Tailoring Completions to Geology: A Machine-Learning Driven Approach

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Abstract

As the unconventional shale industry enters the 2020s, operators have tested the limits of completion intensity and have begun to decrease completion sizes in order to control costs and improve returns. Future gains in profitability will rely on careful analysis of vast amounts of production, completions, and geologic data to find opportunities for improvement. Here, we present a machine-learning based workflow that uses decision-tree based models to recommend completions designs tailored to specific sets of geologic parameters. We build a model to predict gas and condensate production in the Marcellus Shale play of the Appalachian Basin, using publicly available completions, production, and geologic data. The model makes point predictions at 30-day increments out to 720 days. We use the explanatory tool of SHAP (Shapley Additive Prediction) to investigate model behavior and as a method for generating hypotheses. The SHAP approach constructs a model of the decision tree-based model, quantifying the impact of each individual feature in physical units of MCF or barrels. When viewed across multiple wells with different sets of input parameters, the SHAP values describe the model's purely empirical perspective on the relationship between a particular variable and production.In order to isolate variable impacts, we investigate the SHAP values for proppant, fluid, and stage length across different ranges of input geologic parameters. We find that higher-maturity rock is more responsive to increased fluid loading and stage length shortening, but equally responsive to proppant volumes. This empirical result suggests several potential lines of inquiry, including that rock with higher effective permeability may surprisingly be more responsive to fracture complexity rather than fracture propping. It also presents an investment thesis that higher-maturity rocks should receive lower ppg treatments and shorter stage lengths. Finally, we run

hypothetical well designs through the model to show that, indeed, the above recommendation is borne out after incorporating representative drilling and completions costs. We then analyze cost sensitivities of model recommendations with respect to different rock maturities to determine the return of tailored completions under different scenarios, so this approach can be weighed against the benefits of completions standardization, such as operational efficiency gains and commercial benefits of uniform orders.

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