Calculating the Value of the Norwegian Petroleum Reserves with price uncertainty

By: **Ricardo Cayo Leiva**
Supervisor: Sigve Tjøtta

Summary

The aim of this thesis is to calculate the value of the Norwegian oil and gas reserves by using the **Option Price Model (OPM)**, and the results will be compared to those obtained by applying the traditional **net present value.**

When we calculate the value of petroleum reserves there are two important factors to take into consideration: **uncertainty**, connected to oil prices in the future; and **flexibility**, in the sense that the decision to develop can be postponed.
Uncertainty in future oil prices will be modeled as following a random walk, with some specific properties. Flexibility has a value and we will find this value with the help of a numerical example related to the Norwegian oil activity. Since most of the investment opportunities allows for flexibility, the framework of the traditional present value rule turns out to be less appropriate than the option pricing approach when calculating the value of oil and gas reserves. The real option approach, on the other hand, has proved more suitable to treat the problems of both flexibility and uncertainty simultaneously. The value of an oil reserve can be derived from variables that can be observed in the market and can be calculated empirically.

First I define the petroleum leases as a multistage investment problem (Siegel, Smith and Paddock 1988) where each stage can be considered as an option. In that sense , *exploration* can be seen as the option to make the exploration expenditure and receive undeveloped reserves. *Development* means the option to pay a sunk cost and install productive capacity and receive a developed oil field ready for production. Similarly *extraction* means the option to extract the hydrocarbon by paying the operating cost. If *V* is the value of the oil field ready for production, we can find the value of the undeveloped reserve *F(V)* and take the decision of when to develop it once we know this value, as shown in Figure 1.1.

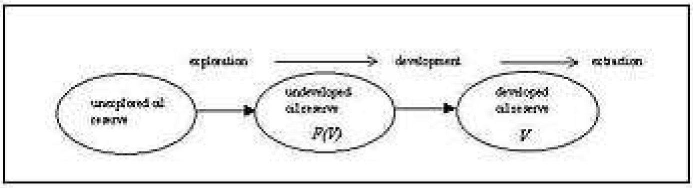

Fig. 1.1

The value of the petroleum reserves can be written as:

$$U_{opt}(.) = U(\underset{+}{P}, \underset{+}{r}, \underset{-}{\delta}, \underset{-}{\pi}, \underset{+}{\sigma}, \underset{-}{a}, \underset{?}{T})$$

The sign under indicates the effect in the reserve value. This means that higher price, higher variance, lower convenience yield , lower growth rate in cost, lower unit cost; all of them independently will increase the value of the petroleum reserves. The risk-free interest rate lead to a higher reserve value. This is because with higher r we discount costs with higher rate , while the incomes remain the same. A positive change in the variance also increase the value of the reserves. This is because higher variability influence the probability distribution, implicit in the price definition, so that big price deviations from the expected price are more probable. The total effect will be positive since we develop the reserve only if the price at the decision period makes the whole project profitable. Time to expiration is also important in the Option approach. Is not sure what will be the total effect of a change in time since there are also other factors that goes in the opposite direction as time increase (or the expiration date is postponed).On one hand the larger the period we have to wait implies higher variation which is positive. At the same time it increase the alternative cost of having the resource in the ground and hence loss the "convenience yield". The cost growth rate will also make the exercise price higher. As a consequence of a higher T all these effects will depend on the relation between them.

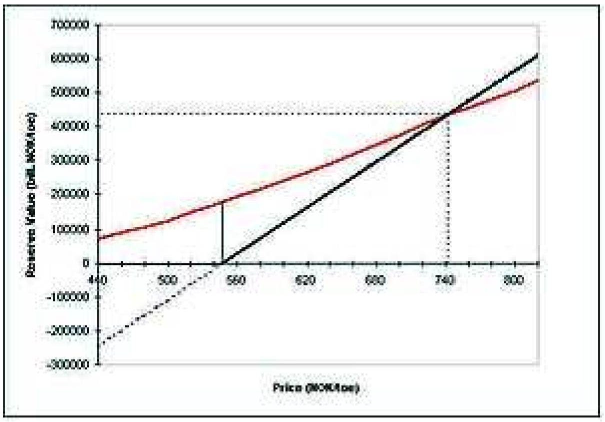

Fig. 4.6 Reserve Value by traditional NPV and Option approach, (European Call Option)

Fig 4.6 indicates the difference in the value of the petroleum reserves under both approaches. It is clear that in this case is better to wait 4 years rather than developing today. The **flexibility value**, that is, the value to have this option open is reflected by the difference in value between this two lines at different evaluation prices.
With a price of 440 NOK/toe this flexibility has a value of around 1 billion NOK . At the break-even price of 548 NOK/toe the flexibility reach the highest value before the two lines meets at a price of 740 NOK/toe. At this price both approaches present similar results of 440 bill NOK.
In Fig. 4.6 both line cross each other reflects the fact that for lower prices today is better to wait or postpone the project. On the other hand, higher prices will indicate that is better to build or develop the reserves immediately. This results indicate that the price of 740 NOK/toe is a critical price at which we are indifferent between developing now or postponing the development by T=4 years. This critical value is higher than the break-even price. The reason for this is that the alternative of developing now is not to reject the project, but postpone it until year T. This last alternative has a value so that if it is optimal to develop the reserve today the value of the field must compensate for the value of the option.

Not included in this summary is the **oil price model** created with the help of the simulation software Powersim (now called Constructor).