IPTC 11969

A Monte Carlo Approach to Value of Information Evaluation

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This paper was prepared for presentation at the International Petroleum Technology Conference held in Kuala Lumpur, Malaysia, 3–5 December 2008.

Abstract

The value of information (VOI) methodology can be used for determining whether further information should be collected before making a decision. Typically, a VOI is calculated on an expected monetary value (EMV) basis by means of a decision tree, and the cost of the information is compared to the VOI to determine whether to undertake further data collection. A majority of VOI studies employ the discrete decision tree approach to VOI evaluation, thus simplifying the problem by reducing the range of the outcomes and the number of uncertainties addressed at the same time.

In order to overcome and address the simplifications introduced when performing a discrete VOI evaluation, a Monte Carlo approach founded on Bayesian decision theory can be applied. This increases computational complexity, but allows for a full uncertainty description of range variables such as oil in place (OIP) and can be integrated with quantitative prospect evaluation methods.

The Monte Carlo VOI (MCVOI) approach is presented and compared to the discrete decision tree approach by means of an appraisal well decision. In addition, a complete MCVOI workflow is proposed.

The paper aims at familiarizing VOI practitioners with the MCVOI approach by explaining how it works and by illuminating its benefits, such as eased expert assessment and getting past discretization of variables that are inherently continuous. The paper also places the VOI approach in a risk management context, thus extending VOI methodology beyond the pure calculation of a VOI number.

Introduction

One of the most useful features of decision analysis is its ability to distinguish between constructive and wasteful information gathering. VOI analysis evaluates the benefits of collecting additional information prior to making a decision. Such information gathering may be worthwhile *if* it holds the possibility of changing the decision that would be made without further information.

The majority of VOI applications in the oil and gas industry are based on a discrete approach whereby the uncertainties, both the ones we hope to learn about but cannot directly observe, and the information gathering results, are discretized into a finite number, usually 2–3, of degrees.[1] Although this discretization is sufficient in many situations, continuous representations of the uncertainties may be more suitable for others, such as the uncertainty in oil in place (OIP) or the production in a given year.

For some combinations of prior probability distributions and likelihood functions, representing the current information and the confidence related to new information, respectively, Bayesian updating of the probabilities (to get the posterior) is straightforward. Conjugate priors are families of distributions that ease the computational burden when used as prior distributions. Given a conjugate prior, there is a set of likelihood functions for which there exist simple formulas for calculating the posterior distribution. Hence, if the analyst believes that one of these conjugate priors and its associated likelihood functions adequately describe the uncertainties, the probability updating part of the VOI analysis is trivial.

However, these theoretical distributions do not always provide good representations of the relevant uncertainties. For example, one of the most commonly used distributions in the oil and gas industry, the triangular distribution, is not a conjugate prior, and hence other methods for Bayesian updating must be used. Other common situations include where the prior or likelihood functions are subjective (elicited) and describe the informed opinion of the expert(s), where the resulting distribution can not be approximated by a theoretical distribution. In this paper we illustrate the use of a general approach for Bayesian updating. This approach will work for any set of continuous distributions for the prior and likelihood function. The

[1] Reference [2] reviews all of the papers on VOI published in the SPE domain.