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Sensitivity of Project Economics to Uncertainty in Type and Parameters of Oil Price Models

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Abstract

Dynamic price models (which replicate the characteristics of real price fluctuations over time, not just the mean) are a crucial element in economic evaluations. However, there has been little systematic evaluation of the effects of uncertainty in what type of model is most appropriate, or of uncertainty in the parameters of such models.

We present the results of a sensitivity analysis of economic metrics to uncertainty in both type of oil price model and in the values of the model parameters. Uncertainty in both arises from arbitrary choices in their derivation from historical data and from uncertainty as to whether the past predicts the future.

We take four types of price model (simple probabilistic, Geometric Brownian Motion, mean reverting, mean-reverting with jumps) and use historical data to derive estimates (and uncertainty therein) of the numerical values of their respective parameters. The impact of model choice and parameter uncertainty is then compared via their impact on economic metrics for a typical field development decision.

Introduction

Uncertainty in hydrocarbon prices is widely recognized as being one of the main factors that drives uncertainty in economic metrics that are used to make decisions. A key component of any evaluation of uncertainty in these metrics, therefore, is a dynamic price model – one that replicates the characteristics of real price fluctuations as a function of time, not just the mean price. At a minimum, dynamic price models are required to predict future cash flows and assess economic risks and opportunities such as: will a decision be profitable or what is the upside potential? Used to their full extent, realistic models of future price variability also enable better decisions by valuing the use of flexibility to manage project uncertainty.

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Even if modeling uncertainty in economic performance is not a desired goal, in the case of non-linear models, using the expected value (mean, average) of future prices will generally NOT give the correct expected value of economic metrics such as NPV, IRR etc. To calculate the correct average it is necessary to model the full range of uncertainty.

Further, if modeling uncertainty in economic parameters is a goal, then just using the P10, P50, P90 etc of future prices will generally NOT give the P10, P50, P90 of the economic metrics. It is necessary to model the full range of possible price profiles.

An important type of non-linear model is one in which choices are made between alternate courses of action as a response to uncertain future prices. For example, decisions to shut-in a field, to accelerate or defer a project, or to expand or contract one. When evaluating whether or not to plan for, and thus pay for, such flexibility it is again essential to have a model of how future prices might evolve, not just an average price or even uncertainty in the average price. Another example of when non-linearity might be important is in predicting the impacts of changes in fiscal terms that are triggered by specific revenue levels.

However, as with many other quantities in models of oil and gas projects, uncertainty does not just lie in the "random" component of a probabilistic model. There is also uncertainty in the ***parameters*** that go into a model and uncertainty in what ***type*** of model best represents the "real world".

To illustrate the above point, consider an analogy with geostatistical models of reservoir properties. One way of estimating the uncertainty is to generate a large number of "realizations" of the property at any location, different realizations resulting from the use of different random numbers. But this process does not fully capture the uncertainty. Suppose a Sequential Gaussian Simulation (SGS) technique was used. This technique requires the use of variogram parameters, which might be uncertain, as might be the suitability of the SGS technique as a model of the real spatial variability.

Although it is well known that oil price uncertainty is a major contributor to uncertainty in project economics, its