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To: Patrick Barickman  
From: Jon Wilkey  
Date: December 2, 2016  
RE: November 2016 monthly report on price forecasting for the R model

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During the month of November work on this project focused on implementing price forecasting options for short, medium, and long term time horizons, as well as updating the user manual to reflect the changes. A summary of the change-log is given below. At this point, the model is ready for final delivery to UDAQ pending approval and payment of the contract with the Univ. of Utah.

## Change-Log

1. Major changes
  - a. Added ARIMA forecasting for medium/long term time horizon
    - i. Fits two ARIMA models:
      1. A user-specified ARIMA model
      2. A automatically selected ARIMA model
      3. Plots long-term forecasts of both ARIMA fits so that user can judge which type (user-specified or automatically selected) of model to use for simulation.
    - b. Overhauled energy price forecasting options
      - i. New possible forecasting models:
        1. User-specified ARIMA model
        2. Automatically selected ARIMA model
        3. EIA forecast with error propagation
        4. Actual energy prices (for cross-validation use only)
        5. Constant prices equal to average of last  $N$  months prior to start of simulation period
        6. User-specified price paths
      - ii. Oil and gas price forecasts can now be specified independent of each other
    - c. Drilling forecast changes
      - i. Added optimization step that searches for the best time delay between energy prices and well completions using the function:

$$W_t = a \cdot OP_{t-N} + b \cdot GP_{t-N} + c$$

where  $W$  is the number of wells completed during month  $t$ ,  $OP$  is oil price,  $GP$  is gas price,  $(a,b,c)$  are coefficients fitted by linear regression, and  $N$  is a vector of 1 to an upper limit specified by the user. The model now fits the above equation (and its simpler variants which include only oil or gas prices separately) for each possible value of  $N$  and automatically selects the value that returns the lowest residual sum of the squares. The selected value of  $N$  is then automatically applied during the Monte-Carlo simulation.

- ii. Added option to allow the user to directly specify the drilling schedule (in the same way that energy prices can be specified).
  - d. Removed and Geometric Brownian Motion (GMB) price forecasting model (which is redundant now that ARIMA forecasting is present - a (0,1,0) ARIMA model is identical to GBM model)
  - e. Revised user-manual to cover the modeling changes.
2. Minor changes
- a. Updated all model input files and IO\_options.R script settings
  - b. Revised Excel export feature
    - i. Previous version of this feature required the installation of Java
    - ii. New version uses a different package that instead requires and uses Rtools
      - 1. Rtools is a standalone program that is part of the R-project and is used for building R and R packages.
      - 2. Made the switch to using Rtools because:
        - a. It poses a lower security risk than a Java installation
        - b. It does not require updating by the user
  - c. Suppressed spurious warning messages in function that fits log-normal distributions to oil decline curve coefficients
  - d. Added option to export plots from postProcess script as either:
    - i. A single PDF file with many single page plots
    - ii. Individual PDF files for each plot
  - e. Automated some labor-intensive input calculations, specifically:
    - i. First purchase price specifications (user had to look at price data and enter the values for the time step just prior to the start of the simulation period)
    - ii. The number of wells drilled just prior to the start of the simulation period.
  - f. Added automatic deletion of large intermediate \*.csv files created as part of the dogmDataUpdate function.