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Characterization of gas and oil portfolios of exploration and production assets using a methodology that integrates value, risk and time

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ABSTRACT

Asset portfolio modelling and optimization are critical activities for upstream (exploration and production) gas and oil companies in order for decision makers to establish the combined value of their assets and to select assets for further development, divestment and/or acquisition. However, it is an activity that is typically not conducted in a standardized and systematic way, with many companies relying on simple deterministic discounted cash flow asset-value-roll-up analysis, but missing vital insight to the subtle, but significant characteristics of their portfolios. A more systematic, multi-stage stochastic methodology is proposed to reveal detailed characterization of gas and oil asset portfolios in terms of value, risk and timing. The non-linear nature of risk is taken into account in an approach to risk analysis that begins at the asset level and progresses through to the pre-corporate rolled-up asset portfolio to post-tax portfolio factoring in the corporate financial dimension. The proposed methodology emphasizes the importance of considering financial and non-financial metrics (i.e. production, reserves and timing) over each year of a planning horizon. In addition, those same metrics summed over all the years of a planning horizon, expressed in terms of risked value and downside risk of the portfolio failing to achieve certain strategic targets identifies feasible envelopes for possible asset combinations. The downside risk measures apply important modifications to standard risk-variance analysis, introducing flexibility into the approach to suit diverse strategic objectives of potential portfolio holders. Further analysis of those risk versus risked value feasible envelopes reveals the efficient frontiers representing the asset combinations that achieve the highest value for specific levels of downside risk. Characterizing a portfolio of gas and oil assets with such a methodology helps to frame multi-objective optimization algorithms tailored to suit the unique characteristics of each asset portfolio. Excel spreadsheets driven by visual basic for applications (VBA) macros offer the advantages of flexibility, transparency and customization to characterize asset portfolios with the methodology proposed. A small portfolio involving eleven exploration, appraisal, development and production gas and oil assets (Portfolio X) is presented to illustrate the benefits of the proposed approach to gas and oil asset portfolio characterization. The diversity in character of conventional and unconventional upstream gas assets makes a portfolio approach to their understanding extremely worthwhile.

1. Introduction

Gas and oil companies typically hold from several to many hundreds of individual assets and need to establish values and understanding for those portfolios of assets, taking into account their corporate financial positions. Based upon the asset portfolio values, decisions are taken regarding capital allocation to individual assets, and regarding which assets to potentially divest or dilute in terms of the beneficial interest the companies hold in them. The value and performance of the asset portfolio is typically gauged in relation to corporate strategic objectives. This means that gap analysis between the current asset portfolio's performance and a company's aspirations often determines which new assets should be acquired and brought into the portfolio to boost its performance in certain directions.

The majority of companies still conduct such analysis in a deterministic way focused on value and time, but with only

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rudimentary attempts to quantify risk, at either the asset or portfolio levels. Techniques have existed for several decades demonstrating that stochastic methods, which use probability distributions to describe uncertainty, provide a useful way to integrate risk/uncertainty analysis into portfolio valuation (Markowitz, 1952, 1987). Yet the majority of companies find stochastic models and the statistical analysis of probabilistic output of Monte Carlo simulations too cumbersome to handle consistently across their organizations. This paper highlights the benefits of a rigorous and systematic stochastic methodology for the assessment of gas and oil portfolios of exploration and production assets that integrates value, risk and time. It identifies the type of portfolio value and characterization that can be established using such models, which is typically beyond the reach of deterministic models. Portfolio X - a hypothetical portfolio of exploration and production assets, at various stages in the upstream cycle, incorporating a combination of exploration, appraisal, development and production assets, is analysed in detail to illustrate the benefits of the methodology proposed.

2. Typical gas and oil portfolio analysis measurements and methodologies

When valuing gas and oil assets it is financial value metrics that sit at the top of the list in terms of a portfolio models output, whether it is deterministic or stochastic. Financial value metrics typically of interest to portfolio decision makers are operating cash flow, post-tax cash flow, pre-tax and post-tax net income, at the asset and/or, more likely, the corporate level, together with various balance sheet metrics related to debt and equity, and specific cost measures, particularly those related to capital investment (capex) requirements (Howell et al., 1998; Wood, 2001). In addition, non-financial metrics are also measured and evaluated, such as gas and oil production (daily or annual rates), gas and oil reserves volumes at particular points in time specified to different levels of confidence and rates at which those reserves and production are replaced.

The typical levels of confidence for reserves quoted are: proved or 90-percentile, often referred to as P90; probable or 50-percentile often referred to as P50, etc.

An asset roll-up approach is typically used to combined by addition the financial and non-financial values of interest of each asset to provide an overall portfolio value, for both deterministic and stochastic methods, because values add linearly implying that the value of the whole reflects the sum of its component parts. Figures 1 to 3 display the results of an asset roll-up for barrels of oil equivalent (boe) production and capital expenditure for Portfolio X based upon the mean values of a stochastic analysis. Similar displays could be produced using deterministic modal values.

These two-dimensional graphics combine value and time, in this case for a planning horizon of 15 years. It is easy to identify the specific contribution of each asset to a specific portfolio value metric in any time period of interest. Moreover, models are structured such that shifting the timing of one specific asset, for instance delaying capital expenditure by one year, can be executed and these displays updated very quickly to reveal the impact of that change at the portfolio level in terms of value and time. Financial value is typically based on discounted cash flow analysis (e.g. Brealey et al., 2014) and the calculation of a net present value (NPV). Although there have been recent studies extolling the virtue of going beyond NPV when calculating the value and selecting assets for gas and oil portfolios, by applying techniques such as real options (e.g. Lin and Ji, 2007), multi-criteria decision modelling (e.g. Walls, 2004; Lopez and Teixeira de Almeida, 2013) and utility theory (Xue et al., 2014), discounted cash flow and NPV remain the cornerstone of petroleum economics and valuation as it is practised by gas and oil companies. The portfolio characterization methodology proposed here sticks with discounted cash flow techniques but makes the case that analysis can go way beyond NPV by embracing stochastic methods and using a suite of risk measurements and adjustments at targeted at various stages of asset and portfolio valuation. Other recent studies also highlight the value of mean-variance stochastic methods in aiding oil and gas production optimization and asset portfolio decision-making (e.g. Capolei et al., 2015; Mutavdzic and Maybee, 2015).

Many companies go little further than deterministic NPV analysis, other than to translate such asset value roll-ups into discounted return on investment (Brealey et al., 2014), such as calculations of internal rates of return (IRR) and into financial statement metrics, such as earnings, earnings before interest, tax depreciation and amortization – EBITDA, etc., electing to treat risk separately in a much more qualitative manner at the asset and portfolio levels. Some companies will adjust the roll-up portfolio values by a simple risk factor (typically on a zero to 1 scale, where zero means something will never happen and 1 means something will happen with certainty) that incorporates opaquely the multiple below-ground and above-ground facets of uncertainty. The problem with risk is that it does not add linearly and it is made up of

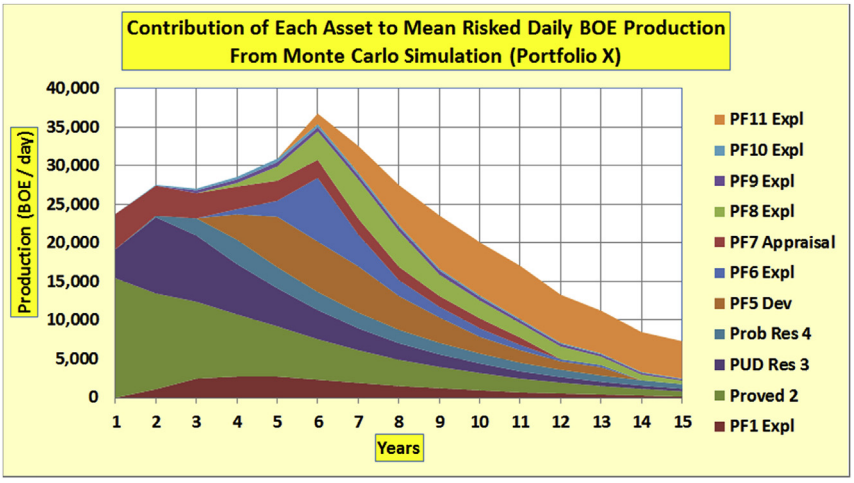

Fig. 1. Portfolio X daily gas and oil (boe) production asset roll up. The contribution of each asset to the mean risked daily boe production from Monte Carlo simulation.