ECONOMETRIC MODELING OF DEEPWATER PETROLEUM EXPLORATION AND DEVELOPMENT OPERATIONS IN THE U.S. GULF OF MEXICO REGION, 1983-2005

(Extended Abstract for the International Association for Energy Economics Conference, San Francisco, CA, June 21-24, 2009)

Omowumi Iledare, Ph.D.
Louisiana State University, Center for Energy Studies
225-578-4552; wumi@lsu.edu

Overview

Petroleum industry analysts once thought that the Gulf of Mexico (GOM) Region could no longer attract the big exploration and production (E&P) investors. However, the GOM has re-emerged as the key focal point of oil and gas activity in the world, especially with respect to deepwater operations The reason for this turnaround has been attributed to several technical advancements in deep offshore drilling and production technology. Because of innovations in technology, areas in the Gulf of Mexico once thought beyond reach in terms of water depth are now explored and developed successfully. Several other factors underlying the turnaround in the attractiveness of the GOM region to E&P investors include the changing structure of the OCS oil and gas industry, government regulatory programs and fiscal incentives, technical progress, and the global market fundamentals resulting in high oil and natural gas prices. This paper presents a hybrid model of deepwater petroleum exploration and development efforts and outcomes in the Gulf of Mexico OCS region from 1983 to 2005.

Methods

A hybrid-modeling framework was used to describe the deepwater reserves generation process. The model consists of three equations that measure a combination of engineering, geological and geophysical data with economic data. This hybrid model should limit the shortfalls of using just an engineering or econometric model specification framework. The model framework applied in this report assumes that profit maximization subject to diminishing rate of reserve discoveries over time is the fundamental driving force underlying petroleum exploration and development effort. As firms explored and discovered new hydrocarbon fields, they would drill more wells within proved fields for finding more resources. Firms follow an exploration and development path that maximizes the net present value of returns from future investments. As output price changes, a competitive firm will alter its drilling effort to satisfy an optimality condition. A log-linear approximation is adopted to estimate exploration and development drilling rate. The assumption underlying the petroleum discovery process is invoked to specify the behavioral relationship between reserve discovery size and its determinant.   If large reserves are discovered first and contain the most reserves then the cumulative reserves added would decrease and cumulative drilling would increase overtime. Also, as technological advancements occur this reduces the rate of decline on reserve additions. Drillings that successfully find new reserves depend on the quality of geological knowledge collected about the basin, which increases with technological advancement. The number of successfully drilled wells will be specified as conditional probability that follows a logistical probability distribution. Technical discovery rate is presented using the logistical transformation technique. The three equations describing gross petroleum reserves generation process in the Gulf of Mexico deepwater, were estimated econometrically using pooled least squares estimation techniques in Quantitative Micro Software (QMS) EViews (v6.O) with corrections for both cross-section heteroskedacticity and contemporaneous correlation.

Results

The drilling rate equation has acceptable descriptive statistics with an adjusted R2 of 0.827. This means that the equation explains above 80 percent of the observed variations in the total number of wells drilled from 1983-2005. However, some variables in the equation did not have the expected signs. Almost all the coefficients that are significantly different from zero are statistically significant at levels of 5 percent or less. Real price of oil, for example, has a coefficient that is statistically insignificant, but the impact of the real price of natural gas is positively significant.

The estimated results for the discovery size equation explain 73 percent of the observed variation in the size of petroleum discovery from 1983-2005. Almost all estimated coefficients are statistically significant at 10 percent or less. The one exception is the fixed effect of the ultra water depth. As anticipated, the size of discovery decreases. The positive coefficient of the dummy included to capture the impact of DWRRA tends to suggest that the Act has a positive impact on discovery size in a statistical sense.

The estimated results for the discovery rate equation are represented as a logistic transformation of the ratio of successful wells to total wells spudded. The estimation explains about 47 percent of the variation over the period 1983-2005. All the variables in the discovery rate equation are statistically significant with the exception of the dummy variable assigned to capture the effects of the DWRRA. The responsiveness to changes in real oil price is positive but negative with respect to real gas price change. Surprisingly, oil and gas prices are highly significant in explaining success ratio.

The three equations together describe the dynamics of the exploration and development process and were applied to estimate the responsiveness of reserves to its determinants in accordance to the functional form adopted to specify and estimate each component of the reserve identity model. The decomposed elasticity estimated from model is presented in Figure 1.

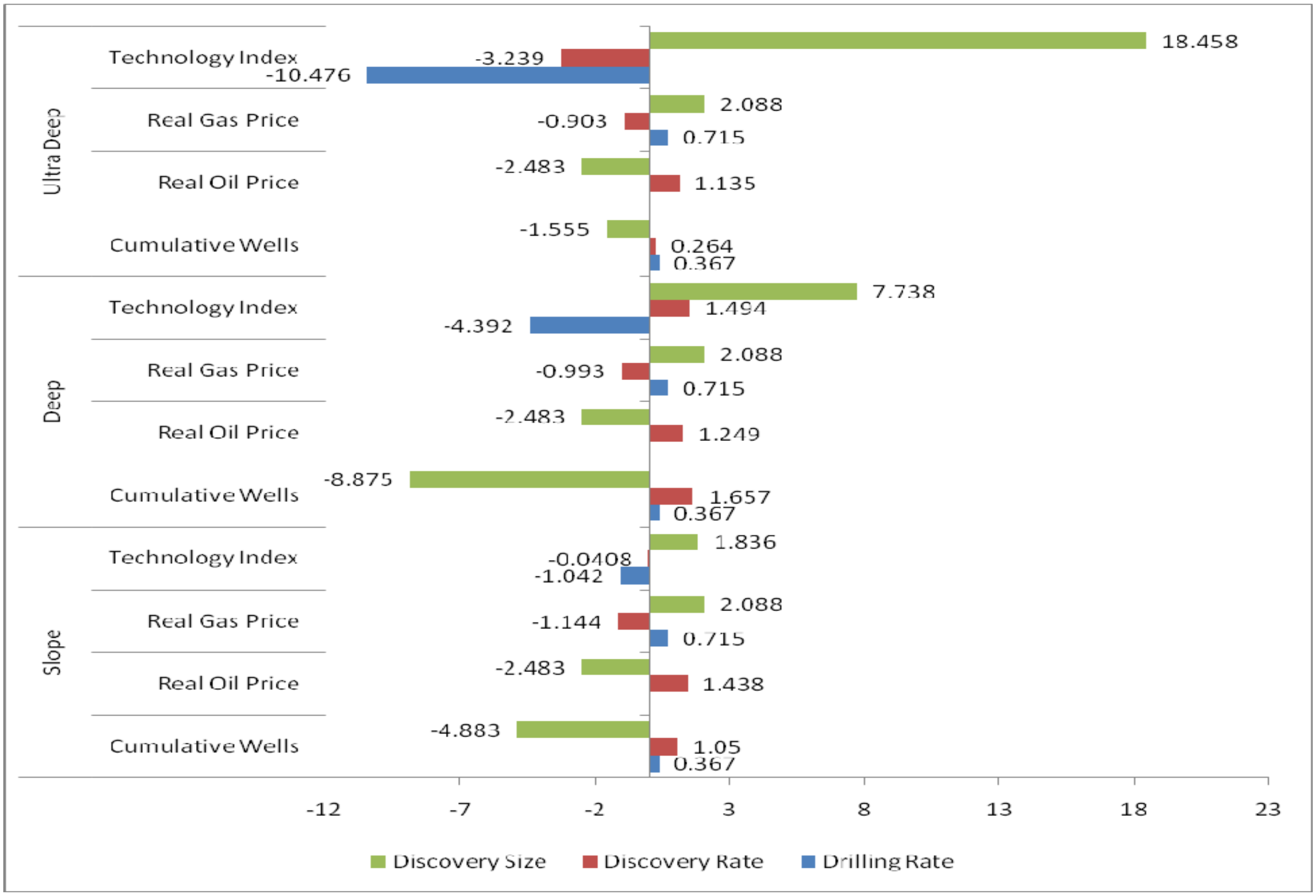

Figure 1. Responsiveness of Discovery Size, Drilling Rate and Discovery Rate to Technology, Economics, and Depletion.

Conclusion

The estimated model results suggest that drilling rate in the GOM deepwater is positively inelastic in its response to a natural gas price change, but shows no evidence of a statistically significant effect of changes in real oil prices on drilling rate. The responsiveness of discovery rate to gas prices is also inelastic but negative, whereas its responsiveness to oil price change is positive and elastic. The responsiveness of discovery rate to oil and natural gas prices becomes less negatively elastic to natural gas prices and positively elastic to oil prices with water depth in the Gulf of Mexico. In the aggregate sense, the overall reserves discovered was found to respond elastically and positively to natural gas price changes, *ceteris paribus*. The proxy for technology in our model is positive and its importance increases with water depth. In general and taking a bigger picture perspective on the statistical model results, there is enough statistical evidence to suggest that the effects of resource depletion on reserves discovered in the GOM deepwater is at present mitigated by advances in technology.