

## Chapter 9: Real options analysis

### Exercises

1. As an avid beer brewer, you invented a brewing process that allows you switch from malted barley to malted wheat and back again without significant cost. You think this could be an important commercial advantage and you ask your assistant to collect and analyse data on the prices of barley and wheat. Which price behaviour of barley and wheat would make the possibility to switch valuable? Be specific in with regard to price level, volatility and correlation.
2. Discuss the following cases from a (real) options point of view:
  - (a) In an article on the financial crisis published in The Guardian of October 16 2008, the well known economist Joseph Stiglitz compared the terms of the rescue packages for banks provided by investor Warren Buffet and the US government: "Buffett got a warrant (=option) - the right to buy in the future at a price that was even below the depressed price at the time. Paulson got for the US a warrant to buy in the future - at whatever the prevailing price at the time."
  - (b) Norsk Hydro considers to expand its aluminium production by installing an aluminium smelter. Smelter installations use standard technology that is available on the market in any quantity. The produced aluminium is a bulk product that is sold in commodity markets by large numbers of producers.
  - (c) The presence of vacant plots of land in city centres.
  - (d) Hewlett-Packard decided to adapt its inkjet printers to local languages in local depositories. Although adaptation in central production facilities is much cheaper, HP's decision proved to be very profitable.
3. In the section about bounds on option prices we saw that American call options on non-dividend paying stocks are never exercised before maturity (bound 9). Explain why real options with a call nature are often exercised early.
4. State Drilling AG has a concession that gives it the right to develop a small natural gas field. The concession expires in one year. The field will produce 100 million m<sup>3</sup> gas per year for 4 years. The investment required to develop the field is \$30 million, to be paid immediately. If development is postponed the investment amount will increase over time with the risk free interest rate. Production and cash flows from selling the gas will start 1 year after the investment. The current gas price is \$0.08 per m<sup>3</sup> but that price develops over time according to a binomial process: after each period the price can go up with 25% or down with 20%. The probability of an upward movement in price is 80%. The risk adjusted discount rate for cash flows from gas production from the field is 16% and the risk free interest rate is 7%.
  - (a) What is the value of the gas reserve in the field?
  - (b) What is the value of the opportunity to develop the field and when should it be developed?

5. The well known investor Peter Smalldale owns a chain of hotels. He plans to expand his activities into a city that has announced its candidacy to host the European football championship 2 years from now. If the city gets the championship, the new hotel's (and the city's) reputation will be made and it will generate a perpetual cash flow of €20 million per year. However, if the city does not get the championship, the hotel will fall into oblivion and the perpetual cash flow will only be €10 million per year. The football association will decide 1 year from now where the championship is to be held. There is general agreement among insiders that the probability that the city in question will get the championship is 37.5%. Peter Smalldale has an offer from CCI, Construction Consortium Inc. to build the hotel for a price of €120 million, to be paid when the offer is accepted. Construction will start immediately and the hotel will be ready 2 years from now, in time for the championship. However, the offer is only valid if accepted immediately.

- (a) If the proper discount rate for cash flows and values from the hotel is 10%, what is the NPV of the project if it is accepted immediately?

Smalldale wants to postpone his investment decision until it becomes known where the championship will be held. CCI can build the hotel in 1 year for the same price of €120 million by allocating a double work force to the project. However, CCI's director followed a course in finance for science and technology students and anticipates that Smalldale will cancel the project if the championship goes to another city. To compensate for the profit that CCI misses if the project is cancelled, it asks an immediate payment of €12 million. When that payment is made, CCI is willing to build the centre in 1 year, starting 1 year from now, for €120 million (to be paid at the start).

- (b) If the risk free rate is 5%, is postponement profitable for Smalldale with this offer from CCI? Calculate the increase or decrease in project value compared with the now-or-never project under (a).
- (c) What is the risk adjusted discount rate for the project opportunity under (b)?
6. In June 2007 the Norwegian company Aker ASA signed a cooperation agreement with the Norwegian Ministry of Trade and Industry and the Swedish Wallenberg group. The cooperation was organized in a new company, Aker Holding, in which Aker ASA held 60% of the shares, the Norwegian state 30% and the Wallenberg group 10%. When the agreement was signed, the total value of the shares was 16 billion ( $10^9$ ) Norwegian kroner. The agreement stipulated that Aker ASA and the Norwegian state would hold their position in Aker Holding for at least ten years, but the Wallenberg group had the right to sell its shares to Aker ASA after four years at their original price plus a return of 10%. In addition, Aker ASA had the right to buy the Wallenberg group's shares after four years at their original price plus a return of 40%. (Data are based on a Press Release from Aker ASA dated 22 June 2007.)
- (a) Describe the position of the Wallenberg group when the deal was signed in terms of option positions. Be precise in style, moneyness and maturity.
- (b) Assuming no dividends, a risk free interest rate of 5% per year, and an annual volatility of Aker Holding returns of 20%, what was the value of the Wallenberg group's right to sell its shares in Aker Holding when the deal was signed?
- (c) Using the same assumptions, what was the value of Aker ASA's right to buy the Wallenberg group's shares when the deal signed?

(d) On January 1 2011 the value of Aker Holding had dropped to 12.5 billion. What was the value of the Wallenberg group's re-sell right then? Assume 6 months to maturity and that the interest rate and volatility remain the same.

7. ShortSight Ltd. is the investment vehicle of three optometrists. It specializes in short term optometry projects of the now or never type. It came across the following project: by investing 10 now ( $t_0$ ) in the design of spectacles, it can let subcontractors produce a party of spectacles which will be ready 1 period later at  $t_1$ . The spectacles will be sold immediately after delivery. The production costs are 67, to be paid upon delivery at  $t_1$ . The price of the spectacles now (at  $t_0$ ) is 75, but that price will increase over the next period with  $\frac{2}{3}$  if the design is well received in the market. On the other hand, if the design is not well received, the price will decrease with  $\frac{1}{3}$  over the next period. Both possibilities have equal probabilities. The risk free interest rate is 10%.

(a) What is the value of the project if accepted completely on a now or never basis?

A newcomer at ShortSight wants to introduce long term thinking by postponing the production decision to next period.

(b) What is the value of the project if the production decision is postponed with 1 period? Assume that the  $t_1$  prices remain the same in  $t_2$  and that the production costs remain constant at 67.