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

24 November 2020 Time: 09.00 - 13.00

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

Problem 1 (weight 25%)

A well known investment strategy is momentum investing: buying recent winners on the stock market and short selling recent losers. The strategy also attracted much attention in the scientific literature. A recent study[1] analyses monthly return data for US common stocks listed on three American stock exchanges (NYSE, AMEX, and NASDAQ) over January 1963 to December 2017. Momentum portfolio returns are computed with an overlapping period approach. At the beginning of each month t, the winner (loser) stocks are identified as stocks in the top (bottom) decile of cumulative returns over months t-6 to t-1. The stocks remain in these portfolios over months t to t+5. The momentum strategy return is the difference in equally-weighted winner and loser portfolio returns. The study reports, among other things, the average returns, the CAPM alpha (or Jensen's alpha) and the three-factor alpha (using Fama and French' three-factor model) for the loser portfolio, the winner portfolio and the winner-minus-loser portfolio (momentum portfolio). Its main results are in Table 1 below; t-statistics, where available, are printed **in bold** under the returns.

Table 1: Monthly momentum portfolio returns

	Portfolio:		
	Loser	Winner	Winner−Loser
Average return	0.63	1.64	1.01
t-statistic			**5.34**
CAPM alpha	−0.51	0.56	1.08
t-statistic	**−3.05**	**3.79**	**5.69**
Three-factor alpha	−0.69	0.53	1.22
t-statistic	**−5.38**	**6.09**	**6.49**

a) Which form of market efficiency is tested in this study?

b) Do any of the results in Table 1 contradict the Efficient Market Hypothesis (EMH)? If so, explain which specific result(s) and why.

[1] Ajay Bhootra: Momentum and the Halloween Indicator: Evidence of a new seasonal pattern in momentum returns, Finance Research Letters, Volume 31, December 2019, Pages 26-31.

Problem 2 (weight 25%)

General Stores is a renowned retailer with department stores in all major cities of the eastern provinces. As a long-established, mature company it has a solid financial basis with substantial financial reserves. Its assets contain a large proportion of real estate because General Stores owns the buildings in which its department stores are located. These buildings are all on prime locations and they are financed with very long term mortgage loans. General Stores' management firmly believes in stability and its loan conditions are kept stable, they are not renegotiated and adapted. The large mortgage loans mean that a large part of General Stores' investments is financed with debt. In a recent report on the retail industry, leading financial analysts calculate General Store's debt-to-value ratio to be as high as 80% in terms of book values. In market value terms it is 75%. In spite of its high debt ratio, the quality of its real estate enables General Stores to borrow at comparatively low rates: its overall cost of debt is 7.5%, 2.5 percentage points above risk free interest rate. Its 10 million outstanding shares have a low volatility, their annual standard deviation is 15%. They currently trade at €25 per share and have a beta of 1.5. General Stores is planning to expand into the western provinces, where a large part of the economic growth is generated. The GoWest project, as they call it, involves opening two department stores in the biggest cities. The sizes of the stores, their assortments and marketing will be the same as the existing stores. However, the real estate market in the west is much more regulated than in the east and purchasing buildings may be difficult. To speed up the project, General Stores plans renting the buildings for its department stores. There are good opportunities to rent. The GoWest project will require an investment of €100 million and it is expected to generate a perpetual after tax cash flow of €10 million per year, starting one year after the investment is made. Without mortgage loans, General Stores estimates that it will be optimal to finance 50% of the project with debt. The bank made an offer for a long term loan but, without the security of real estate, it charges an interest rate of 8.5%. The rest of the investment will be financed with equity from retained earnings. General Stores maintains its policy of financial stability: the loan will not be renegotiated and adapted. On financial markets, the expected return of the market portfolio is 17.5%. The corporate tax rate is 30%. In view of the long terms of the loans, they can be treated as perpetual loans.

a) Should General Stores take on the GoWest project or not? Show calculations to support your answer and make additional assumptions if necessary.

Problem 3 (weight 30%)

DSM is a medium-sized European pharmaceutical company. It acquired a good reputation as a producer of statins and it has since diversified into a broad range of pharmaceutical products. It is also an important producer of vaccines and it is in the race to develop a vaccine against COVID-19. It presently conducts a large scale, double blind clinical test of its most promising vaccine. The results of such tests cannot be predicted, but they will become available three months from now. Large scale clinical test are extremely expensive and the results will have a big impact on the value of DSM. A negative result will mean a large loss and DSM will lose its leading position in the COVID-19 race. A positive result will give a strong boost to DSM's profitability and value. You see an opportunity to profit from the possible developments of DSM and you have collected the following data. DSM shares currently trade at a price of €60, they have an annual volatility of 40% and pay no dividends. The risk free interest rate is 5% per year. Also traded are European call and put options on DSM shares; the available exercise prices of puts and calls are €50, €55, €60, €65, and €70. The available maturities are 2, 3 and 4 months.

a) Design an option position that profits from both positive and negative results of DSM's clinical test and calculate how much it costs to set up the position. Use calculations to support your answer and make additional assumptions if necessary.

Problem 4 (weight 20%)

Suzan Hol (2008)[2] analyses the financial structure of a sample of more than 14000 nonlisted firms in Norway. She runs regressions of leverage (the ratio of debt to total assets) on a number of explanatory variables. Some of her results are in Table 2 below; t-statistics are printed **in bold** next to the coefficients.

Table 2: Estimates from fixed-effects regression analysis

Explanatory variable	Coefficient	t-statistic
Depreciation/Total costs	−0.14	**−7.68**
Sales growth	3.33	**1.16**
Current assets/Total assets	−0.21	**−17.28**
ln(Total assets)	−0.03	**−16.96**

a) With which theory or theories of capital structure is the estimation result with respect to the ratio Depreciation/Total costs in line?
Trade-off theory
Pecking order theory
Both
Neither

b) With which theory or theories of capital structure is the estimation result with respect to Sales growth in line?
Trade-off theory
Pecking order theory
Both
Neither

c) With which theory or theories of capital structure is the estimation result with respect to the ratio Current assets/Total assets in line?
Trade-off theory
Pecking order theory
Both
Neither

d) With which theory or theories of capital structure is the estimation result with respect to ln(total assets) in line?
Trade-off theory
Pecking order theory
Both
Neither

[2] Suzan Hol and Nico van der Wijst, The financial structure of nonlisted firms, Applied Financial Economics, 2008, 18, 559–568.

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
24 November 2020 Solutions

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

Problem 1 (weight 25%)

a) Momentum strategies are based on the continuation of patterns in pricing histories, no other data are used. So tests of this strategy are tests of weak form market efficiency.

b) The returns of the momentum portfolio (of 1.01) and its alpha coefficients (of 1.08 and 1.22) are significantly larger than 0 and therefore contradict the EMH. In an efficient market, the simple extrapolation of recent developments in stock prices should not give excess returns. The constituting elements of the strategy, i.e. the alphas of the loser and winner portfolios, are also significantly different from zero and contradict the EMH. Negative alphas usually mean underperformance, but here they represent the short selling part of momentum investing, so a positive contribution to the excess returns of the strategy. Overall, the momentum strategy in the paper appears to generate excess returns, but the paper does not mention transaction costs, nor does it make clear that the short selling part of the strategy can be (easily) implemented for all the stocks.

Problem 2 (weight 25%)

As always, the relevant data refer to the project. Since the project is in the same line of business as General Stores' other activities, we can use the parent company's data to calculate the OCC. It follows from the problem text that the financial policy is predetermined debt (not renegotiated and adapted). And since the loans can be treated as perpetual loans, the Modigliani-Miller assumptions apply. The cost of debt is given as 7.5%. The equity beta is given as 1.5, the return of market is 17.5% and the risk free interest rate is implicitly given as 5%. Hence, the CAPM gives the cost of equity as $r_e = 0.05+1.5(0.175-0.05) = 0.2375$. The market value of equity is 10 million outstanding shares at €25 per share, so €250 million in total. With a D/V ratio of 0.75 (in market values), equity is 25%, so the total market value of General Stores is €1000 million. The OCC is then:

$$
\begin{aligned}
r_a &= r_d(1-\tau)\frac{D}{V-\tau D} + r_e\frac{E}{V-\tau D} \\
r_a &= .075(1-.3)\frac{750}{1000-.3\times 750} + .2375\frac{250}{1000-.3\times 750} = 0.1274
\end{aligned}
$$

It is also possible to this in terms of betas by first calculating the beta of debt (with the CAPM in reverse), then use the formula to find the asset beta and then use the CAPM to find r_a. We can also use the formula for r_e in reverse:

$$\begin{aligned} r_e &= r_a + (r_a - r_d)(1-\tau)\frac{D}{E} \\ 0.2375 &= r_a + (r_a - .075)(1-.3)\frac{750}{250} \Rightarrow r_a = 0.1274 \end{aligned}$$

Alternatively, we can first calculate General Stores' WACC:

$$\begin{aligned} r' &= r_e\frac{E}{V} + r_d(1-\tau)\frac{D}{V} \\ r' &= .2375\frac{250}{1000} + .075(1-.3)\frac{750}{1000} = 0.09875 \end{aligned}$$

and the use the MM formula in reverse to find r_a :

$$\begin{aligned} r' &= r_a(1-\tau L) \\ 0.09875 &= r_a\left(1 - .3\frac{750}{1000}\right) \Rightarrow r_a = 0.1274 \end{aligned}$$

With this OCC, the cost of equity for the project is:

$$\begin{aligned} r_e &= r_a + (r_a - r_d)(1-\tau)\frac{D}{E} \\ r_e &= 0.1274 + (0.1274 - .085)(1-.3)\frac{.5}{.5} = 0.157 \end{aligned}$$

So the project WACC is

$$\begin{aligned} r' &= r_e\frac{E}{V} + r_d(1-\tau)\frac{D}{V} \\ r' &= 0.157\frac{.5}{1} + .085(1-.3)\frac{.5}{1} = 0.1083 \end{aligned}$$

Alternatively, we can use the MM formula:

$$\begin{aligned} r' &= r_a(1-\tau L) \\ r' &= 0.1274\left(1 - .3\frac{.5}{1}\right) = 0.1083 \end{aligned}$$

With this WACC, the present value of the perpetual cash flow is $\frac{10}{0.1083} = 92.336$, so the project's NPV is $92.336 - 100 = -7.664$. General Stores should not take on the GoWest project.

APV can also be used. The base case PV is $10/0.1274 = 78.493$ and the value of the tax advantages are τD or $.3 \times 50 = 15$. So the APV is $78.493 + 15 - 100 = -6.507$, which leads to the same conclusion.

This is not required for the exam, but a more precise APV can be obtained by defining capital structure in project market values in stead of the investment amount. This involves solving the following simultaneous equations:

$$\begin{aligned} B &= 78.493 \\ D &= 0.5 \times APV \\ TA &= (0.3 \times 0.085 \times D)/0.085 \\ APV &= B + TA \end{aligned}$$

where B= base case value, D=debt and TA is tax advantage. The computer easily finds this solution: $APV = 92.345$, $B = 78.493$, $TA = 13.852$, $D = 46.172$, which corresponds to the NPV calculated with the WACC. Notice that debt (46.172) is 50% of the project's market value (92.345).

Problem 3 (weight 30%)

An option position that profits from large positive or negative changes in the value of the underlying is the long straddle. It consists of a long call and a long put with the same exercise price, which should be equal (or close) to the current stock price. The call pays off in case of a price increase (positive test results), the put in case of a price decrease (negative test results). The options should mature when the test results become available, so 3 months from now. Since no precise dates are specified, a time to maturity of 4 months is also correct, but not 2 months. To calculate how much it costs to set up a long straddle we have to calculate the option prices. Starting with the call, we collect its determinants from the question text:
$S_0 = 60$ so we take $X = 60$, $r_f = 5\%$, $T = 0.25$ and $\sigma = 0.4$; the call price is then:

$$O_{c,0} = S_0 \times N(d_1) - X \times e^{-rT} \times N(d_2)$$

with

$$d_1 = \frac{\ln(S_0/X) + (r + \frac{1}{2}\sigma^2) \times T}{\sigma\sqrt{T}} \quad \text{and} \quad d_2 = d_1 - \sigma\sqrt{T}$$

Plugging in the numbers:

$$d_1 = \frac{\ln(60/60) + (0.05 + \frac{1}{2} \times 0.4^2) \times 0.25}{0.4\sqrt{0.25}} = 0.1625$$

and

$$d_2 = 0.1625 - 0.4\sqrt{0.25} = -0.0375$$

The areas under the normal curve are: $N(d_1) = \text{NormalDist}(0.1625) = 0.56454$ and $N(d_2) = \text{NormalDist}(-0.0375) = 0.48504$. The call price then is:

$$O_{c,0} = 60 \times 0.56454 - 60 \times e^{-0.05\times0.25} \times 0.48504 = 5.132$$

The corresponding formula for a European put is:

$$O_{p,0} = Xe^{-rT}N(-d_2) - S_0N(-d_1)$$

$\text{NormalDist}(-0.1625) = 0.43546$ and $\text{NormalDist}(0.0375) = 0.51496$ so the value of the put is:

$$O_{p,0} = 60e^{-0.05\times0.25} \times 0.51496 - 60 \times 0.43546 = 4.386$$

Since the options are European and the stock does not pay dividends we can also use the put-call parity:

$$\begin{aligned} O_{p,0} &= O_{c,0} + Xe^{-rT} - S_0 \\ &= 5.132 + 60e^{-0.05\times0.25} - 60 = 4.386 \end{aligned}$$

So it costs $5.132 + 4.386 = 9.518$ to set up the position.

To make the long straddle profitable, the stock price must change, either upward or downward, with more than the future value of the amount necessary to set up the position. So it has to change with more than $9.518 \times e^{0.05\times0.25} = \pm 9.6377$. This is $9.6377/60 = 0.16$ or more than + or - 16% of the current price, a big impact. The profit diagram for long straddle is depicted in Figure 1 below.

An alternative correct position is the short butterfly (as in the December 2018 exam). This position assumes that the price will not move far beyond the break-even points (which is not obvious in the question text). Compared to the long straddle, the advantage of the short butterfly is that the break-even points are closer to the current stock price. Its disadvantage is that it only profits from the option premiums, not from the stock price

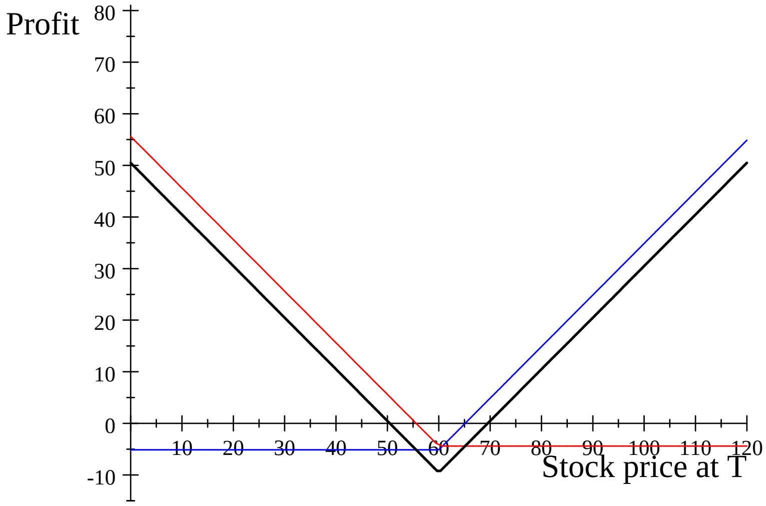

Figure 1: Profit diagram for a long straddle

changes. A short butterfly is equivalent to a bear spread plus a bull spread, so that is a correct position as well. Other correct positions are the strangle (a long straddle with different exercise prices for the put and call: $X_p < S_0 < X_c$), the strap (a long straddle with 2 calls instead of 1) and the strip (a long straddle with 2 puts instead of 1). The latter three are not discussed in the the reading list for the course. A split-strike conversion (as in the May 2020 exam) is not a correct answer to the question. It does not profit from both positive and negative results of DSM's clinical test, as required, but it largely eliminates their effects on the stock price. A single bull spread or bear spread is also an incorrect answer to the question.

Problem 4 (weight 20%)

a) Depreciation is an example of a non-debt tax shield and as such it is an inverse indicator of the tax advantage of debt. The trade-off theory predicts a negative relation between this variable and leverage and its regression coefficient is significantly negative, so in line with the trade-off theory.

b) Growth is predicted to be negatively related to leverage by both the trade-off theory and the pecking order theory. Its regression coefficient is not significantly different from zero, so the result is in line with neither the trade-off theory nor the pecking order theory.

c) The ratio of fixed-to-total assets is an indicator of the tangibility of assets, so an inverse indicator of default costs. The trade-off theory predicts a positive relation between fixed-to-total assets and leverage. Here, the complement of fixed assets is used (current assets), so the trade-off theory predicts a negative relation between this variable and leverage. Its regression coefficient is significantly negative, so in line with the trade-off theory.

d) Size is an inverse indicator of both default risk (the probability of default decreases with size) and default costs (which are proportionally lower for larger firms). Hence, the trade-off theory predicts a positive relation between this variable and leverage. Its regression coefficient is significantly negative, so this is not in line with the trade-off theory. The pecking order does not predict an effect of size, so the result is in line with neither theory.