# Well Cost Analysis

**for the**
**Oklahoma Commission on**
**Marginally Producing Oil and Gas Wells**

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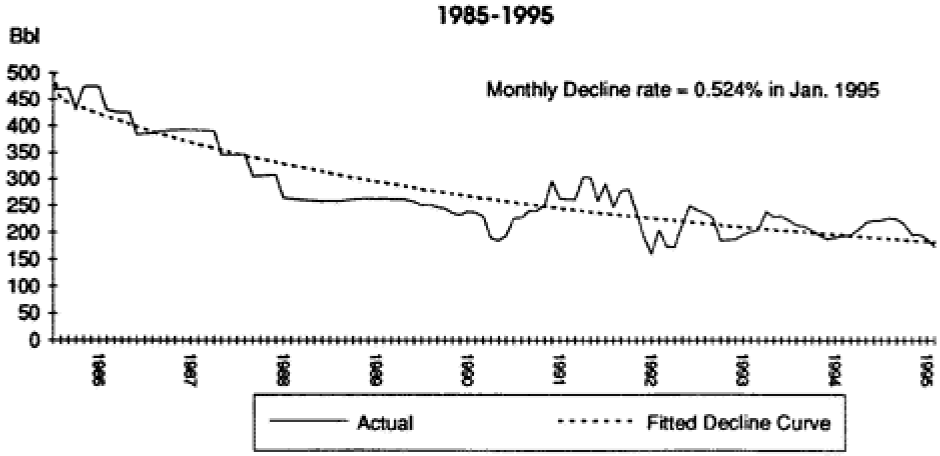
Introduction

An economic model of oil well operation is constructed in order to test the response of future oil output to changes in the severance tax rate. The study consists of three primary components: 1) A theoretical model that allows the determination of well lifetime as a function of oil prices, historic decline rates, and minimum required profit; 2) production cost data for a sample of oil leases in Oklahoma; and 3) calculation of historic rates of decline for a sample of approximately 200 oil leases.

*Decline Rates and Production* Costs Cost data were collected as part of a random survey of oil and gas lease operators in Oklahoma. Production costs consist of operating costs net of severance taxes and estimated royalties. Equipment and construction costs, depletion allowances, and income taxes are not included as part of production costs. Decline rates were estimated for approximately 200 leases from data obtained from Geo Information Systems at The University of Oklahoma Energy Center. A decline rate was determined for each lease and matched with cost data from the survey. If the lease produced both oil and gas, decline curves were estimated for both and a weighted average decline rate was calculated. An example of an oil lease decline curve is shown in Figure 1.

**Figure 1: Monthly Production of Oil from Survey Lease #156, 1985-1995**



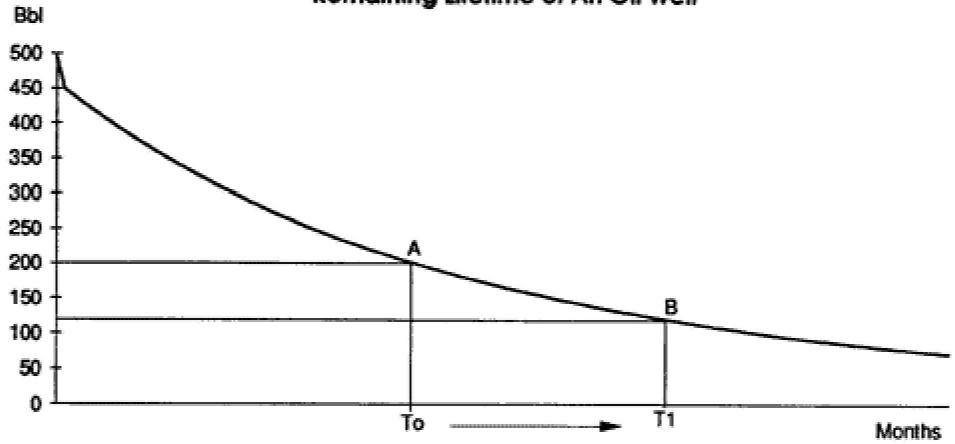
Monthly data for some oil leases are very discontinuous since a significant portion of Oklahoma oil leases produce in very small quantities. This is primarily due to the fact that available data actually measure taxable sales of oil during a particular month, not necessarily production of oil. For example, a very small producer could store production for several months in tanks on-site, then sell the oil periodically. Only at the time of sales are severance taxes collected and the transaction is recorded by the Oklahoma Tax Commission. Leases of this type were aggregated with other similar leases in order to produce a more stable decline curve.

## *Economic Model*

The economic model used to examine the impact of severance tax increase on oil output in California is modified for use in this study, closely following the analytical technique described in Deacon et al. (1990). But instead of examining an increase in severance taxes, this study uses the model to analyze a decrease in the severance tax rate.

The initial task consists of determining the current productive lifetime of lease output. As shown in Figure 2, lease output typically declines over the long run due to the particular geological and hydrologic characteristics of the reservoir. The rational lease operator will terminate production when revenue per unit of production, net of severance taxes, royalties, and production costs, equals a minimum required level of profit per unit of production.

**Figure 2: Effect of a Decrease in Production Cost On the Remaining Lifetime of An Oil Well**




Increases in net revenue will increase the productive lifetime of the lease. These increases may arise from higher prices for oil, lower production costs, improved production technology, or lower severance tax rates. Figure 2 shows the effect on well lifetime and cumulative production from a cut in costs, severance tax reduction, or any increase in profit per unit. In the initial situation the lease will operate until production reaches point A on the decline curve. At this point net revenue less production costs per unit of output will equal minimum required profit per unit of output, thus causing the well to be shut-in at time To. A cut in costs will increase the effective lifetime of the well from To to T1, thus causing cumulative output to rise, albeit at a lower monthly rate. The cumulative increase in output attributable to the cost cut is the area under the decline curve outlined by the points To, A, B, and T1. The task consists of estimating the value of this area for the leases in the sample then aggregating to the population of oil leases. Analytical details of the economic model are presented in the Appendix.

Results Table 1 shows the results of reducing severance tax rates among the population of wells, about 35,700, with monthly profits per well less than $900 including leases for which monthly profit per well is negative. A cut in the severance tax of one percentage point will have the effect of increasing the lifetime of the average well by just 2 months. However, this increase is enough to generate an increase in production of 1.2 million BOE during the first three years of the tax cut. A total of 1.4 million additional BOE will be produced by the end of ten years after the tax cut for these wells, while the twenty year impact will be about 1.5 million BOE. A tax rate cut of 3 percentage points would increase production by 3.5 million BOE by the end of three years, while a complete elimination of the severance tax would generate an additional 7.9 million BOE in three years and 10.5 million BOE after ten years.

Limiting the analysis to leases undergoing severe financial stress should result in greater impacts. Table 2 shows the results of cutting severance tax rates for a selection of leases with monthly profit per well less than $300, including leases for which monthly profit per well is negative. A cut of the gross production tax rate by one percentage point (from 7 percent to 6 percent) will increase production by 1.2 million BOE by the end of the first three years. A complete removal of the severance tax on production from these wells would increase output by 34.9 percent in three years and 40 percent in ten years. Note that these proportional increases in production are much higher than achieved in Table 1. Limiting the analysis to wells that are the most financially distressed will result in greater percentage increases in output over time.

Cuts in severance tax rates will result in increased output of oil and gas production from oil leases. Targeting the cut to the leases most in financial need will result in the greatest impact relative to baseline production.

**Summary Table 1**
Population of Wells: All oil leases with gross monthly operating margins between $0 and $900.

37,153 active wells
28,957,499 baseline BOE

| Cut in Severance Tax Rate (points reduced) | Three Year Cumulative Change in Production (BOE) | Percent of Baseline | Ten Year Cumulative Change in Production (BOE) | Percent of Baseline | Twenty Year Cumulative Change in Production (BOE) | Percent of Baseline | Thirty Year Cumulative Change in Production (BOE) | Percent of Baseline | Months Added to Lifetime of Average Well |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1,090,805 | 3.8% | 1,448,011 | 5.0% | 1,767,549 | 6.1% | 1,876,145 | 6.5% | 2 |
| 3 | 3,239,962 | 11.2% | 4,300,951 | 14.9% | 5,250,059 | 18.1% | 5,572,618 | 19.2% | 5 |
| 7 | 7,411,451 | 25.6% | 9,716,016 | 33.6% | 11,947,788 | 41.3% | 12,747,428 | 44.0% | 12 |

**Summary Table 2**
Population of Wells: All oil leases with gross monthly operating margins between $0 and $300

26,564 active wells
17,152,115 baseline BOE

| Cut in Severance Tax Rate (points reduced) | Three Year Cumulative Change in Production (BOE) | Percent of Baseline | Ten Year Cumulative Change in Production (BOE) | Percent of Baseline | Twenty Year Cumulative Change in Production (BOE) | Percent of Baseline | Thirty Year Cumulative Change in Production (BOE) | Percent of Baseline | Months Added to Lifetime of Average Well |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1,092,666 | 6.4% | 1,283,919 | 7.5% | 1,407,905 | 8.2% | 1,458,224 | 8.5% | 2 |
| 3 | 3,245,489 | 18.9% | 3,813,557 | 22.2% | 4,181,827 | 24.4% | 4,331,287 | 25.3% | 5 |
| 7 | 7,424,092 | 43.3% | 8,723,556 | 50.9% | 9,565,977 | 55.8% | 9,907,867 | 57.8% | 13 |

**Appendix: Details of the Economic Model**

The economic model is as follows: Let

P(t) - price net of severance taxes, royalties, and production costs at time t; prices used in the model are average prices that prevailed during the first half of 1995

Qo - physical output from the average well on a lease at time Zero (first half 1995), measured in barrels of oil equivalent

P(t)Qo - gross profit in time t

B(t) - minimum monthly profit required per well to keep well active, measured per unit of production

To - time at which the well is shut-in or plugged; remaining economic life of the well

a - the monthly rate of decline of lease production; $0<a<1$.

The economic lifetime (measured from first half of 1995) is determined as the solution of the equation:

$$P(To)\ Qo\ e^{-aTo} - B(To)\ Qo = 0 \qquad (1)$$

or

$$To = \ln(B(To)) / P(To)) / -a \qquad (2)$$

Equation 1 shows that the well will be shut-in (Qo=0) when gross profit per unit (P(t)) declines to a level equal to the minimum required profit per unit of output (B(t)).

The effect of changes in the severance tax rate can be shown by determining the remaining life of the well assuming a lower severance tax rate is in effect. Let

Ps(t) - price net of royalties and production costs at time t, but with a lower severance tax rate that P(t)

T1 - remaining lifetime of the well with a lower severance tax rate

The new remaining lifetime of the well is determined by solving equation (3) for T1:

$$Ps(T1)\ Qo\ e^{-aT1} - B(T1)\ Qo = 0 \qquad (3)$$

It can be shown that

$$T1 - To = (1/a) \ln [\ Ps(T1) / P(To)] \qquad (4)$$

assuming B(t) does not vary with time. Using *p* as the rate of change of real net output prices and *s* as the *change* in the severance tax rate,

$$Ps(T1) = (1 - s)\ P(To)\ e^{p(T1-To)} \qquad (5)$$

Of course if severance tax rates are cut *s* will be negative.
Notice that when real net production prices remain constant ($p$=0) then

$$Ps(T1) = (\ 1 - s)\ P(To) \qquad (6)$$

With a severance tax cut the term (1 - *s* ) is positive and Ps(T1) > P(To), implying that T1 > To. In other words, the remaining lifetime of the well is increased with a severance tax reduction.

The effect on output resulting from increasing well lifetime from To to T1 can be determined by solving equation (7):

$$\Delta Q = \int_{To}^{T1} Qo\, e^{-at} dt$$

$$= (Qo/a)\ (e^{-aTo} - e^{-aT1}) \qquad (7)$$

**Reference**

Deacon, Robert, Stephen DeCanio, H.E. Frech, III, and M. Bruce Johnson, Taxing Energy, Oil Severance Taxation and the Economy, New York: Holmes and Meyer, 1990.

For more information about this report, please contact the Commission on Marginally Producing Oil and Gas Wells at 1-800-390-0460.

**www.marginalwells.com**