Estimation of Efficiency among Operators in the Barnett Shale Play

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Objective

1. Estimate revenue efficiency for wells drilled in the Barnett shale formation and examine how the revenue efficiency varies among operators in the Barnett
2. Decompose revenue efficiency into its component parts – technical efficiency and allocative efficiency – to determine the sources of revenue inefficiency

Method

We use a two-stage semi-parametric approach that consists of data envelopment analysis (DEA) in the first stage, followed by a truncated linear regression analysis in the second stage

Stage 1 – DEA Linear Programming Problems

$$\max_{y,\alpha} py \quad s.t.: \quad x_i \geq X\alpha \quad y \leq Y\alpha \quad \alpha \geq 0$$

The optimal solution, **(y*,α*)**, yields the maximum possible revenue, **py***, given the inputs and output prices

$$RevEff_i = \frac{py_i}{py_i^*}$$

$$\max_{\theta,\lambda} \theta \quad s.t.: \quad x_i \geq X\lambda \quad \theta y_i \leq Y\lambda \quad \lambda \geq 0$$

$$TecEff_i = \frac{1}{\theta_i^*} \qquad AllEff_i = \frac{RevEff_i}{TecEff_i}$$

Stage 2 – Truncated Linear Regression

In the second stage, the efficiency scores estimated above are regressed against operator indicator variables (*OP*) and well-specific geologic characteristics (*z*) using a bootstrapped truncated linear regression.

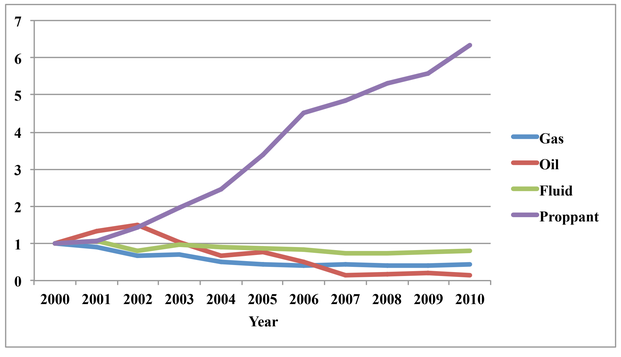
$$\widehat{Eff}_i = z_i\eta + OP_i\mu + e_i \leq 1$$

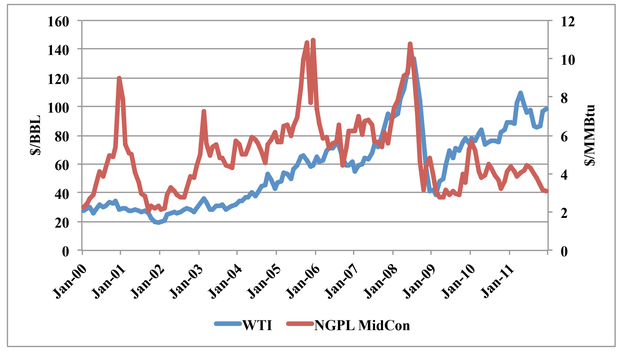
Introduction

- Efficiency analysis rests on the assumption that for any production set, there exists a frontier that represents the maximum output that can be derived from the observed inputs given the existing production technology. This true frontier is approximated using the observed production data.
- **Revenue efficiency** is a measure of a firm's ability to maximize revenue given the inputs, outputs and output prices. **Technical efficiency** measures whether a revenue inefficient firm is producing too little of the outputs given the inputs and the production technology, while **allocative efficiency** measures if the firm is producing the optimal mix of the outputs given market output prices

Data / Observations

- 11,362 wells drilled between 2000 and 2010
- Gas and oil production for each well
- Oil price (West Texas Intermediate)
- Gas price (NGPL Mid-Con)
- Quantity of fluid and sand used to fracture each well
- Well length; geologic variables

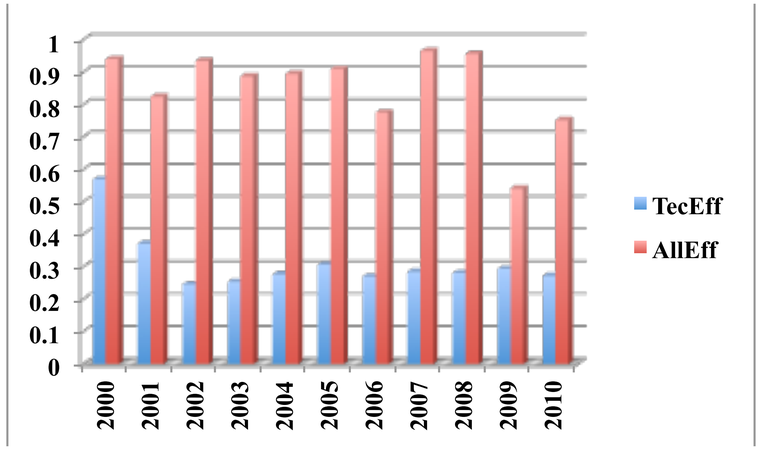




Results

Table below gives the sign of the coefficients of the operator indicator variables relative to Devon, the omitted group in the regression and also the largest operator in the Barnett

Positive	Not significant	Negative
Crown Equipment	Lakota Energy	Quicksilver
Antero Resources	Ryder Scott	EOG
JW Operating	Arrington D	Republic Energy
Denbury Onshore	Chief Oil & Gas	Burlington
Sullivan Hollis	Encana	Dallas Production
DTE Gas	Williams Production	Hallwood Energy
Range Production	Chesapeake	Star of Texas
XTO	Carrizo Oil & Gas	Winchester Production
	Western Chief	Adkins RL
	N. Texas Llano	Tejas Western
		Aruba Petroleum



Conclusion

- Most of the revenue inefficiency stems from technical inefficiency and not allocative inefficiency
- The estimated revenue efficiency scores are a relatively good indicator of the economic performance of the wells. More than 70% of the wells reported to have been plugged and abandoned belong to the bottom quintile of efficiency scores