

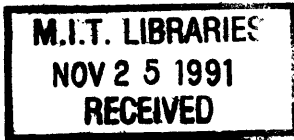
USA Oil/Gas Production Cost: Recent Changes

by

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USA OIL/GAS PRODUCTION COST: RECENT CHANGES

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ABSTRACT

During 1984-1989, oil development investment cost in the USA fell, but only because of lower activity. The whole cost curve shifted unfavorably (leftward). In contrast, natural gas cost substantially decreased, the curve shifting rightward. This is an additional reason why measures of cost or value "per barrel of oil equivalent" should be avoided.

Oil and gas reserves are inventories, renewable by investment. A key variable is the investment cost per incremental barrel or cubic foot. Experience in the USA is particularly interesting because it is by far the oldest and most intensively exploited hydrocarbon province. The steadiness of reserve additions after 1930 (excluding Alaska), when exploration became less and less rewarding, is striking. [Adelman 1991a] The collapse and recovery of oil prices in recent years has in effect performed an experiment worth analyzing.

We have two methods to measure investment per unit. One is to divide annual development expenditures, oil and nonassociated gas separately, by respective annual reserve-increments. This can only be done in those (very few) countries where reserves are measured by some publicly stated process which is the same year by year.

Every investment to create reserves is in competition with every other investment expenditure. Hence the annual average is a valid measure of cost for any given year. It is not a meaningless jumble of what could be done over various years. Furthermore, since reserve-additions by more intensive development are an alternative to, and in competition with, reserve-additions by discovery and development, changes in development cost are a surrogate or proxy for changes in exploration cost.

The second method is based on the idea of a supply curve.

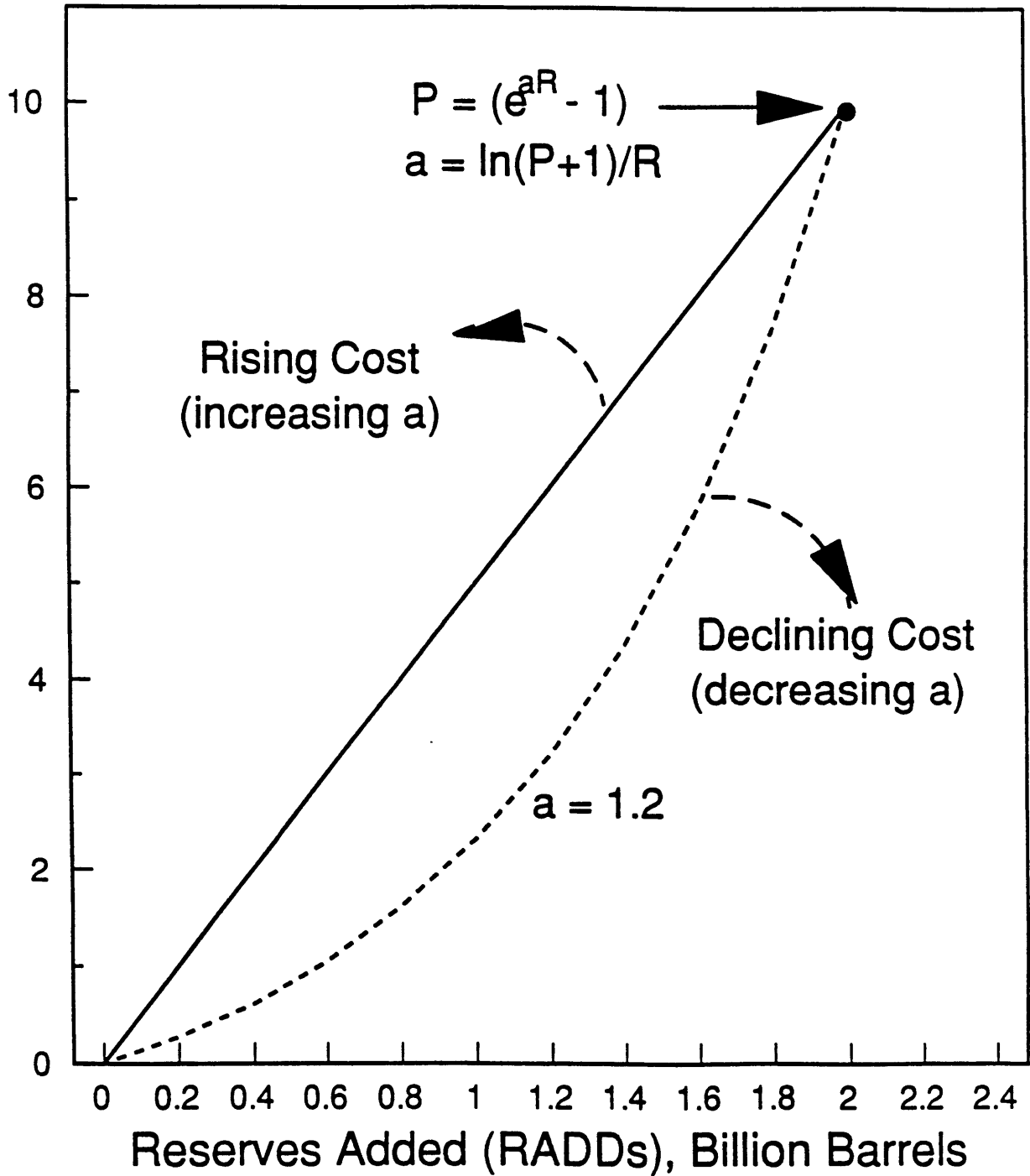
[FIGURE 1 HERE]

Figure 1

Hypothetical Supply Curves

Corresponding to a Given Price, RADDs

Price in Dollars



In Figure 1, the horizontal axis represents reserve-additions; the vertical represents the current price. In any given year, we have just one observation, which in our example is assumed as \$10 per barrel, 2 billion barrels added. But we have some prior knowledge of the curve. It must pass through the origin; zero price, zero additions. Furthermore, the only reasonable assumption is that the more we add, the more expensive it becomes to add more. Hence we assume the simplest kind of increasing cost function, an exponential. Then if P=the current price, Q is the current reserve-addition, and c is an empirical constant:

$$P = e^{cQ} - 1$$

$$\ln (P+1) = cQ$$

$$c = \ln (P+1) / Q \quad [1]$$

This slope coefficient c sums up the supply curve. If it increases over time, the curve has rotated to the left, and cost has increased; a decrease means a rightward shift and lower cost. However, c is an ordinal number only; it is stated in money units, but cannot be added to any other.

[TABLE I HERE]

Table I, column 1, states development capital expenditures. Drilling-completion expenditures for new oil wells are directly measurable, and they are more than half the total. Other outlays have been allocated by drilling-completion expenditures.

Column 2 shows annual reserve-additions, and column 3 the unit development investment, in money of the day. A new series for drilling factor prices (which I think is superior to the series of the Independent Petroleum Association of America) allows

TABLE I
TWO MEASURES OF DEVELOPMENT COST, OIL & NATURAL GAS 1984-1989

DEVELOP. CAPITAL EXPEND. (BIL \$) (1)	RES. ADDED (B BRLS or TCF) (2)	NOMINAL DEVELOP. COST (\$/bbl or per mcf) (3)	DRILLING FACTOR PRICES (1984=100) (4)	R E A L DEVELOP. COST (\$/bbl or per mcf) (5)	NOMINAL PRICE (\$/bbl or per mcf) (6)	R E A L PRICE (\$/bbl or per mcf) (7)	SUPPLY PRICE INDEX (8)
-----CRUDE OIL-----							
YEAR							
1984	16.2	3.8	4.16	100.0	4.16	25.88	0.88
1985	15.7	3.0	5.20	98.0	5.30	24.09	1.07
AVG	16.0	3.4	4.68	99.0	4.73	24.99	0.98
1986	10.1	1.4	6.98	87.5	7.97	12.51	1.89
1987	7.1	3.2	2.19	78.4	2.80	15.40	0.93
AVG	8.6	2.3	4.59	83.0	5.39	13.96	1.41
1988	8.3	2.4	3.48	84.5	4.12	12.58	1.16
1989	5.4	2.3	2.39	83.2	2.87	15.85	1.33
AVG	6.8	2.3	2.94	83.9	3.50	14.22	1.24
----NONASSOCIATED NATURAL GAS-----							
1984	10.5	12.45	0.84	100.0	0.84	2.28E	0.10
1985	11.1	9.6	1.16	100.8	1.15	2.28	0.12
AVG	10.8	11.0	1.00	100.4	1.00	1.14	0.11
1986	6.6	12.9	0.51	89.4	0.57	1.73	0.08
1987	4.7	10.3	0.46	73.6	0.62	1.50	0.11
AVG	5.6	11.6	0.48	81.5	0.60	1.62	0.10
1988	5.5	20.2	0.27	80.8	0.34	1.75	0.06
1989	7.4	13.2	0.56	87.6	0.64	1.74	0.08
AVG	6.5	16.7	0.42	84.2	0.49	1.75	0.07

SOURCES: Development capital expenditures, API: Survey on Oil & Gas Expenditures, Table II (allocated between gas and oil by proportion of completed well costs).

Reserve additions from DOE:EIA, excluding associated gas and natural gas liquids.

Drilling factor prices from Joint Association Survey, App. I

Oil prices from Monthly Energy Review

Gas prices are annual averages of Columbia Gas Louisiana laterals, from Natural Gas Clearing House, reprinted in Oil & Gas Journal.

Supply Price Index = $\ln(\text{Real Price} + 1) / \text{Reserve additions}$

us to state the real unit cost (column 5). A similar adjustment to the nominal price yields the real price (column 7), which enables us to calculate the supply price index (column 8).

Roughly speaking, the two years 1984-85 represent pre-crash conditions. It is probably necessary to take 1986 and 1987 together, since the latter year showed to some extent a restoration of what panic in the former had removed. In oil, real development cost per barrel fell by 26 percent from 1984-85 to 1988-89, while the real price was down by one third. Standing alone, this would explain some part at least of the drop in real investment and in output. A more discouraging snapshot is in the supply price index, where the ζ -coefficient actually rises substantially, from an average .98 in the pre-crash years to 1.24 in the post-crash. In other words, the decline in average real cost was a movement down along the curve, while the curve itself shifted unfavorably, to the left.

The USA is not running out of oil; but given recent prices and costs, the industry is out of equilibrium and contracting toward it. The end-point of decline had not yet been reached by end-1989.

For nonassociated natural ("gas-well") gas, where prices and costs can be unambiguously reckoned without the need of allocation of oil-cum-gas production, the picture is very different. Real development cost (col. 5) is down by half, and the supply price index (col. 8) is down by a third, indicating a substantial rightward shift of the supply curve. Reserve-additions have increased greatly. This confirms industry sentiment that supply is easily expanded, and that production is limited by demand.

Natural gas looks set to displace considerable amounts of oil in North America (for I believe Canadian developments are going in parallel). This will bear closer attention, and one first step might be, in discussion of oil and gas supply, to cease using "barrels of oil equivalent", which have never made sense and which today are statistical gibberish.

As noted earlier, we can derive estimated finding costs from development costs. (For a proof, see [Adelman 1991b]) We cannot estimate finding costs directly because, first, most finding cost is joint. Econometric analysis might give us marginal relations, but only with data on the amounts of oil and gas found year by year, not merely what has been developed into new proved reserves. No such numbers exist. The financial press frequently quotes "finding costs per barrel of oil equivalent". This equals the sum of exploration plus development expenditures, oil and gas together, divided by increments to proved reserves, oil plus thermal equivalent of gas. But not only does it omit newly-found undeveloped reserves, there is no stable or necessary relation of oil to gas in respect of price, value, or cost. "Finding cost per barrel of oil equivalent" amounts to adding apples to oranges, then dividing by pineapples plus bananas. It deserves no attention.

Recent U.S.A. history also helps us appraise a number which has recently gained wide credence by endless repetition: that the average investment needed to add a barrel of daily capacity in the OPEC nations is \$10,000. It is easily proved [Adelman 1991b] that if K =development expenditures, R =reserves added, and Q =annual capacity added, that $K/Q = K/Ra^2$, where $d = Q/R =$ the annual depletion

/decline rate. That rate has long been in the neighborhood of 10 percent in the United States. As shown in the upper panel of column (3), \$2.94 is the most recent value of K/R. Dividing it by .01, and multiplying by 365, gives us an estimate for the USA of \$10,700 per daily barrel. An OPEC average barely lower is not even remotely credible.

REFERENCES

- [Adelman 1991a] M. A. Adelman, "Finding-Development Costs in the United States 1918-1988", forthcoming in J. R. Moroney, ed., Advances in the Economics of Energy and Resources (Greenwich, Conn.: JAI Press, 1991)
- [Adelman 1991b] -----, "User Cost in Oil Production", forthcoming in Resources & Energy 1991