Drilling Portfolio Performance and the Role of Survival Bias in Volume Estimates

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Summary

A detailed review of 215 drilling projects covering exploration and development wells from the Netherlands shows that, on average, only 58% of the promised pre-drill volumes are being matured. This implies a clear and significant bias in the evaluation process. A breakdown of the underlying reservoir parameter estimates indicates that most parameters have a tendency of being predicted too optimistically. Modelling synthetic portfolio drilling shows that this bias can (partly) be explained by the phenomena of Survival Bias. This type of Selection Bias might be unavoidable but the effect can be minimized by careful, high quality subsurface evaluation work where uncertainties are being understood and being reduced. In addition, a pre-drill volume discount factor could be systematically implemented to protect the investment decision against the effect of over-promise. The synthetic portfolio modelling approach presented here provides a framework that allows improved estimates of drilling portfolio delivery by estimating prediction biases quantitatively.

Introduction

Both exploration and development opportunities need to be described accurately in terms of volumetrics and risks as these assessments provide critical input to the ranking and maturation prior to FID. Typically the top ranking targets within a portfolio that meet economic screening criteria are pursued first. After some time the economically drillable portfolio might become exhausted and it is time for fundamentally new play concepts or even to move on to other basins. In this process it is important to understand how well the exploration and development activities deliver with respect to the pre-drill assessments. Historical drilling results can be used to undertake an after-action review to test the accuracy of the pre-drill prospect evaluations. Published statistics on this topic are sparse as project outcomes are often considered confidential. Nevertheless, there are indications that overpromise is quite common in the E&P industry (ref 2, 3).

EBN is the Dutch state company participating in most oil and gas exploration and production in the Netherlands and is therefore in an excellent position to conduct such analysis. For this purpose hundreds of well results have been analysed and compared with pre-drill predictions. One observation is that in the Netherlands, well outcomes fall short to pre-drill promises in term of volumes. Only 58% of the gas volumes have been matured compared to the pre-drill MSV estimates. (fig.1)

Several reasons have been suggested (ref 3, 4) that could explain this bias towards overpredictions. These include *cognitive bias* (e.g. the well-known explorers *rosy glasses mentality*) and *evaluation tool induced bias* (e.g. seismic imaging artefacts). Also little is known about which prospect parameters in particular are responsible for prediction errors. In ref 2 an analysis of depth prognosis versus actual depth from wells drilled in the Netherland has been presented. Also here a depth bias and a possible correlation with volume prediction bias has been observed. In this presentation a breakdown of prediction errors for key prospect parameters will be given. Most of these parameters show a clear bias towards overpromise. This effect might be explained by the phenomenon of Survival Bias (SB). SB is well known from evolutionary biology. SB in this context is sampling (or selection) bias in portfolio ranking where measured datapoints (executed drilling projects) are not representative of the entire population (i.e. project portfolio). Modelling results indicate that SB can explain overpromise quantitatively. It also provides insight under which conditions SB is significant.
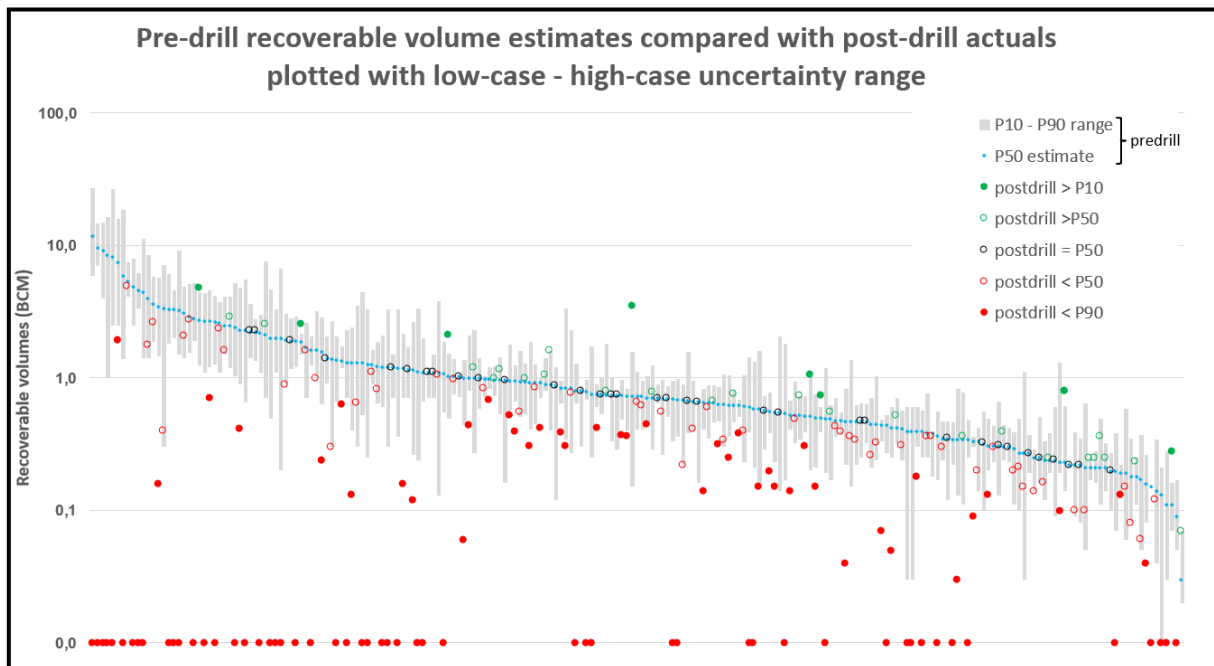

Fig. 1 Volume delivery vs promise diagram. Each drilling project is represented by mean success volume recoverable (MSV), volumetric prediction range and actual volume as evaluated after drilling. (data sorted on MSV). Red dots delivered below the low case prediction. Dry holes are plotted at the 0.0 RV axis. N= 215

Method

In order to assess historic exploration predictions from the Netherlands a database has been compiled with prospect parameter predictions and actuals as evaluated after drilling. Where available, prediction ranges (P10, P90 estimates) have also been taken into account. EBN is tracking this information systematically and for this analysis, 215 drilling projects from the period 2004-2019 have been taken. Data refers to exploration, appraisal and development projects. These drilling projects have a common objective, namely, to mature economic hydrocarbon resources. For this study, data has been restricted to gas reservoirs as oil constitutes only a relatively small component of Dutch EP activities. The pre-drill prognosed resource information is generally supplied by Operators to the investors (including EBN) as part of the documentation supporting the investment decision. Once executed, the post-drill data (actuals) are also provided. From the subsurface parameters being prognosed, the reservoir depth is very straightforward to check once drilled. Parameters such as porosity, gas-saturation, gas-water contact, net to gross require some petrophysical analysis but are also fairly well constrained after logging. Gas Initially In Place (GIIP) and Recoverable Volumes (RV) are estimates based on well tests and/or updated static models. Further volumetric updates can take place during field life e.g. via material balance plots, but those later refinements are, for practical reasons, beyond the scope of this analysis. As risking and uncertainties are important aspects of drilling projects, there is little point is assessing individual project outcomes to validate the quality of the predictions. Hence a statistical approach looking at a significantly large number of well results should be taken to draw conclusions on the quality of the predictions and the overall portfolio performance. Analysing prediction quality of specific reservoir parameters allows an investigation of which static model input parameters are dominating the prediction uncertainty.

In the second part of this study, exploration drilling is stochastically modelled using Monte Carlo simulations. Synthetic exploration portfolios with specific statistical characteristics are stochastically generated, ranked and "drilled on paper" according to certain ranking criteria. Introduction of *noise* (i.e. imperfections in the pre-drill opportunity evaluation process) is an important aspect. Subsequently, the outcomes (actuals) can be compared which the predictions in a statistical manner. In this way, the presence of bias can be studied and quantified at a portfolio level. Finally prediction bias as observed in the historical data can be compared quantitatively with the modelled results.

Modelling the exploration portfolio makes use of major simplifications. Each prospect is represented by two parameters only : 1) Expectation Volume (EXP = Risked Volume = Probability of Success (PoS) x Mean Success Volume (MSV)) and 2) Unit Technical Cost (UTC) representing the total cost of the base case development per cubic meter of gas. For both parameters pre-drill estimates are generated stochastically using real data and perturbed with assumptions of evaluation noise (error/uncertainty/bias). With these realized parameters and assuming a gas price the economic value of each prospect can be estimated, which determines the prospect ranking order. Subsequently the top 50% best ranking prospects are 'drilled on paper', with the assumption that remaining opportunities remain sub-economic and will remain un-drilled.
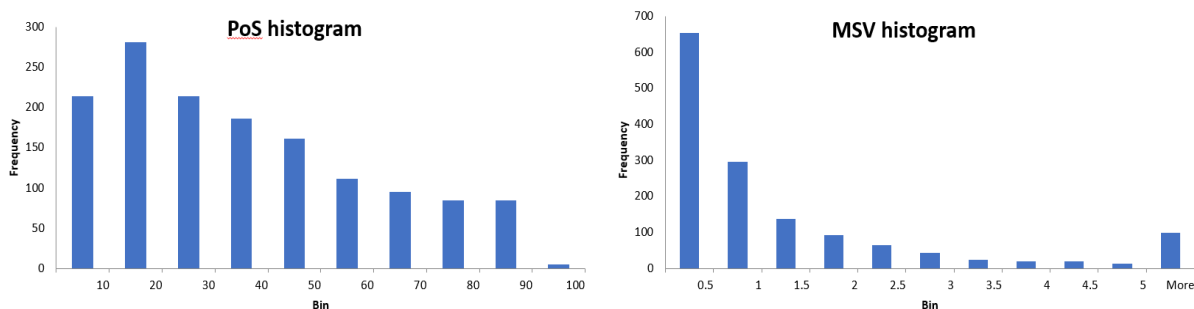

Fig 2 Prospect portfolio characteristics from the national Prospect database. Left: PoS, right: MSV. These parameters have been used to constrain the simulated portfolios.
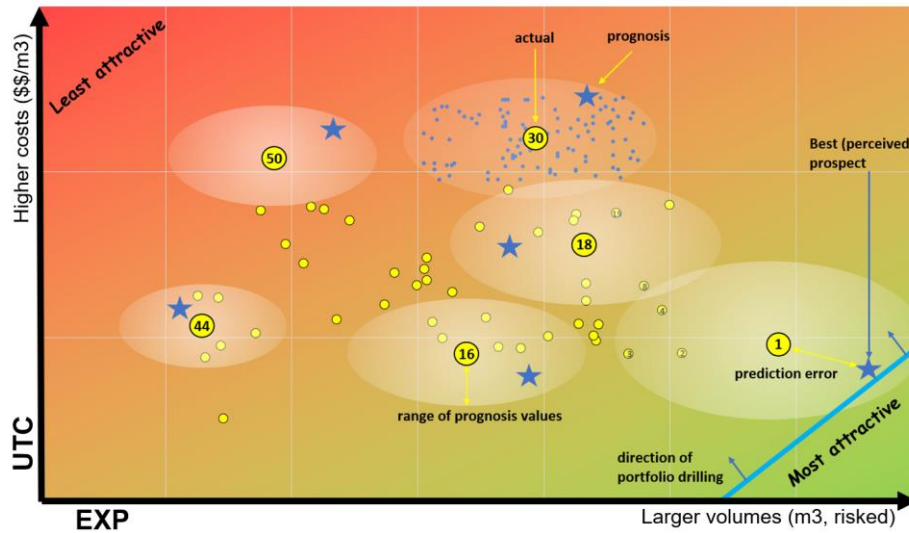
Fig. 3 Synthetic Exploration portfolio modelling. Prospects actuals are plotted as yellow dot. Predictions (based on Monte Carlo runs assuming imperfect data) by blue dots (here only indicated for prospect #30). The randomly selected prediction is indicated by a blue star. The portfolio is "drilled" from bottom right (attractive) towards top left. Modelling parameters include: 50 prospects of which the top 25 are selected based on perceived attractiveness. Each prospect has a Monte Carlo realization drawn from the uncertainty ranges in EXP and UTC. This process is repeated 100 times using random realizations. The prediction errors are subsequently averaged.

Results

By comparing pre- and post- drill volumes from 215 drilling projects conducted in the Netherlands in the period 2004-2019, an under-delivery of 42% in recoverable volumes can be observed at portfolio level. Subsequently the prediction quality of the following reservoir parameters have been analysed: reservoir depth, column height, porosity, net-to-gross, saturation, reservoir pressure. With the exception of net-to-gross, all these parameters indicate overpromise with the combined effect being that the overpromise in volumes can easily be explained.

Synthetic portfolio modelling has been conducted to test the effect of SB. Modelling is based on portfolio statistics, guided by characteristics of the actual prospect database, and shows a performance bias towards overpromise depending on model parameters. In the given model the prediction bias shows a strong correlation with the uncertainty in EXP. The effect of SB increases with:
   a) more noise in the data (i.e. more uncertainty in the evaluation)
   b) increased clustering in the ranking parameters (typical for creamed portfolios)
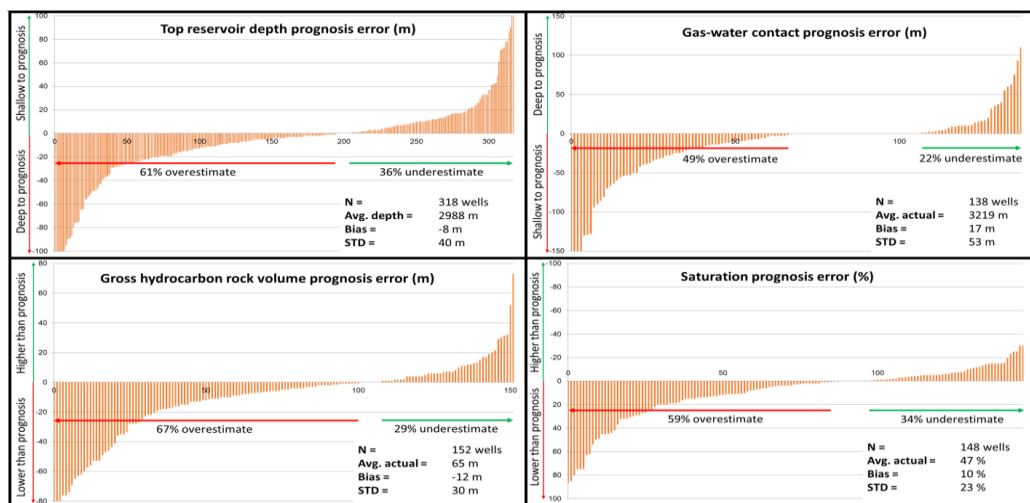

Fig 4. Reservoir parameters: prediction errors. Lob-sided distribution towards the left implies overpromise on volumes at portfolio scale.
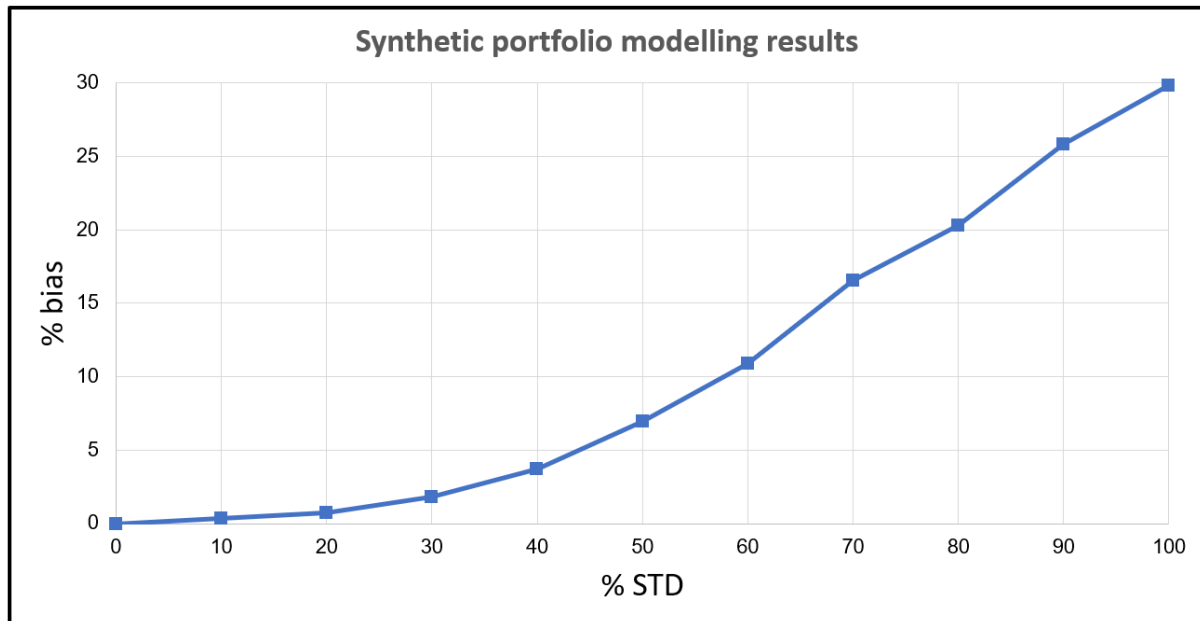
Fig 5. Prediction bias factors (expressed as % on the recoverable volume at portfolio level) as a function of the EXP random errors (expressed as % standard deviation of the EXP). Example; if the EXP volumetric estimates (all prospects) have an STD uncertainty of 60%, the portfolio is expected to deliver 11% less than promised. (see fig 3 for modelling parameters.)

Conclusions

A detailed review of 215 drilling projects covering gas exploration and development wells from the Netherlands shows that, on average, only 58% of the promised pre-drill volumes are being matured. A breakdown of the underlying reservoir parameter estimates indicated that most parameters have a tendency of being predicted too optimistically.

Modelling synthetic portfolio drilling shows that this bias can (partly) be explained by the phenomena of Survival Bias. This type of Selection Bias might be unavoidable but the effect can be minimized by careful, high quality subsurface evaluation work where uncertainties are being understood and being reduced. In addition, a pre-drill volume discount factor could be systematically implemented to protect the investment decision against the effect of over-promise. The synthetic portfolio modelling approach presented here provides a framework that allows improved estimates of drilling portfolio delivery by estimating prediction biases quantitatively.

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