NTNU Trondheim
Norwegian University of
Science and Technology

Faculty of Economics
Department of Industrial Economics
and Technology Management

Contact person for the exam:
Name: D. van der Wijst
Phone: 73593511

EXAM IN COURSE TIØ4146
FINANCE for SCIENCE and TECHNOLOGY STUDENTS
29 November 2019 Time: 09.00 - 13.00

Aid A: All calculators allowed
All printed and written material allowed

Problem 1 (weight 30%)

The financial services company S&P Global regularly publishes analyses of performance in the mutual funds industry. The underlying data source for their analyses is the Mutual Fund Database of the University of Chicago. For their July 2019 report they used only actively managed, domestic US equity funds; index funds, sector funds and index-based funds were excluded. The funds were sorted (from high to low) by their performance over the five-year period ending in March 2014 and divided in four equally large groups (i.e. quartiles). Thus, the first quartile contains the funds with the highest performance, etc. The same procedure was followed for the five-year period ending in March 2019. The so-called transition matrix in Table 1 below shows how the first-period quartiles are distributed over the second-period quartiles.

Table 1: Five-year transition matrix

Ending March 2014		Ending March 2019 Quartiles				Periods not comparable:	
Quartiles	No. of funds	1st	2nd	3rd	4th	Merged/ Liquidated	Style changed
1st	498	16%	17%	23%	32%	11%	1%
2nd	498	21%	21%	21%	22%	14%	1%
3rd	497	26%	23%	18%	10%	21%	2%
4th	498	15%	17%	17%	15%	27%	9%

a) Which form of market efficiency is tested by the S&P analysis and do any of the results in Table 1 contradict the Efficient Market Hypothesis (EMH)? If so, explain which specific result(s) and why.

Problem 2 (weight 30%)

The well known investor Peter Smalldale owns a chain of hotels, spread over the Nordic countries. His company, Raspberry Holdings, has a book value of €1500 million (10^6), 1125 million of which is debt. Although the hotel business is rather volatile, the bank was willing to finance a large part of the hotels because most of Raspberry Holdings' capital is invested in buildings on attractive locations in city centres. The bank charges a modest interest rate of 7%, but the amount of debt and its interest rate are frequently renegotiated and adjusted. Raspberry has 60 million shares outstanding; they have a

beta 1.2 and they currently trade at €20 per share. Smalldale is considering going into the tour operator business. The international tour operator Thom Cook suddenly went bankruptcy and its Nordic subsidiary, Wings, came up for sale for €650 million. Smalldale thinks that important synergies and economies of scale can be achieved by combining the hotel and tour operator businesses. This would increase Wing's expected yearly after tax cash flow from €80 million to €90 million. Because Smalldale invests 'for all eternity', as he calls it, the cash flow can be considered a perpetuity. Independent market analysts have reported that tour operators in this part of the world are, on average, financed with 30% debt, on which they pay an average interest rate of 8.5%. The average equity beta of tour operators is 1.6. All debt in the tour operator business is rebalanced. Smalldale, who is used to the high debt ratios in the hotel business, wants to finance the takeover with 60% debt. However, the bank is rather sceptical about financing such a large part of what it sees as a risky takeover. The bank is only willing to lend the money against an interest rate of 9% and under the condition that the debt will be frequently renegotiated and adjusted. The rest of the takeover will be financed with equity; Raspberry holds large amounts of retained earnings in offshore bank accounts. The corporate tax rate is 25% and on financial markets the risk free interest rate is 5% and the market risk premium is 8%.

a) Should Raspberry Holdings take over Wings for €650 million or not? Show calculations to support your answer and make additional assumptions if necessary.

Problem 3 (weight 30%)

NordicTele is a young and dynamic high-tech company, specialized in developing apps for smartphones. Their first few apps were very successful, both technically and commercially, and NordicTele is now an established name in the app world. Their next big project is SuperApp, that will connect a whole range of household appliances to smartphones. The technology behind SuperApp was demonstrated to be OK, but financially the project seems unprofitable. SuperApp will require an investment of €35 million today and is expected to generate after tax cash flows of €15 million per year for 3 years, starting one year after the investment. In addition to being short-lived, projects on the app market are also very risky: the cash flow values have an annual volatility is 25%. SuperApp is such a risky project and it has a drift / discount rate of 16% and this gives the project a negative NPV of more than €1 million. The CEO suggests to drop the project, but one employee, who took a course in finance for science and technology students, suggests that three years from now the new 5G (fifth generation) mobile network will be in place, giving net applications much greater capabilities. If SuperApp is then already successfully established in 4G, it can be re-launched in 5G on a 3 times larger scale than the current project. This possibility could make the combined project (very) profitable. The decision to launch SuperApp5G would have to be made three years from now. It will be just as risky and short-lived as the 4G project, have the same volatility and discount rate, and require an investment of three times the investment in the 4G project (i.e. €105 million in today's value, but this amount increases with risk free interest rate over time). It is expected to generate yearly cash flows of €70.24 for three years (i.e. three times those of the 4G project in present value terms), starting one year after the investment. On financial markets the risk free interest rate is 5% and the market risk premium is 8%.

a) Should NordicTele launch the SuperApp project or not, taking the opportunity to re-launch after 3 years into account? Show calculations to support your answer and make additional assumptions if necessary.

Problem 4 (weight 10%)

In problem 2 it is mentioned that the bank was willing to finance a large part of Smalldale's hotels because most of Raspberry Holdings' capital is invested in buildings on attractive locations in city centres. It is also mentioned that tour operators are, on average, financed with only 30% debt. Explain this difference in capital structure using one (or more) of the capital structure theories we have discussed.

NTNU Trondheim
Norwegian University of
Science and Technology

Faculty of Economics
Department of Industrial Economics
and Technology Management

Contact person for the exam:
Name: D. van der Wijst
Phone: 73593511

EXAM IN COURSE TIØ4146
FINANCE for SCIENCE and TECHNOLOGY STUDENTS
29 November 2019 Solutions

Aid A: All calculators allowed
All printed and written material allowed

Problem 1 (weight 30%)

Analysing the persistence in mutual fund performance is a test of strong form of market efficiency, because the expertise, models and databases of mutual funds are not public information. The Efficient Market Hypothesis predicts that funds cannot consistently outperform the market, i.e. deviations from risk-adjusted expected returns are random. If this is the case, then the ranking in the second period will be independent of the ranking in the first period. If performance would be persistent, the percentages on the main diagonal of the transition matrix would be very high (100% with complete persistence). If excess performance is random, the first period quartiles will be evenly distributed over the second period quartiles on each row. We see that the percentages are reasonably uniformly distributed over the second period quartiles on each row. Over-weighted cells, if any, are not on the main diagonal. This leads to the conclusion that the July 2019 report of S&P does not contradict the EMH. However, the first period quartiles are not exactly uniformly distributed over the second period quartiles, and in the absence of a statistical test the importance of the differences is debatable. Notice that this persistence test is independent of the level of fund performance; the index is not mentioned. In this sense it is comparable with a runs test: flipping a coin 20 times and getting first 10 'heads' and then 10 'tails' is not random, even though the score is 50-50. Similarly, it would contradict market efficiency if the same funds do better (or worse) than the rest in both periods, even if the level of fund performance does not contradict market efficiency. Also notice, however, that a pure random distribution would mean that 25% of each quartile ends up in the same quartile next period.

Problem 2 (weight 30%)

As always, the project characteristics determine the parameters of the investment decision. Smalldale's hotels are in another line of business, so Raspberry's details are irrelevant. We start by calculating the cost of equity in the tour operator business with the CAPM and the given equity beta and market risk premium:

$$r_e = 0.05 + 1.6 \times 0.08 = 0.178$$

We can now unlever to find the OCC in the tour operator business:

$$r_a = \frac{0.3}{1}0.085 + \frac{0.7}{1}0.178 = 0.15$$

Alternatively, we could have used MM proposition 2 in reverse:

$$0.178 = r_a + (r_a - 0.085)\frac{0.3}{0.7} \;\Rightarrow\; r_a = 0.15$$

This can also be done in terms of betas. Next, we calculate r_e for the takeover project with MM proposition 2 and the project's details:

$$r_e = 0.15 + (0.15 - 0.09)\frac{0.6}{0.4} = 0.24$$

We can now calculate the project's WACC:

$$r' = 0.09(1 - 0.25)\frac{0.6}{1} + 0.24\frac{0.4}{1} = 0.1365$$

If we assume that debt is periodically rebalanced we can use the Miles-Ezzell formula:

$$\begin{aligned} r' &= r_a - \frac{D}{V} r_d \tau \left(\frac{1 + r_a}{1 + r_d}\right) \\ r' &= 0.15 - \frac{0.6}{1} 0.09(0.25)\frac{1.15}{1.09} = 0.1358 \end{aligned}$$

With a discount rate of 13.65%, the value of a perpetual cash flow of €90 million is $90/.1365 = 659.34$. The NPV is, thus, $659.34 - 650 = 9.34 > 0$, Raspberry Holdings should take over Wings for €650 million. If we use the discount rate corresponding to periodical rebalancing, the numbers are $90/.1358 = 662.74$ and $662.74 - 650 = 12.74$, which leads to the same conclusion.

APV can also be used. We first calculate the base case present value, the cash flow discounted at the OCC:

$$\frac{90}{0.15} = 600$$

The only side effect is the tax advantage: $\tau r D = 0.25 \times 0.09 \times 0.6 \times 650 = 8.775$. The tax advantage should be discounted at the OCC because debt is rebalanced:

$$\frac{8.775}{0.15} = 58.5$$

This gives an adjusted present value of $-650 + 600 + 58.5 = 8.5$. Assuming periodical rebalancing, the value of the tax advantage is :

$$58.5 \times \frac{1.15}{1.09} = 61.72$$

This makes the adjusted present value $-650 + 600 + 61.72 = 11.72$ which leads to the same conclusion: Raspberry Holdings should take over Wings for €650 million.

This is not required for the exam, but we can calculate APV more precisely by defining the project's capital structure in terms of market values (instead of the investment amount). Then we set up the following equations:

$$\begin{aligned} BaseCase &= 600 \\ Debt &= 0.6 \times APV \\ TaxAdvantage &= ((0.25 \times 0.09 \times Debt)/0.15) \\ APV &= BaseCase + TaxAdvantage \end{aligned}$$

Solving the four simultaneous equations we find:

$BaseCase = 600$

$APV = 659.34$

$TaxAdvantage = 59.341$

$Debt = 395.6$

This gives the exact same solution as the WACC (9.34). We see that debt is a bit higher in market value terms: 395.6 versus 390 (=0.6×650). If we assume periodical rebalancing, the third equation becomes:

$$TaxAdvantage = ((0.25 \times 0.09 \times Debt)/0.15) \times \left(\frac{1.15}{1.09}\right)$$

and the solution:

$BaseCase = 600$

$APV = 662.95$

$TaxAdvantage = 62.95$

$Debt = 397.77$

This gives a bit higher NPV: $662.95 - 650 = 12.95$, again (almost) the same as WACC solution.

Problem 3 (weight 30%)

In discounted cash flow terms, the 5G project simply triples the loss of the 4G project. However, the project has both volatility and time before a decision has to be made, so real options analysis is called for. The possibility to re-launch SuperApp on a 3 times larger scale is equivalent to a European call. The option is far out-of-the-money, but out-of-the-money options can have a high value, particularly if their maturity is long and the market is very volatile, as is the case here. Its value can be calculated as follows. The present value of the expected cash flows from the SuperApp4G is:

$$\frac{15}{1.16} + \frac{15}{1.16^2} + \frac{15}{1.16^3} = 33.688$$

giving a net present value of $33.688 - 35 = -1.312$, stated in the text as 'more than 1 million'. The value of the cash flows evolves over time with a return (drift) of 16% and a volatility of 25%. We can model this dynamic process in discrete time, with the binomial model, or in continuous time, with the Black and Scholes model. For the binomial model we have to transform the continuous time volatility parameter into the 'up' and 'down' factors of the binomial model. Since the given interest rate and volatility are annual values, it is easiest to use three periods[1] of a year. The up and down factor then are:

$$u = e^{\sigma\sqrt{\delta t}} = e^{.25\sqrt{1}} = 1.284$$

and

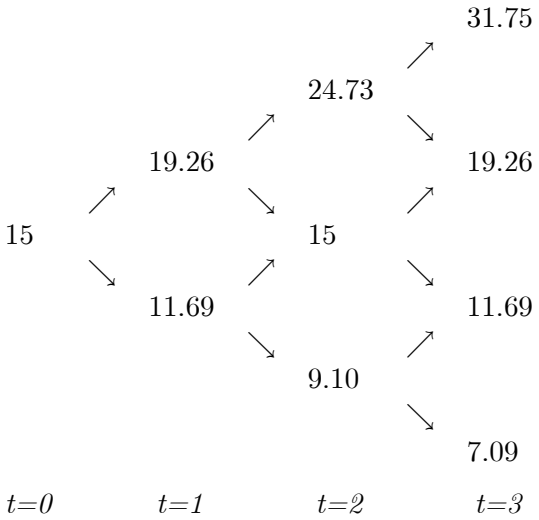
$$d = e^{-\sigma\sqrt{\delta t}} = e^{-.25\sqrt{1}} = 0.779$$

so that

$$p = \frac{e^{r\delta t} - d}{u - d} = \frac{e^{0.05\times 1} - 0.779}{1.284 - 0.779} = 0.539$$

With these parameters, the binomial tree for the yearly cash flow values becomes:

[1] It is also possible to use different periods, e.g. 2 periods of 1.5 years or 1 period of 3 years, but then the interest rate and volatility have to be adjusted accordingly.



Value tree for yearly cash flow values

At t=3, the decision about the SuperApp5G has to be made, based on the expected yearly cash flow values. In the upper node, that value is 31.75. The SuperApp5G is three times the SuperApp4G, so an expected yearly cash flow value of $3 \times 31.75 = 95.25$. This gives the cash flows over the project's life a present value of:

$$\frac{95.25}{1.16} + \frac{95.25}{1.16^2} + \frac{95.25}{1.16^3} = 213.92$$

Notice that an equivalent procedure would be to apply the up and down factors to the present value of the cash flows from the 4G project and multiply the result by 3. (In the upper node, for example, $33.688 \times 1.284^3 = 71.313$ and $71.313 \times 3 = 213.94$). Applying this procedure to the other end nodes of the tree we get the following possible cash flow values of the 5G project:

$$19.26 \times 3 = 57.78 \quad \text{and} \quad \frac{57.78}{1.16} + \frac{57.78}{1.16^2} + \frac{57.78}{1.16^3} = 129.77$$

$$11.69 \times 3 = 35.07 \quad \text{and} \quad \frac{35.07}{1.16} + \frac{35.07}{1.16^2} + \frac{35.07}{1.16^3} = 78.763$$

$$7.09 \times 3 = 21.27 \quad \text{and} \quad \frac{21.27}{1.16} + \frac{21.27}{1.16^2} + \frac{21.27}{1.16^3} = 47.77$$

These cash flow values can be obtained ('bought') by investing the equivalent of 3 times 35, compounded with the risk free interest rate: $3 \times 35 \times 1.05^3 = 121.55$. Of course, the follow-up option will only be exercised if it is profitable to do so, so its t=3 values are:

$\max[0, 213.92 - 121.55] = 92.37$

$\max[0, 129.77 - 121.55] = 8.22$

$\max[0, 78.763 - 121.55] = 0$

$\max[0, 47.77 - 121.55] = 0$

Calculating these values down the tree with the binomial model we get as t=2 values:

$$\frac{0.539 \times 92.37 + 0.461 \times 8.22}{1.05} = 51.026$$

$$\frac{0.539 \times 8.22 + 0.461 \times 0}{1.05} = 4.2196$$

and 0.

as t=1 values:

$$\frac{0.539 \times 51.026 + 0.461 \times 4.2196}{1.05} = 28.046$$

$$\frac{0.539 \times 4.2196 + 0.461 \times 0}{1.05} = 2.1661$$

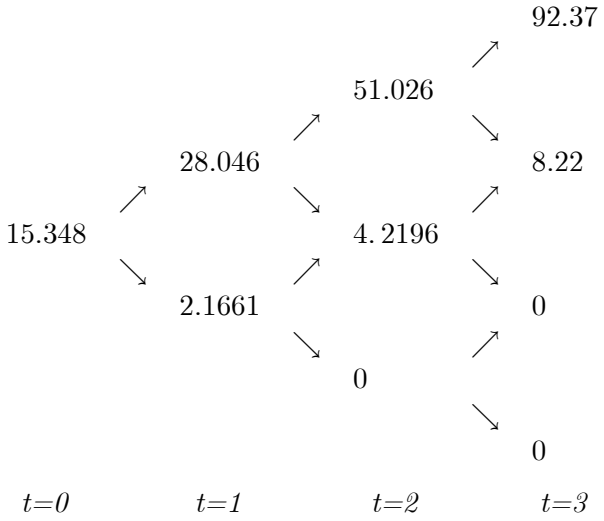
and as t=0 value:

$$\frac{0.539 \times 28.046 + 0.461 \times 2.1661}{1.05} = 15.348$$

It is also possible to perform the calculations in one step (leaving out the zeros):

$$\frac{0.539^3 \times 92.37 + 3 \times 0.539^2 \times 0.461 \times 8.22}{1.05^3} = 15.348$$

The calculations are summarized in the following tree:



Value tree for the option to do a follow-up project

We can also model the option in continuous time with the Black and Scholes model. The underlying value is the present value of the three yearly cash flows of the 5G project. The yearly expected value at t=3 is €70.24, so their present value at t=3 is:

$$\frac{70.24}{1.16} + \frac{70.24}{1.16^2} + \frac{70.24}{1.16^3} = 157.75$$

and their value today is $157.75/1.16^3 = 101.06$. An equivalent calculation is, of course:

$$\frac{70.24}{1.16^4} + \frac{70.24}{1.16^5} + \frac{70.24}{1.16^6} = 101.06$$

or simply 3 times the present value of the cash flows from the 4G project: $3 \times 33.688 = 101.06$. The exercise price is three times the investment amount of the 4G project, compounded with the risk free interest rate: $35 \times 3 \times e^{3 \times 0.05} = 121.99$. The option matures 3 years from now and the volatility and the risk free interest rate are given as 25% and 5%, respectively. Thus, the five determinants of the Black and Scholes option price are: $S_0 = 101.06$, $X = 121.99$, $r = 0.05$, $\sigma = 0.25$ and $T = 3$.

$$\begin{aligned} d_1 &= \frac{\ln(S_0/X) + (r + \frac{1}{2}\sigma^2)T}{\sigma\sqrt{T}} \\ &= \frac{\ln(101.06/121.99) + (0.05 + 0.5 \times 0.25^2)3}{0.25\sqrt{3}} = 0.12823 \end{aligned}$$

and

$$d_2 = d_1 - \sigma\sqrt{T} = 0.12823 - 0.25\sqrt{3} = -0.30478$$

NormalDist$(0.12823) = 0.55102$
NormalDist$(-0.30478) = 0.38027$ so that the call price is:

$$\begin{aligned} O_{c,0} &= S_0 N(d_1) - X e^{-rT} N(d_2) \\ &= 101.06 \times 0.55102 - 121.99 e^{-0.05\times 3} \times 0.38027 \\ &= 15.759 \end{aligned}$$

approximately the same price as we found with the binomial model.

The SuperApp4G has a NPV of $33.688 - 35 = -1.312$, but the option to launch the SuperApp5G makes the combined project profitable:

$$-1.312 + 15.759 = 14.447$$

So NordicTele should launch the SuperApp project.

Problem 4 (weight 10%)

Buildings on attractive locations in city centres have a high resale value. In case of a bankruptcy, such assets can be transferred to a new owner without much costs and without losing much value. So they give security to loans. In terms of the trade-off theory of capital structure, such assets have low costs of bankruptcy/financial distress and this gives an optimal capital structure with much debt. Tour operators, on the other hand, usually operate from rented rooms in shopping centres and their main investments are in computer systems and travel networks, which have few, if any, alternative uses. Such assets have high costs of bankruptcy/financial distress and this gives an optimal capital structure with little debt. Occasionally, though, large tour operators like the recently failed Thomas Cook, may own a fleet of aircraft which have a high second hand value.