Financial Instruments

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Homework 4

Due at the beginning of class 5

1 Barings / Leeson position on Nikkei options

On February 26, 1995, Barings, Britain's oldest merchant bank, went bankrupt due to USD 1.3 billion (bn) losses in derivative securities from a single trader, Nick Leeson. The collapse occurred because Barings could not meet the enormous trading obligations established by Leeson in the name of the bank. When it went into receivership on February 27, 1995, Barings, via Leeson, had outstanding notional futures positions on Japanese equities and interest rates of USD 27 bn: USD 7 bn on the Nikkei 225 equity contract and USD 20 bn on Japanese government bond (JGB) and Euroyen contracts. But that's just part of the story. In addition to these positions, on December 24th 1994, Leeson also sold 35,500 Nikkei calls and 35,500 put options with the same strike price of $K = 19,750$ index points and the same maturity of $T = 2$ months. On the day Leeson sold the options, the Nikkei was trading at 19,634 points[1].

(1) What is the name of the option strategy (i.e. short 1 call and short 1 put with same strike price and same maturity) that Leeson set up?

(2) Under what condition is such a strategy profitable at maturity? What are the risks for a trader that sets up this strategy?

(3) Consider just 1 call and 1 put. Draw, on the same chart, the profit diagram at maturity, in Japanese Yen (JPY), of each option, as well as the profit diagram, still at maturity and in JPY, of the entire strategy (i.e. the combination of the

[1] The actual numbers have been slightly modified to simplify the exercise. For further reference please visit https://www.sciencedirect.com/science/article/pii/S0927538X0100004X

two options). Label the points where the profit of the strategy intersects the x axis, and show their values.

To carry out the computations you need to know that, on December 24th 1994, 1 Nikkei call option with strike equal to $K = 19,750$ was priced JPY 9.90 m and 1 Nikkei put option with strike equal to $K = 19,750$ was priced JPY 9.80 m. Assume that the 2-months interest rate is 0 (in this way you can show the full value of the option premium in the profit diagram, without worrying about time value of money) and that each Nikkei option trades on JPY 10,000 times the index value. (*Tip: You can think about everything using the contract size where 1 option is on 10,000 units of the index*)

(4) Consider now the scale of the entire strategy (i.e. 35,500 positions). Draw the profit diagram at maturity, in JPY, of the entire strategy. Label the points where the profits of the entire strategy intersects the x axis, and show their values.

On January 17 1995 the well known Kobe earthquake hit Japan's industrial heartland. That day the Nikkei 225 was at 19,350. It ended that week (on Friday January 20 1995) slightly lower at 18,950. Three days later, on Monday January 23, the Nikkei dropped 1,000 points to 17,950. The large declines in Japanese equities, post-earthquake, made the market more volatile.

(5) What is the effect of an increase in stock market volatility on Leeson position? No calculations needed, just a directional answer (i.e. position value increases / decreases) and provide intuition for why this happens. (*Tip: you may find it helpful to draw two profit diagrams for the strategy and to assume two different distributions of the Nikkei values. An very extreme, but helpful, simplification in the first chart you could assume that Nikkei prices at maturity are normally distributed, with mean equal to option strike price and with a given unknown variance - just draw a bell curve centered at K -, while in the second chart you could assume that Nikkei prices also have a normal distribution with the same mean as in the first chart, but with a much larger variance, so much bigger tails*)

By February 24th 1995 (the option maturity date) the Nikkei reached 17,473 points.

(6) What was the final profit / loss of Leeson Nikkei 225 options strategy on February 24th 1995?

As a final remark, the Baring / Leeson example is an interesting case study for many reasons. First, besides the option portfolio, Leeson's positions included massive bets on index futures. Second, most of the transactions were not authorized by Barings headquarters; Leeson was indeed able to create an account (named "Error Account 88888") through which he executed his unauthorized trades and, at the same time, hid the true size of his positions and P&L to the bank. The Baring / Leeson episode is often cited as an example of bad operational risk management. Even though one may tempted to view the Barings debacle as being caused by just one individual - the "rogue trader" (there is a movie about it!) - the fiasco should also be attributed to the underlying structure of the firm, in particular, to the lack of internal checks and balances.

2 Binomial Trees - The case of FDA drug approval

Vanda Pharmaceutical is a biopharmaceutical company with a focus on the development and commercialization of clinical-stage product candidates for central nervous system disorders. On July 28 2008 the company was waiting for the FDA's response to a Drug Approval Application submitted for "iloperidone", an investigational atypical antipsychotic that was reviewed for the treatment of schizophrenia. We will analyze FDA approval implications on Vanda stock price using binomial trees.

Today, $t = 0$ is July 28 2007; in 1 year's time, that is $t = 1$, depending on whether FDA approves the drug application, analysts believe that Vanda stock price can either be $S_{1,u} = 21$ with probability $q = 0.7$, or $S_{1,d} = 10$ with probability $(1 - q) = .3$. Assume that the firm has a CAPM beta equal to $\beta = 2$, that the annualized continuously compounded risk free rate is $r = 5.00\%$, and that the annually compounded Expected Excess Return on the market (or market risk premium) is $E[RP] = E[r_m] - r_f = 6.44\%$

(1) What is the expected return on the stock according to CAPM? (*Tip: note that the risk free rate provided is continuously compounded, but in the CAPM equation you need to plug the annually compounded equivalent*)

(2) What is the value S_0 of the stock on July 28 2007, that is 1 year before FDA's approval decision?

(3) Compute value of an at-the-money European call option with maturity $t = 1$ year using:

   (a) **The dynamic replication methodology.** Please follow the steps listed below:

      (i) Compute the time $t = 0$ position in stocks and bonds.

      (ii) Compute the value of the portfolio at time $t = 0$.

      (iii) Show that the replicating portfolio replicates the option payoffs on the tree.

   (b) **The risk neutral methodology.** Please follow the steps listed below:

      (i) Compute the risk neutral probabilities.

      (ii) Compute the expected stock price at $t = 1$ (July 28 2008) under the risk neutral probabilities.

      (iii) Compute the expected stock price at $t = 1$ under the probabilities assumed by the analysts. Are the two time $t = 1$ expected prices computed above equal or different? Discuss.

      (iv) Compute the option value under the risk neutral probabilities. Is it the same as in (3.a.ii)?

(4) Fix the strike price of the call option to the value you calculated in part (3). How would the value of the option change if:

   (a) the probability (assumed by the analysts) that FDA approves the drug becomes $q^{new} = 80\%$? Provide some intuition. (Hint: remember that this changes the implications for the current stock price given the other assumptions ...)

   (b) the probability (assumed by the analysts) that FDA approves the drug becomes $q^{new} = 80\%$ and CAPM beta of the firm becomes $\beta^{new} = 3.14$? Provide some intuition.

(5) What is the value of a European at the money put option? To compute it you can use any methodology you like. Please show calculations.

(6) What is the value of an at the money forward contract (forward price equal to the current stock price)? As above, to compute it you can use any methodology you like. Please show calculations.