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Real Options Approach for Economic Evaluation of Oil and Gas E&P Projects Under Geological and Market Uncertainties

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Introduction

Flexibility is a key driver of value in oil and gas exploration and production projects. Traditional project evaluation methods, such as discounted cash flow (DCF) and the Net Present Value (NPV), are widely used in the industry (Smith, 2014). However, these approaches are static and do not account for the value created by managerial flexibility and the ability to respond to future uncertainties (Dixit & Pindyck, 1994). In reality, decision-makers often have the option to expand, delay, suspend, or abandon projects as new information becomes available. This set of choices—known as "real options"—represents an important source of value that is not captured by conventional NPV analysis (Trigeorgis, 1996; Bratvold & Begg, 2010).

The theory of real options provides a modern framework to quantify the value of flexibility in investment decisions, especially under uncertainty. In this work, we demonstrate that greater flexibility increases the overall value of petroleum projects. Our analysis considers both market and project uncertainties. For market uncertainties, we use the Schwartz and Smith two-factor model to represent the stochastic behavior of oil prices (Schwartz & Smith, 2000), and the geometric Brownian motion to forecast operational costs. For geological uncertainties, we adopt the benchmark Egg Model, which consists of 101 realizations to represent the uncertainty in reservoir permeability (Jansen et al., 2014).

By integrating these advanced models, we are able to provide a more realistic and robust evaluation of oil and gas projects, highlighting how managerial flexibility and uncertainty quantification can significantly increase project value.

Methods

This work applies the real options theory to evaluate the value of flexibility in oil and gas projects. Real options analysis extends traditional financial models by incorporating the possibility of future decisions under uncertainty, such as expanding, delaying, or abandoning a project (Trigeorgis, 1996; Dixit & Pindyck, 1994). This approach is particularly relevant for oil and gas projects, where uncertainties and high capital investments are significant.

To represent the evolution of operational costs, we use the geometric Brownian motion (GBM), a widely adopted stochastic process in financial modeling. The GBM assumes that costs evolve continuously over time with a certain level of drift and volatility, allowing us to model unpredictable changes in operational expenses (Hull, 2018).

For the oil price forecast, we employ the two-factor model developed by Schwartz and Smith (2000). This model captures both short-term fluctuations and long-term trends in commodity prices, providing a more realistic representation of oil price dynamics compared to simpler models. The model combines a mean-reverting process for short-term deviations and a Brownian motion for long-term price movements.

Geological uncertainty is addressed using the Egg Model, a benchmark geological ensemble that consists of 101 realizations of reservoir permeability (Jansen et al., 2014). Each realization leads to a different production profile, thus quantifying the impact of subsurface uncertainty on future oil production.

To account for the combined effects of these uncertainties and managerial flexibility, we run 10,000 Monte Carlo simulations. In each simulation, we generate possible trajectories for oil prices, operational costs, and production profiles. The average Net Present Value (NPV) obtained from these simulations, considering the available real options, represents the value of the project with flexibility.

Results and Conclusions

The results of our simulations show that the Net Present Value (NPV) of the project is significantly higher when flexibility is incorporated through real options analysis, compared to the traditional approach with no flexibility. This confirms that managerial flexibility—such as the option to expand, delay, or abandon operations—adds substantial value to oil and gas projects, especially in the presence of market and technical uncertainties.

Furthermore, our findings indicate that the greater the flexibility allowed over the project's lifetime, the higher the overall project value. The ability to make decisions at the right time, based on favorable market conditions and updated information, is crucial. Effective timing of decisions—such as investment, suspension, or abandonment—enables project managers to maximize value and reduce risks.

In summary, incorporating real options and flexibility in the project evaluation provides a more realistic and valuable assessment for decision-making in oil and gas exploration and production projects.

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