EXAMINATION II:

Fixed Income Valuation and Analysis

Derivatives Valuation and Analysis

Portfolio Management

Solutions

Final Examination

September 2014

Question 1: Fixed Income - Derivatives – Portfolio Management

a)

a1)

We apply the Bootstrapping method to calculate the spot rates, working on a unit notional amount (N = 1). Be $R_{swap,nY}$ the annual par rate swap for year "n", and $R_{spot,nY}$ the annual spot rate for year "n".

Spot rate 1 year = Par yield 1 year = 0.5000%.

Spot rate 2 years:

$$1 = \frac{R_{swap,2Y}}{(1+R_{spot,1Y})} + \frac{R_{swap,2Y}+1}{(1+R_{spot,2Y})^2} \Leftrightarrow 1 = \frac{0.75\%}{(1+0.5\%)} + \frac{0.75\%+1}{(1+R_{spot,2Y})^2}$$

$$\Leftrightarrow R_{spot,2Y} = \sqrt{\frac{0.75\%+1}{1-\frac{0.75\%}{(1+0.5\%)}}} - 1 = \sqrt{\frac{1.0075}{1-\frac{0.0075}{1.005}}} - 1 = 0.7509\%$$

Or alternatively:

$$df_{2years} = 0.9851 = \frac{1}{(1+R_{spot,2Y})^2} \Leftrightarrow R_{spot,2Y} = \sqrt{\frac{1}{0.985149}} - 1 = 0.7509\%.$$

Spot rate 4 years:

$$1 = \frac{R_{swap,4Y}}{(1+R_{spot,1Y})} + \frac{R_{swap,4Y}}{(1+R_{spot,2Y})^2} + \frac{R_{swap,4Y}}{(1+R_{spot,3Y})^3} + \frac{R_{swap,4Y}+1}{(1+R_{spot,4Y})^4} \Leftrightarrow$$

$$1 - \left[\frac{1.25\%}{(1+0.5\%)} + \frac{1.25\%}{(1+0.7509\%)^2} + \frac{1.25\%}{(1+0.9527\%)^3}\right] = \frac{1.25\%+1}{(1+R_{spot,4Y})^4} \Leftrightarrow$$

$$R_{spot,4Y} = \sqrt[4]{\frac{1.25\%+1}{1-\left[\frac{1.25\%}{(1+0.5\%)} + \frac{1.25\%}{(1+0.7509\%)^2} + \frac{1.25\%}{(1+0.9527\%)^3}\right]}} - 1 = 1.2584\%$$

Or alternatively:

$$[1+R_{spot,4Y}]^4 = [1+R_{spot,3Y}]^3 \cdot [1+R_{forward,3Y,4Y}]$$

$$[1+R_{spot,4Y}]^4 = [1+0.9527\%]^3 \cdot [1+2.1811\%] = 1.051294$$

And $R_{spot,4Y} = 1.2584\%$

a2)

The forward interest-rate $F_{t-1,t}$ is the 1-year interest rates for a forward contract starting in t-1 and maturing in t. It is calculated from:

$$(1+R_{spot,t-1})^{t-1} \cdot (1+F_{t-1,t}) = (1+R_{spot,t})^t \Rightarrow F_{t-1,t} = \frac{(1+R_{spot,t})^t}{(1+R_{spot,t-1})^{t-1}} - 1$$

$$F_{2,3} = \frac{\left(1+R_{spot,3}\right)^3}{\left(1+R_{spot,2}\right)^2} - 1 = \frac{\left(1+0.9527\%\right)^3}{\left(1+0.7509\%\right)^2} - 1 = 1.357\,4\%$$

$$F_{4,5} = \frac{\left(1+R_{spot,5}\right)^5}{\left(1+R_{spot,4}\right)^4} - 1 = \frac{\left(1+1.4118\%\right)^5}{\left(1+1.2584\%\right)^4} - 1 = 2.0277\%$$

a3)

Discount factors calculation: $df_t = \frac{1}{\left(1+R_{spot,t}\right)^t}$

$$df_3 = \frac{1}{\left(1+R_{spot,3}\right)^3} = \frac{1}{\left(1+0.9527\%\right)^3} = 0.971955 \cong 0.9720$$

$$df_4 = \frac{1}{\left(1+R_{spot,4}\right)^4} = \frac{1}{\left(1+1.2584\%\right)^4} = 0.951209 \cong= 0.9512$$

b)

b1)

The term structure of interest rates relates to the zero coupon or spot rates, while the market yield curve relates to the yield to maturities expressed by the market prices. Analysts and economists use the term structure of interest rates for a number of applications. Some of the most common include:

- Calculate the present value PV of financial assets by discounting their cashflows
- Estimate the dynamics of the financial markets
- Forecasting future interest rates
- Constructing and managing portfolios
- Building and managing hedging strategies
- Implementing models to predict economic growth formulating monetary policies
- Estimating the cost of capital over long periods
- Estimating future inflation rate
- ....

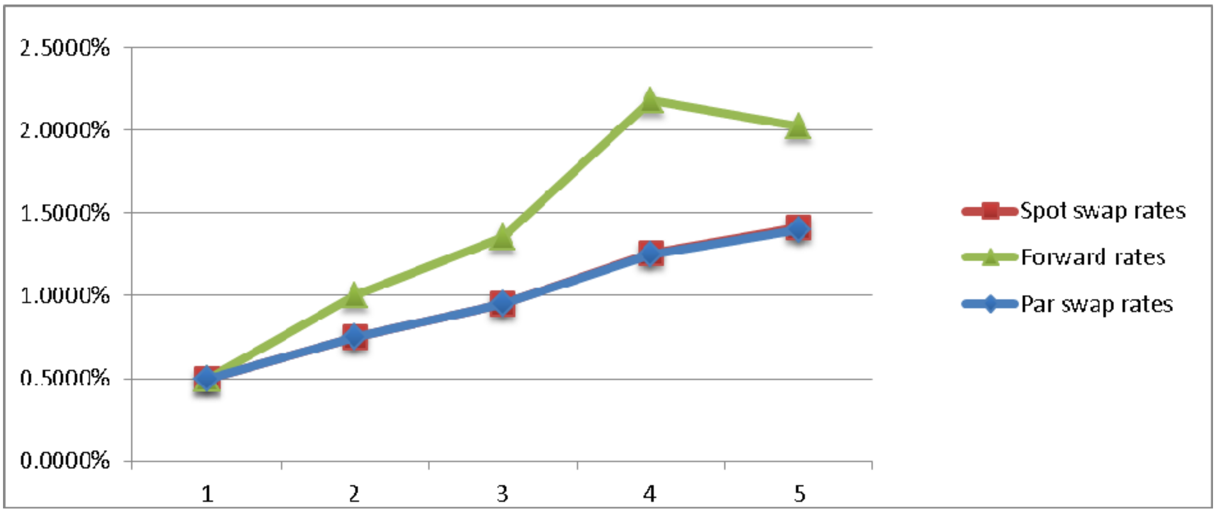
And they also are useful in fixed income derivative pricing

b2)

The par curve has a positive slope. This will lead to having a spot curve laying above the par curve, and a forward curve laying above the par and spot curve. All of them having a positive slope.

The general implications about rates in the future drawn from yield curve shapes are straightforward: a positive yield curve is an expectation that yields in the future will be higher, and an inverse yield curve implies that they will be lower.

The following graph is not required and is shown only for pedagogical reasons.
The spot curve lays slightly above the par curve, although not visible on the graph due to the very small differences:



c)

c1)

<u>Bond 1 (Calculated spot curve):</u>

$$B_1 = \frac{3}{(1+R_{spot,1Y}+0.65\%)} + \frac{3}{(1+R_{spot,2Y}+0.65\%)^2} + \frac{103}{(1+R_{spot,3Y}+0.65\%)^3} \Leftrightarrow$$

$$B_1 = \frac{3}{(1+0.5\%+0.65\%)} + \frac{3}{(1+0.7509\%+0.65\%)^2} + \frac{103}{(1+0.9527\%+0.65\%)^3} \cong 104.09$$

[with the given spot curve: $B_1 = 104.08$]

<u>Bond 2 (Calculated spot curve):</u>

$$B_2 = \frac{4.5}{(1+0.5\%+0.65\%)} + \frac{4.5}{(1+0.7509\%+0.65\%)^2} + \frac{4.5}{(1+0.9527\%+0.65\%)^3} + \frac{104.5}{(1+1.2584\%+0.65\%)^4}$$

$$\Rightarrow B_2 = 110.00$$

[with the given spot curve: $B_2 = 110.00$]

c2)

The YTM of bond 1 solves following equation:

$$104.086 = \frac{3}{(1+YTM_1)} + \frac{3}{(1+YTM_1)^2} + \frac{103}{(1+YTM_1)^3}$$

With a financial calculator we get $YTM_1 = 1.59\%$

The YTM of bond 2 solves following equation:

$$110 = \frac{4.5}{(1+YTM_2)} + \frac{4.5}{(1+YTM_2)^2} + \frac{4.5}{(1+YTM_2)^3} + \frac{104.5}{(1+YTM_2)^4}$$

$$\Rightarrow YTM_2 = 1.88\%$$

c3)
The YTM implied by the price of Bond 1 is 1.59%, smaller than the 1.65% given in Table 2.

The YTM implied by the price of Bond 2 is 1.88%, greater than the 1.85% given in Table 2.

The fund manager will therefore choose Bond 2, because it offers a yield premium compared to the benchmark YTM curve (i.e. it is at discount in terms of cash price).

d)
d1)
As seen in c3), the YTM implied by the price of Bond 2 is 1.88%,

$$\frac{\Delta P}{P} = -D^{\text{mod}} \cdot \Delta y \Leftrightarrow \frac{\Delta P}{P} = -\frac{D}{(1+y)} \cdot \Delta y = -\frac{3.76}{(1+1.88\%)} \cdot 0.30\% = -1.11\% .$$

d2)

$$\Delta P = -P \cdot \frac{D}{(1+y)} \cdot \Delta y = -110 \cdot \frac{3.76}{(1+1.88\%)} \cdot 0.30\% \cong -1.22$$

d3)

$$P^{new} = P^{old} + \Delta P = 110 - 1.22 = 108.78$$

e)
The modified duration is only a **linear approximation** of the full price change due to a change in the interest rates. It doesn't consider the convexity of the bond, that is dependent on the particular features of the specific bond in terms of expiry date, amount of coupons, payment dates of the coupons, redemption price of the bond, amortizing of the nominal redemption value if any, call/put options if any.

In addition, the modified duration is a good approximation of bond's price change only if:

- it's assumed that the yield curve is "flat".
- a limited (small) interest rate change is considered.
- a parallel shift of the interest rate curve is considered.
- an instantaneous interest rate change is considered.

f)
The main factors that affect the yield spread are the following:

- Maturity of the instrument: the general rule of the pure price of time tells us that investors require a higher yield to maturity to keep securities with a longer expiry date. This is because the longer the maturity the higher is the risk of the investment. This general rule also involves the yield spread: as generally observed in the market a higher yield spread is required for longer investments, since there is less predictability of the risk factors;
- Creditworthiness of the issuer: the creditworthiness of the issuer, interpreted as the probability of default, clearly affects the yield: the higher the probability of default [i.e. the lower the creditworthiness of the issuer], the higher the required yield, to compensate for the possible losses due to default;

- Embedded options: many bond issues include provisions granting either the issuer or the bondholder, one or more options to take some actions such as repaying the bond before the maturity (call option for the issuer) or being redeemed before maturity (put option for the borrower). The option benefits the party who can choose to exercise it (the holder of the option) at the cost of the party who has written it. The advantage of holding an option has to be paid for a yield differential. Since each option has to be paid for, a bond with an embedded call provision should lead to a higher yield (the issuer has to pay for the call option) than a similar bond without the call provision itself. Conversely, a puttable bond should carry a lower yield (the bond holder has to pay for the option he holds) than a similar bond without the put provision.
- Tax status of the instrument: since investors will base their bond investment decisions on the net yield, a taxable bond has to pay a higher gross yield to maturity in order to compete with a tax exempt bond or with bonds with a different tax rate. Therefore the yield spread will be higher than that of tax exempt bond.
- Liquidity of the security: the lower the liquidity of the bond, the higher the yield required by the investors. The yield spread will be higher compared to liquid bonds [and usually Treasuries, taken as proxy for the risk-free asset, are very liquid].

g)
The modified duration of the portfolio is: $D^{mod} = \frac{3.76}{(1+1.88\%)} = 3.69$

$$N_f = -\frac{S_0 \cdot MD_S}{F_T \cdot MD_{CTD}} = -\frac{\begin{pmatrix}\text{Market value of}\\ \text{portfolio to hedge}\end{pmatrix} \cdot \begin{pmatrix}\text{Modified duration}\\ \text{of the portfolio}\end{pmatrix}}{\begin{pmatrix}\text{Market value of}\\ \text{one futures contract}\end{pmatrix} \cdot \begin{pmatrix}\text{Modified duration}\\ \text{of CTD}\end{pmatrix}} = -\frac{10\,\text{million} \cdot 3.69}{122{,}500 \cdot 4.5} \cong -67$$

To hedge the “long” position on Bond 2 the fund manager has to sell 67 Euro-Bobl Futures expiry December 2014.

h)
In order to hedge the position on the bond from a credit quality deterioration of the issuer, the fund manager could buy a single name CDS (Credit Default Swap) or CDS Indexes on the relevant sector/expiry [Credit risk itself is composed of two risks: risk of default and risk of change in the credit quality producing credit spread volatility].

i)
i1)
The duration of the collared floating rate note is higher than that of the floating rate note without collar. This is because while for the plain vanilla floater (without collar) the duration is usually assumed to be equal to the time to the next coupon payment (max 1 year in this case), the collared floater has a coupon structure similar to a fixed coupon bond, because the cap and floor are set very close to each other.

i2)
Assuming an identical OAS over Libor for both bonds, the collared floater will produce a lower price. The reason is:

- Price plain floater bond + Floor option – Cap option = Price collared bond
- Price plain floater bond + Floor option = Price floor bond

Compared to the floor floater bond, the investor on the collar floater bond sells the cap option. This allows him to capture the option premium in the form of a lower bond price, due that it's assumed an equal spread over Libor for both bonds.

Question 2: Derivative Valuation and Analysis

a)

$$C_E - P_E - S + \frac{K}{1+R\cdot\tau} \overset{!}{=} 0$$

Put-call-parity is valid for options with strike 10:

$$C_E - P_E - S + \frac{K}{1+R\cdot\tau} = 2.16 - 0.21 - 11.72 + \frac{10}{1+4\%\cdot 0.6} = -0.004 \cong 0$$

Put-call-parity is violated however for options with strike 14:

$$C_E - P_E - S + \frac{K}{1+R\cdot\tau} = 0.37 - 2.43 - 11.72 + \frac{14}{1+4\%\cdot 0.6} = -0.108$$

The put with strike 14 seems to be overvalued, respectively the call with strike 14 seems undervalued. Therefore, since $C_E < P_E + S - \frac{K}{1+R\cdot\tau}$ (whereas equality should hold), you buy the lefthand side [which is cheap], and sell the righthand side [which is expensive]:

(i) buy 1 call contract for EUR 37.

(ii) sell 1 put contract for EUR 243.

(iii) sell 100 stocks receiving EUR 1,172.

(iv) invest EUR 1,367.19 [$= \frac{1{,}400}{1+4\%\cdot 0.6}$] at the riskless interest rate.

The profit per option contract is EUR 10.81.

b)

$F_{t,T} = S\cdot(1+R\cdot\tau)$, where $\tau = T - t$.

Therefore, $F_{t,T} = 11.72\cdot(1+4\%\cdot 0.6) = 12.001$

c)

Since the futures price is 12, we choose the strike K = 12 options.

To work on 10 million stocks you have to use $\frac{10\,\text{million}}{100} = 100{,}000$ option contracts. We sell 100,000 call option contracts and buy 100,000 put option contracts.

The initial cash outflow is: $100{,}000\cdot 100\cdot(0.90 - 0.94) = -400{,}000$ EUR.

[Note: The initial cost is not zero because the put-call-parity is violated here. In fact it should hold:

$$C_E - P_E - \frac{S\cdot(1+R\cdot\tau) - K}{1+R\cdot\tau} \overset{!}{=} 0 \Leftrightarrow C_E - P_E = \frac{F-K}{1+R\cdot\tau}.$$

Here with F = K it should be: $C_E - P_E = 0$.]

A synthetic futures contract displays the same payoffs at expiration as the original futures contract itself. However, there is **no marking to market** along the way. Hence the position is in fact a synthetic forward.

d)
Yes it is possible.

If we use 100,000 strike K = 10 options instead, we receive immediately:
$100{,}000 \cdot 100 \cdot (2.16 - 0.21) = 19{,}500{,}000$ EUR.

Again, this is a short position in a **synthetic forward**. This time the delivery price is 10 instead of 12. The relative loss of 20 million EUR at expiration is exactly offset by the amount received today:
$19{,}500{,}000 \cdot (1 + 4\% \cdot 0.6) = 19{,}968{,}000 \cong 20\,\text{million EUR}$.

Note that put-call-parity is valid for these OTM puts. Therefore, notwithstanding the partial liquidation of the stock portfolio, the client saves 400,000 EUR compared to c).

e)
You have to trade 100,000 option contract each, because considering the option size = 100 you work on 10 million stocks.

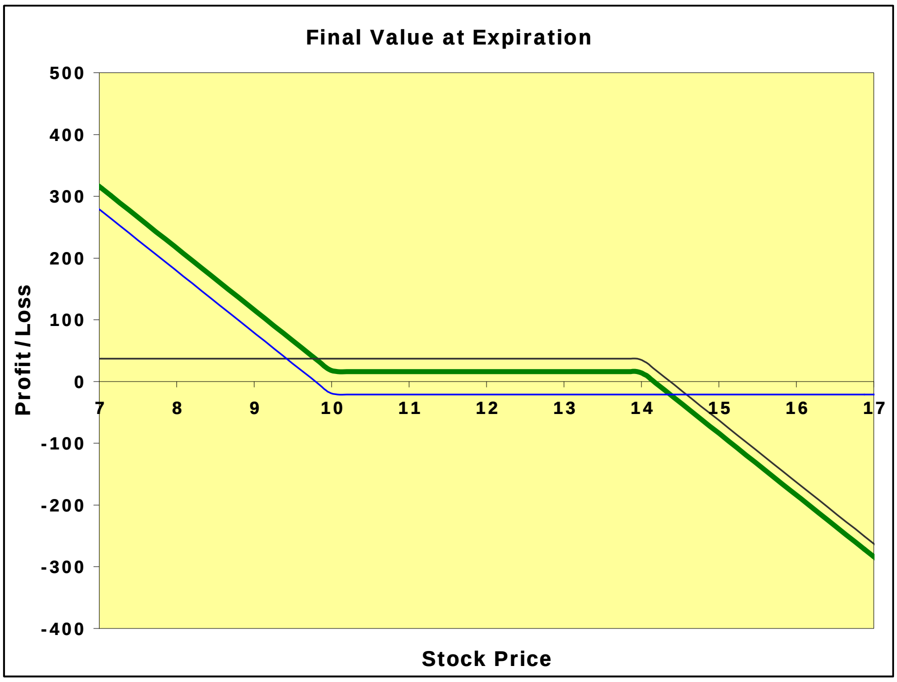
The initial income of the short bull cylinder is:
$100{,}000 \cdot 100 \cdot (0.37 - 0.21) = 1{,}600{,}000$

The final P/L of the short bull cylinder is:
$$V_T = 100{,}000 \cdot 100 \cdot \left[0.16 \cdot (1 + 4\% \cdot 0.6) + \max(0, 10 - S_T) - \max(0, S_T - 14)\right]$$
$$\Rightarrow V_T = 10{,}000{,}000 \cdot \left[0.16384 + \max(0, 10 - S_T) - \max(0, S_T - 14)\right]$$

or simply

$S_T \leq 10:$	$10{,}000{,}000 \cdot [10.16384 - S_T]$
$10 < S_T \leq 14:$	1,638,400
$S_T > 14:$	$10{,}000{,}000 \cdot [14.16384 - S_T]$

The following diagram shows the final value of the short bull cylinder at expiration per contract size [k = 100]:



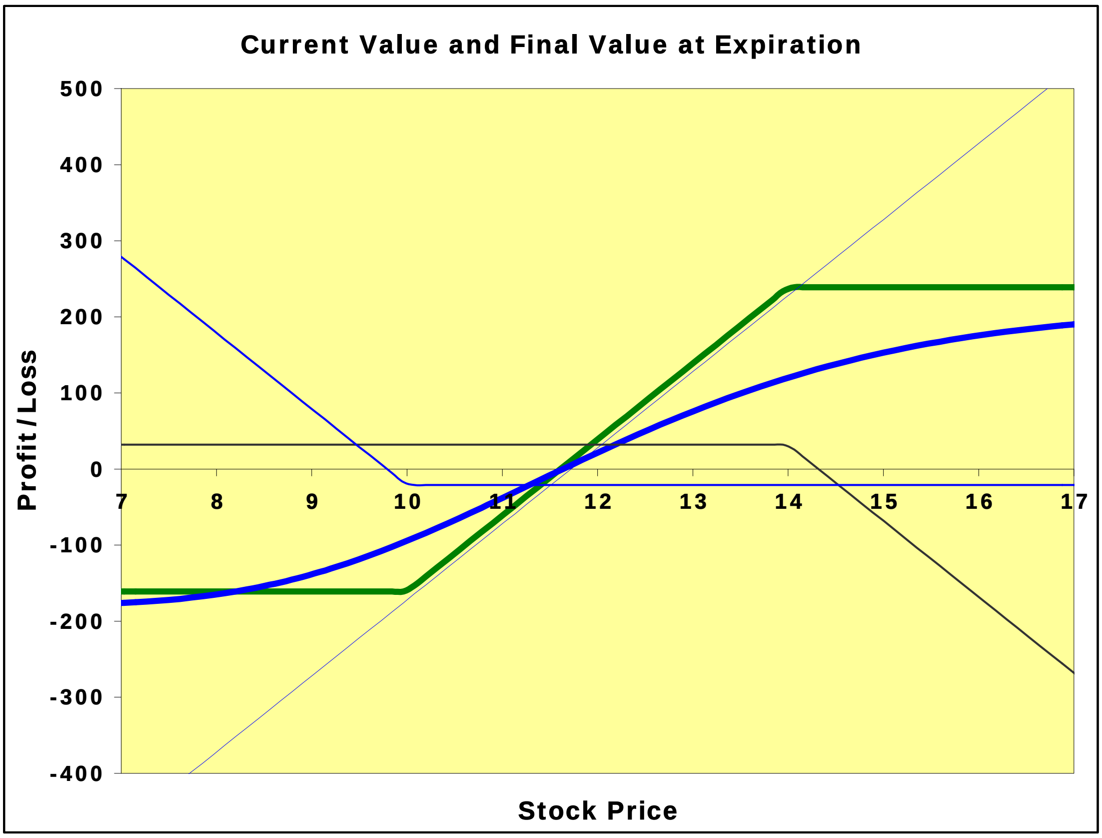
f)
Total delta = $10{,}000{,}000 \cdot [1 - 0.27 - 0.16] = 10{,}000{,}000 \cdot [0.57] = 5{,}700{,}000$
Total gamma = $10{,}000{,}000 \cdot [0 - 0.132 + 0.102] = 10{,}000{,}000 \cdot [-0.03] = -300{,}000$

With:
Delta stock = 1
Delta call (K = 14) = 0.27
Delta put (K = 10) = -0.16
Gamma stock = 0
Gamma call (K = 14) = 0.132
Gamma put (K = 10) = 0.102
[Note: keep in mind that you are using a short position in a bull cylinder, i.e. using short calls and long puts.]

The delta of the new portfolio is about 58% of the original stock position. The portfolio is still moderately bullish.

The gamma of the new portfolio is negative the position value is a concave function of the underlying stock price.

The following graph is not required, but presented for pedagogical purposes only:
The following diagram shows the current and the final value at expiration of the total position containing the stocks (long) and the bull cylinder (short). The new position displays a risk exposure similar to a bull spread.



g)
To end up with a total delta of zero you have to short N bull cylinders:

$$\text{Total delta} = 0 \Leftrightarrow 10{,}000{,}000 + N \cdot 100 \cdot [-0.27 - 0.16] = 0 \Leftrightarrow N = \frac{100{,}000}{0.43} = 232{,}558$$

The gamma then becomes:

$$232{,}558 \cdot 100 \cdot [0 - 0.132 + 0.102] = 23{,}255{,}800 \cdot [-0.03] = -697{,}674$$

which means that the position value is still concave in the underlying stock price.

h)
For American options the put-call parity becomes:

$$S - K < C_E - P_E < S - \frac{K}{1 + R \cdot \tau} \Leftrightarrow 11.72 - 16 < 0.13 - 4.28 < 11.72 - \frac{16}{1 + 4\% \cdot 0.6}$$

$$\Leftrightarrow -4.28 < -4.15 < -3.905$$

Hence, the put-call-parity for American options with strike K = 16 is complied.

i)
Early exercise can destroy an option strategy. A riskless position with European options can become hazardous if American options are used instead.

Fortunately in case of the sold synthetic forwards and the sold bull cylinders, the analysis keeps more or less valid due to the following reasons:

(i) There are no dividend payments announced until expiration of the options. Hence, if we are short in American calls, they are not optimally exercised early against us. Theoretical prices of corresponding American and European calls are equal. In this situation American calls can be treated as if they were European type. The risk of an unexpected dividend announcement during the remaining lifetime of the option must be considered carefully, however.

(ii) If we are long in American puts, we are free not to use our right of early exercise. We can turn an American option into a European one deliberately. This is not always for free: In case of the at-the-money puts with strike 12 in part c) it costs us 400,000 EUR, which is the lost early exercise premium. In case of the out-of-the-money puts with strike 10 in part d) and later on it is indeed costless.

Question 3: Portfolio Management

a)

a1)

The reason why the IRR is inappropriate is that it is a value-weighted [dollar-weighted] measure – the value of the portfolio at the end of any period affects performance. As the size of the portfolio changes, periods in which the portfolio is larger will be more heavily weighted in the IRR calculation. The cash inflows and outflows to the portfolio affect the IRR, but are not under the control of the portfolio manager. Since the inflows and outflows are not under the control of the portfolio manager, using the IRR as a measure of performance is improper.

a2)

The proper measure of performance, that is not dependent on the size of the portfolio, is the annualized realized rate of return (time weighted return). Using that measure, we have:

Growth Manager $= \left[(1.06 \cdot 1.20)^{1/2} - 1\right] \cdot 100 = 12.78\%$

Value Manager $= \left[(1.223 \cdot 1.04)^{1/2} - 1\right] \cdot 100 = 12.78\%$

On this basis, the two managers have achieved equal performance.

a3)

The difference in the two manager's IRR evaluations actually arose as the result of the sponsor's actions. When EUR 100 million was removed from each portfolio, the result for the growth portfolio was to increase the return weighting on the first year of poor performance and decrease the return weighting for the second year of good performance. For the value portfolio, however, the result was to increase the weighting on the first year of good performance and decrease the return weighting on the second year of poor performance. This distorted the results in opposite directions for the two funds. The annualized realized return is not value weighted, since it is not affected by the cash flows of the portfolio.

b)

b1)

- Bonds are less specific in their risk characteristics and so are much more interchangeable than equities.
- Bond indices usually have an essentially higher number of securities than equity indices.
- The turnover in bond indices is substantially larger than for equity indices (because a significant amount of bonds mature or is issued each year).
- Normally a non-negligible part of the bond market is (very) illiquid (so that there are no futures on those bond indices).

b2)

(i) Full replication (exhaustive sampling)

Description:
- Buy and maintain a perfect copy of the index, with the same weights and assets as in the index.

Advantages:
- Simple
- No rebalancing if the index is a capitalisation-weighted index
- No tracking error (if there are no transactions)
- No systematic error caused by a wrong selection

Drawbacks:
- Generally time consuming to set up and maintain
- More costly, as there are many and many small holdings, illiquid stocks, round lots, dividends reinvestments, etc.
- You have to rebalance often, including during right-issues, which is costly

In general:
- Good for indices built on a small number of assets
- Not good for small size portfolios

(ii) Stratified sampling

Description:
- The asset choice and weighting is decided on the basis of common groups (industries, countries, etc.). The portfolios are built using a systematic methodology without any strict quantitative support.

Advantages:
- Easy to implement
- Cheaper than the full replication because there are less assets and less small transactions

Drawbacks:
- Danger of bias in selection, for instance, systematic overweighting of the large firms
- Tracking error cannot be predicted

In general:
- You can use that for bigger indices without any large quantitative support.
- You can use this for markets where you can find relative good groups which represent the major exposures

(iii) Optimised sampling

Description:
- The portfolios are build using a quantitative optimising model:
- Find the major factors which drive stock prices.
- Fix the rules (transactions, sizes, ...)
- Minimise the variation between the various risk factor exposure relative to the exposures of the index

Advantages:
- Tracks closely
- Tracking error is predictable
- Cheaper than full replication (less assets, less small transactions)
- The danger of a bias in the exposure is lower.
- The starting portfolio and external restrictions can be considered in the optimisation process.
- An optimisation between costs and tracking error (volatility) is possible

Drawbacks:
- There is a risk of a wrong model or empirical non-significance
- You have to reallocate more often than with full replication
- More pre-work (complex model specification, estimation)
- More complicated than the stratified sampling

In general:
- You can also use this for bigger indices with a strong quantitative support.
- You can use this for markets where the major driving factors can be reproduced with simple measures

(iv) Synthetic replication (synthetic indexing)

Description:
- Mimic the index using derivatives instruments

Advantages:
- Cheap to set up and maintain (cheaper transactions, no or small custody fees, tax deductions (for instance withholding tax), etc.)
- You can use arbitrage opportunities (options vs. futures)
- Fine tuning is possible
- Tracking error is small (as long as the underlying index corresponds to the benchmark)
- Quickly implemented

Drawbacks:
- There may be roll over costs
- There may be mispricing of futures
- Counterpart risk is large
- Tracking accuracy varies if the underlying index does not correspond to the benchmark

In general:

- Can be used as a complement for the indexation, with the big disadvantage of the concentration of counterpart risk. You can also prefer that for small portfolios, for fine-tuning, or for investors which cannot recover their withholding tax.
- Use may be limited for a small number of indices

b3)

(i) Exhaustive sampling (full replication) and (iv) Synthetic replication

These methodologies are practically impossible to implement (see the conditions mentioned in b1).

(ii) Stratified sampling

The goal is to restrict the number of bonds in the indexed portfolio and to avoid the illiquid segment of the benchmark, thereby getting no trades in too small bond positions.

Feasible steps in building an indexed portfolio:

- The universe of the benchmark bonds is partitioned into cells based on specific characteristics (like sector, duration, time to maturity, quality rating, etc.).
- Evaluation of the weight of each cell by using the weights of the bonds in the benchmark.
- Selecting a limited number of bonds out of the cell and creating with them a price-weighted subportfolio matching the characteristics of the whole cell.
- Determining the appropriate weight of each cell in the indexed portfolio.

(iii) Optimised sampling

Background: The availability of bond risk models has made this approach applicable.

Feasible steps in building an indexed portfolio:

- Predetermination of an ex-ante value of the tracking error of the indexed portfolio relative to the benchmark.
- Using an optimiser for portfolio construction taking the trade-off between factor risks and transaction costs into account.
- Allowing the indexer to vary the bonds considered in the indexed portfolio and at the same time controlling the (chosen) level of expected tracking error.

b4)

For the SMI we will use the full replication method because any other method would bring too high tracking error with itself. The SMI includes a relatively small number of companies and enables the purchase of all stocks even for small portfolios because of the good liquidity of the big cap market in Switzerland.

[N.B.: The only exception to a full replication could be the use of one single stock category for all companies as the behavior of these stocks is very similar and give no additional specific risk if the weighting scheme of companies in the index is strictly reproduced.]

For the MSCI Europe ex-Switzerland we can use either the stratified sampling or the optimisation method. These methods allow to avoid the illiquid segment of the benchmark, to keep trades a reasonable size and to limit administrative costs.