 30\%) = \text{EUR} - 455$$

The VaR is -455 EUR.

c3)

X Corporation stock's return r_X and risk (variance) σ_X^2 can be expressed using the domestic stock market index's return r_M and risk (variance) σ_M^2, the β against the index, the residual return against the index ε_X, and its risk (variance) σ_ε^2:

$$r_X = \beta_X \cdot r_M + \varepsilon_X$$
$$\sigma_X^2 = \beta_X^2 \cdot \sigma_M^2 + \sigma_\varepsilon^2$$

In this case, $\beta_X = 1$ and the expected values of both r_X and r_M are 4.0%, so the expected value of ε_X is 0%

If interest, domestic stock market index dividends, and domestic stock market index and future basis risks can be ignored, the domestic stock market index and futures can be assumed to be fully synchronized in their price movements. Therefore, creating a short position with EUR 1,000 in notional principal futures the same as the market value of X Corporation stock will offset the portion that is linked to r_M, resulting in post-hedge risk (standard deviation) of σ_ε.

Hence:

$$\sigma_\varepsilon = \sqrt{\sigma_X^2 - \beta_X^2 \cdot \sigma_M^2} = \sqrt{0.30^2 - \left(1.0^2 \cdot 0.20^2\right)} = \sqrt{0.05} = 0.2236068\cdots \approx 22.36\%$$

Expected return after hedging is:

$$E\left(r_X - r_M\right) = E\left(\beta_X \cdot r_M + \varepsilon_X - r_M\right) = E\left(\varepsilon_X\right) = 0\%$$

From the standard normal distribution table, the probability of a value smaller than 1.65 standard deviation is 95%, so the 95% value at risk for 1 year after hedging is:

$$\begin{aligned}\text{Post - hedge VaR}\left(95\%\right) &= V_0 \cdot \left(0 - 1.65 \cdot \sigma_\varepsilon\right) \\ &= 1000 \cdot \left(-1.65 \cdot 22.36\%\right) \\ &= -368.951 \approx \text{EUR} - 369\end{aligned}$$

c4)

If futures on the domestic stock market index are sold and the stock market rises, there will be a margin call corresponding to the unrealized losses on the futures. In addition, there are no ultra-long futures that extend for 10 years, making it necessary to continually roll over futures with shorter contract months. If at that time there is a rise in the stock market, money will be required to settle the position.

At the current point in time, X Corporation stock accounts for the majority of Mr. C's financial assets, and the stock cannot be sold for 10 years. Mr. C will presumably therefore find it difficult to provide for margin calls or rollover settlements, which will be a major demerit to the full-hedge strategy.

Moreover, as X Corporation stocks are not fully correlated to the stock market index, it could happen that in 10 years from now, (i) the index is higher, creating a loss on the short future position, and (ii) X Corp stock price is lower than today, creating a loss on the stock position. Double pain and no hedge!

c5)
Advantage:
By buying put options you keep the upside potential open.

Disadvantage:
But the put option has an initial cost that the future does not have.

c6)

- If the realised volatility of the domestic stock market index (futures) is higher than initially expected (implied volatility of options), costs will be higher than purchasing options, and performance after hedging may be worse.
- There may be situations in which it is impossible to adjust hedge ratios as desired, for example, when there is a jump in the futures market. It is therefore possible that the loss on the hedge will be greater than the cost of purchasing options.
- Depending on the market environment, required futures trading volumes may increase, resulting in higher than expected transaction costs.

d)
d1)
The timings of the cash flows made by the investor may have a significant impact on the gain and loss on the return of an investment portfolio. For example, if the investment is made before an important decline of (resp. an important rise in) the fund, the return of the investor will be lower (resp. higher) to that of the fund.

The money weighted rate of return (MWR) is used to measure the return experienced by an investor, reflecting the comprehensive or total return including the timing effect of external cash flows.

The time weighted rate of return (TWR) is used to measure only the return produced by the portfolio manager, not affected by the timing of external cash flows (implicitly assuming that the portfolio manager has no discretion over the timing of external cash flows).

The Fund Y's performance is calculated through the TWR. Ms D's investment performance is calculated through the MWR.

d2)
The internal rate of return (IRR) is known as true MWR because it is a precise method for calculating a MWR. For a specific measurement period, the IRR is the return or interest rate that causes the ending market value and the interim external cash flows to be discounted to the beginning market value. Thus IRR is calculated making some implicit assumptions that external cash inflows are financed at an interest rate (finance rate) that is identical to IRR and external cash outflows are reinvested at an interest rate (reinvestment rate) that is identical to the IRR. The calculation of IRR is not trivial and it needs an interpolation technique or iterative process to calculate IRR.

d3)
The original Dietz method assumes that the net cash flow takes place in the middle of the period, so that the weighted cash flow is equal to 1/2 of the NCF. The average invested capital (AIC) is then calculated as follows:

$$\text{AIC} = \text{MV}_{\text{begin}} + \frac{1}{2} \cdot \text{NCF}$$

[Note:The modified Dietz method uses the actual timing of external cash flows to weight cash flows and calculate the AIC.]

Original Dietz Formula for MWR is:

$$\begin{aligned} \text{MWR} &= \frac{(\text{MV}_{\text{end}} - \text{MV}_{\text{begin}}) - \text{NCF}}{\text{MV}_{\text{begin}} + \frac{1}{2} \cdot \text{NCF}} \\ &= \frac{(11{,}787 - 1{,}000) - 11 \cdot 1{,}000}{1{,}000 + \frac{1}{2} \cdot 11 \cdot 1{,}000} = -3.28\% \end{aligned}$$

d4)
True time-weighted rate of return is a return that is completely unaffected by the timing of external cash flows. Hence, the total investment period is split into as many sub-periods as needed starting and ending at the time when a cash flow takes place. The returns for each period are then compounded to calculate the total period return.

For Ms D, we can calculate the returns for each month and aggregate them. Here we have NAV data which is actually unaffected by external cash flows and gives the correct TWR as 20%. Calculation can be shown as below:

$$\text{TWR} = \frac{112}{100} \cdot \frac{120}{112} \cdot \frac{160}{120} \cdot \frac{175}{160} \cdot \frac{135}{175} \cdot \frac{130}{135} \cdot \frac{110}{130} \cdot \frac{110}{110} \cdot \frac{115}{110} \cdot \frac{117}{115} \cdot \frac{118}{117} \cdot \frac{120}{118} - 1 = \frac{120}{100} - 1 = 20\%$$