

## ARLEY CASE STUDY

Done by

Joonha Yoon

Sunjie Hou

Veeraj Gadda

**Question 1.** If we want to price options on Arley, how might we estimate a volatility for a stock, given that it doesn't exist yet? What data might help you? Outline a feasible statistical procedure and describe how it could be implemented.

### **SOLUTION:**

The Arley's stock hasn't gone public. So, we must estimate the expected volatility for stock price by analyzing the volatility of comparable publicly traded companies' stock. This can be implemented in two ways:

#### **FIRST METHOD:**

Firstly, the historical data of comparable publicly traded companies' stock price, and their financial report data is gathered. Then, we calculate their financial ratios, like book-to-market ratio, earning per share, gross profit, etc. When we compare these ratios with Arley's, we select 3-5 similar companies to be our comparable companies. Then we calculate their historical stock price volatility, using a combination method to combine them.(use linear combination method, for example). We take this combined price as Arley's pseudo historical price volatility. Finally, we use GARCH(1,1) Model to estimate its future volatility.

#### **SECOND METHOD:**

For this method, we are going to use Black-Scholes Model to do the job. Now, the information of comparable companies' option is needed. First, according to the financial ratios, we need to select the comparable companies. Secondly, for the selected guideline comparable companies, collect the self-reported stock price volatility. Thirdly, we calculate the implied volatility of the comparable companies' traded stock options using Black-Scholes Model. Finally, we use this to estimate the volatility of Arley's

**Question 2.** Assume a volatility of 40% and treat the put like an ordinary European option. What stock price makes the stock-plus-put package worth \$8 per share? (In other words, how much do the investment bankers think the stock is worth if they are valuing the put this way?)

### **SOLUTION:**

For this question, we use B-S formula to calculate the approximate stock price which makes the stock-plus-put package worth \$8 per share. To find the solution, we solve the following equation:

$$P+S=8$$

Where P is calculated with B-S formula, it contains the unknown: S. And volatility is 40%, strike price is 8\$, risk free rate is the 2-year government bond rate, which is 11.14%.

R code is as following:

```
BS<-function(s0) {  
  r<-0.1114  
  q<-0  
  del<-0.4  
  k<-8  
  t<-2  
  d1<-(log(s0/k)+(r-q+0.5*del^2)*t)/(del*t^0.5)  
  d2<-(log(s0/k)+(r-q-0.5*del^2)*t)/(del*t^0.5)  
  p<- -s0*exp(-q*t)*pnorm(-d1)+k*exp(-r*t)*pnorm(-d2)  
  return(p+s0-8)  
}  
root<-uniroot(BS,lower = 0, upper = 8,tol = 1e-10)  
root
```

The result is: S=6.679123

**Question 3.** Now value the put taking into account the company's option to redeem the shares with bonds. Assume the terms of the bond are such that it would trade at its face value if Arley issued it today, or equivalently, that its fair 2-year forward price today is par (1).

**SOLUTION:**

The company has an option to redeem the shares with bonds instead of paying cash. Taking this option into consideration, we use the Margrabe's formula to calculate the value of the put. We assume that the bond would have similar volatility as long-term Baa industrial bonds. By analyzing the historical data of yields on long-term Baa industrial bonds, we estimate the volatility of the company's bond to be around 1.6%. We also assume that the bond's fair market value at the maturity of the option is \$8. We use the stock price that is calculated in the previous question. We use the two-year treasury yield as the risk free rate, the same as the previous question.

Margrabe's formula gives us:  $P(S_t, B_T, t, T) = -S_t N(-d_1) + B_T * \exp(-r(T - t)) N(-d_2)$

Where  $d_1 = \frac{\ln\left(\frac{S_t}{B_t}\right) + \frac{1}{2}\sigma^2(T-t)}{\sigma\sqrt{T-t}}$

$d_2 = d_1 - \sigma\sqrt{T-t}$  and

$$\sigma = \sqrt{\sigma_S^2 + \sigma_B^2 - 2\rho\sigma_S\sigma_B}$$

To calculate the volatility, we need to estimate the correlation between the two assets. The company's bond and its stock should have a positive correlation. If we choose 0.1 as the correlation, then the put value is \$1.23. If we choose 1 as the correlation, the put value is \$1.25. The put value does not change a lot, based on different assumptions we had on correlation.

**Question 4.** If you are the CEO of the company, does your answer to Question 3 make you more or less willing to give investors the put along with the share for \$8 in the IPO (as compared with the analysis in Question 2)?

**SOLUTION:**

As the question 3 shows, if such redeem option exists, the value of the put option will be around \$1.25. And according to Question 2, if we want to make the stock-put package worth \$8, we need the stock price to reach \$6.68. And we can do a simple subtraction on it,  $8 - 6.68 = \$1.32$ , which is higher than \$1.25. From this point, if we were the CEO of Arley, we would rather be more willing to give the investors the package of put and stock, since the price of the put option is lower than the theoretical value.

However, if we put the transaction cost into consideration, we might get another result. Since the difference between \$1.32 and \$1.25 are very narrow, if the transaction cost of selling the put option or getting the put option during IPO is more than 7 cents, there will be no benefits to give the investors the package of stock and put option. On the other hand, if

we company indeed give all the investors put options, it might give some other potential investors a impression that a great number of investors would like to short the stock or the price of Arley will go down. This will influence the long-term progress and development of Arley.

In that case, if we are the CEO of Arley, making money in a short-run should not be the only purpose I got. I should take further things into consideration, and giving too many put options in the market seems to be able to some money in the next 2 years, but it might influence the whole brand of Arley. Putting all things together, as an aggressive group, we would still like to give the stock-put package, and the leave the problem behind.