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## **VALUING UN-DISCOVERED PETROLEUM RESOURCES IN THE SEA AREAS OFF THE LOFOTEN ISLANDS IN NORTHERN NORWAY: A COMBINED MONTE-CARLO AND SCENARIO PLANNING APPROACH**

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### **OVERVIEW**

Knowledge of a country's oil and gas resources and the expected economic value of these resources are essential for the Government and the Parliament to formulate an effective petroleum-, energy- and economic policy.

Norway is the 5th largest oil exporter (including NGL/condensate) and 3<sup>rd</sup> largest gas exporter in the world. There are still large parts of the Norwegian Continental Shelf which the Norwegian Parliament has yet not opened for petroleum activities, including all of the northern Barents Sea and the sea areas off the Lofoten islands (NPD 2009).

In Norway there is now a debate whether to open the sea areas off the Lofoten islands for petroleum activity or not. The economic effect of future offshore oil and gas development off the Lofoten area is together with the possible effect for the fisheries and the environment important elements in the opening debate.

This paper describes and quantifies the expected and potential economic benefits based on the assessments of petroleum resources in the area.

### **METHOD**

The economic analysis is often done deterministic by calculating the value based on a mean development scenario. This method does not illustrate the resource and economic upside potential effects of a decision to open up a new area for exploration. We have used economic Monte Carlo simulation based on geological play analysis to calculate the economic value of the whole resource distribution.

In evaluating petroleum exploration projects such modeling is useful when there is a presumed probability distribution for the future forecasted outcomes or when there are lower levels of uncertainty. As uncertainty increases and forecasting becomes difficult, the value of these kind of modeling techniques decreases. The value of these techniques decreases also because of dependency among the petroleum resources. The resources or petroleum prospects are said to be "dependent" or "associated" if drilling success on one petroleum prospect increases the conditional probability of success on others. This creates option-values that can be reached by sequential exploration of the dependent resources.

Stochastic dynamic programming techniques can be applied to identify the option-values created by sequential exploration of the dependent petroleum resources. That approach relies heavily on computational power but does not contribute much economic insight regarding the elements of a successful sequential investment strategy. Of course, as the size of the portfolio of petroleum prospects grows, dynamic programming solutions impose ever larger computational demands and information requirements.

## RESULTS

In this paper, borrowing from the strategic management literature, we argue that it may be useful to employ a scenario-modeling approach to petroleum upstream projects when faced with high levels of uncertainty and sequential investments.

In order to illustrate our argument, we combine scenario planning and Monte Carlo simulating techniques to value yet to find petroleum resources off the coast of the Lofoten islands in Norway. Combining economic Monte Carlo simulation based on geological play analysis with scenario analysis represents, in our view, a new promising approach to estimating the economic value of undiscovered oil and gas resources in an unknown area.

## REFERENCES

1. Alessandri, T. M., m.fl. (2004): "Managing risk and uncertainty in complex capital projects", *The Quarterly Review of Economics and Finance* 44(5), 751-767.
2. Cornelius, Peter, Mattia Romani og Alexander Van De Putte (2004): "Three decades of scenario planning in Shell: experience and possible extensions in the future", Paper presented for the 24<sup>th</sup> IAEE conference, Washington D.C, July 10<sup>th</sup> 2004..
3. Goodwin, Paul & Wright, George (2009): *Decision Analysis for Management Judgement*, Wiley.
4. Miller, K.D og Waller, H. G. (2003): "Scenarios, real options and integrated risk management", *Long Range Planning* 36(1), 93-107.
5. Newendorp, P. D. (1975): *Decision Analysis for Petroleum Exploration*. PennWell Books, Tulsa Oklahoma.
6. Norwegian Petroleum Directorate (2009): Petroleum resources on the Norwegian Continental Shelf.
7. Smith, J. L & Thompson, R. (2003): "Managing a Portfolio of real Options: Sequential Exploration of dependent Prospects", mimeo.
8. Smith, J. L & Thompson, R. (2005): "Diversification and the Value of Exploration Portfolios", mimeo.
9. Van der Heijden, K., Bradfield, R., Burt. G., Cairns, G., & Wright. G (2002): *The sixth sense: Accelerating organizational learning with scenarios*. Chichester: Wiley.
10. Wright, G. & P. Goodwin (2009): "Decision making and planning under low levels of predictability: enhancing the scenario method"; *International Journal of Forecasting* 25(2009) 813-825.