Gathering Real Options with Value of Information: A case in an Oil and Gas New Frontier

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Abstract

Oil and gas (O&G) companies have changed their profile in pursuing potential reserves in new frontier areas. Entry into business opportunities has been cautious, as the ongoing energy transition requires positioning in reserves with lower carbon footprints and pollutants. Minimal investments are made in the exploratory period and are essential in separating an environmentally and economically efficient portfolio. Thus, an investment program in information to de-risk exploratory prospects is essential to avoid failures and better estimate the commercially recoverable volume before a high-cost investment.

Usually, the decision-making does not consider calculating information benefit for exploratory block acquisition. When it is done, the value of the decision does not add the benefit of postponing the high-cost investment of a wildcat well. This paper systematizes the appreciation of the option to invest in the exploratory well combined with the de-risking information investment, with binomial and least-square Monte Carlo approaches, associating the theory of real options (RO) with the value of information (VOI).

Introduction

The movement of O&G companies in new frontier areas is careful due to the energy transition to a low-carbon matrix. The exploration and production contracts allow the companies to manage the sequence of investments (Begg and Bratvold, 2002), being able to better drive towards a cleaner matrix. The value of opportunities within the contract area is affected by commodity prices, modeled by RO, and the effect of investments in knowledge is modeled with VOI concepts (Dias, 2004). Flexibility contributes to de-risking the projects and is vital for a better company allocation portfolio.

Investment in knowledge is the way to reduce the technical-geological uncertainty of projects, which is more significant in the exploratory phase than in the production phase (Haskett, 2003). In the appraisal phase, the wells' number and location are relevant to delimit the deposit, as well as the seismic detailing of the reservoir (Cook, 2021). Similarly, Bickel (2014) builds a pilot for non-conventional reservoirs with a gaussian likelihood function and a precision function for the expected volume. Fedorov et al. (2020) present the benefit of information from sequences of wells for the depletion curve of a marginal field, also considering the price uncertainty in the model. Seismic is also relevant in the production and delimitation phase, as seen in Bickel et al. (2008) and Pickering and Bickel (2006).

Nonetheless, the exploratory phase has a set of more fundamental uncertainties, such as the existence of hydrocarbons and the first estimation of the expected hydrocarbon volume (Dias, 2004). Seismic methods are the main ways to estimate the prospects' first parameters. The application of better technologies reduces the initial uncertainty, mainly for reservoirs with an expected Direct Hydrocarbon Indicator response (Rocky et al., 2021). Other indirect methods, such as Controlled Source Electromagnetic (CSEM), also reduce the technical-geological uncertainty of new frontier prospects (Eidsvik, 2008).

The model used here is the business model from Dias (2004). Due to the uncertainty of the existence of hydrocarbon, we apply the Expected Monetary Value formula (Rose, 2001). Due to the contract period, price uncertainty, and investment flexibility, we add the ideas of real options in exploration from Dias (2010) and the knowledge investment concept of the value of information from Dias (2002).

Exploration Contract

The exploratory contract offers several flexibilities for the O&G company. The example of this paper considers a three-year exploratory contract, with no obligation to drill the wildcat well (I_W) and an obligation to acquire 3D seismic information (I_K), which can be exercised at any time during the contract. The investment in information needs to be acquired, processed, and interpreted. The investing company desires to have the interpretation as soon as possible, so that information would impact the technical project parameters at the end of the first year (figure 1). After the exploratory period, the company decides to continue with the appraisal and production phases or abandon the project.

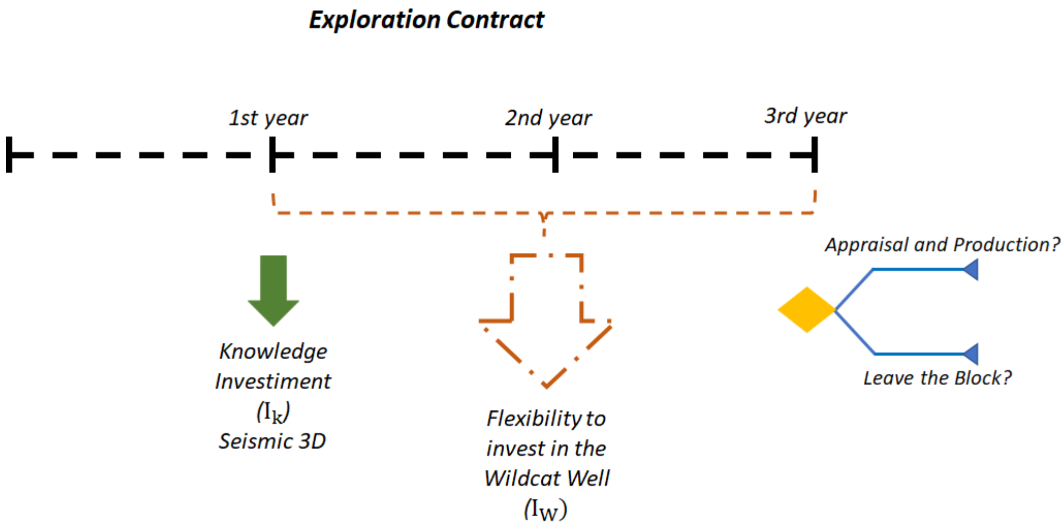

Figure 1: Exploration Model Contract

These data are geophysical details about the local geology and inferences about the reservoir, considered imperfect information (Sorenson, 1984). The information is intended to reduce the project's technical uncertainty and better evaluate the option of drilling the wildcat well. In most cases, the best geophysical technique is 3D seismic, whereas other types of technologies may be used, such as electromagnetic and gravimetric methods.

From the investor's perspective, drilling the exploratory well before data interpretation is not rational, as it de-risks the project and is less costly than the well. Our model tries to capture this characteristic, so it is only possible to invest in the exploratory well after acquiring the information. Therefore, before investment $\mathrm{I_K}$, which is a European option, and after $\mathrm{I_K}$, an American option concerning investment $\mathrm{I_W}$ until the end of the exploratory contract. This mechanism is not contractual but a consideration from the company's best point of view.

References

Bickel, J. Eric, Richard L. Gibson, Duane A. McVay, Stephen Pickering, and John Waggoner. 2008. "Quantifying the Reliability and Value of 3D Land Seismic." *SPE Reservoir Evaluation & Engineering* **11**(5) 832-841. **doi:** 10.2118/102340-PA.

Cook, M. (2021). Appraisal planning. In *Developments in Petroleum Science* (Vol. 71, pp. 101-131). Elsevier.

Cox, John C., Stephen A. Ross, and Mark Rubinstein. "Option pricing: A simplified approach." *Journal of financial Economics* 7, no. 3 (1979): 229-263.

Dias, M. A. G. (2002). Investment in information in petroleum, Real Options and revelation. In *Proceedings of the 6th Annual International Conference on Real Options. Real Options Group at Cyprus, Cyprus*.

Dias, M. A. G. (2004). Valuation of exploration and production assets: an overview of real options models. *Journal of petroleum science and engineering*, *44*(1-2), 93-114.

Dias, Marco Antonio Guimarães. "Calculating real option values." *Wiley Encyclopedia of Operations Research and Management Science* (2010).

Eidsvik, J., Bhattacharjya, D., & Mukerji, T. (2008). Value of information of seismic amplitude and CSEM resistivity. *Geophysics*, *73*(4), R59-R69.

Haskett, W. J. (2003). Optimal appraisal well location through efficient uncertainty reduction and value of information techniques. In *SPE Annual Technical Conference and Exhibition*. OnePetro.

Longstaff, F. A., & Schwartz, E. S. (2001). Valuing American options by simulation: a simple least-squares approach. *The review of financial studies*, *14*(1), 113-147.

Fedorov, S., Hagspiel, V., Lerdahl, T., Idris, A., & Ghahfarokhi, A. J. (2020). Staged Development of a Marginal Oil Field Under Technical and Market Uncertainty: The Olympus Case. In *SPE Annual Technical Conference and Exhibition*. OnePetro.

Rose, P. R. (2001). *Risk analysis and management of petroleum exploration ventures* (Vol. 12). Tulsa, OK: American Association of Petroleum Geologists.

Roden, R., Forrest, M., & Holeywell, R. (2012). Relating seismic interpretation to reserve/resource calculations: Insights from a DHI consortium. *The Leading Edge*, *31*(9), 1066-1074.

Sorenson, S. R. (1984). Calculating the value of seismic information. In *SEG Technical Program Expanded Abstracts 1984* (pp. 176-178). Society of Exploration Geophysicists.