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## SUCCESSFUL EFFORTS AND FULL COST ACCOUNTING AS MEASURES OF THE INTERNAL RATE OF RETURN FOR PETROLEUM COMPANIES

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# Successful Efforts and Full Cost Accounting as Measures of the Internal Rate of Return for Petroleum Companies

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Successful efforts and full cost reporting have been the primary methods of financial reporting for oil and gas producing companies for many years. Their very different approaches have made financial reporting in these industries controversial. The primary characteristic of successful efforts reporting is that only costs directly associated with productive properties are capitalized; by contrast, full cost reporting capitalizes all costs incurred in finding and developing oil and gas reserves. Therefore the reported income and asset base of a firm will depend on the method chosen.

The Energy Policy and Conservation Act of 1975 requires the Securities and Exchange Commission to develop accounting practices to be followed for presenting information for use in an energy data base. At first, the SEC left the standard setting to the accounting profession's Financial Accounting Standards Board, and in Financial Accounting Standard No. 19--Financial Accounting and Reporting by Oil and Gas Producing Companies--successful efforts accounting was proposed as the standard. However, this standard

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was so controversial that that the SEC reversed its policy of adopting FASB standards and has proposed its own rules. These rules allow the continuation of both full cost and successful efforts reporting and experimentation with a third method, called Reserve Recognition Accounting.

The principle of RRA is the determination of the present value of reserves and yearly changes in the value of these reserves. RRA is not the focus of this paper.

Among the issues raised, in choosing the financial reporting standard, has been the effect the standard would have on capital costs, access to capital markets, and competition in the oil and gas industries. The focus of this paper is to determine which of these accounting methods provides a book rate of return closer to the actual economic rate of return (i.e., the internal rate of return) of a firm. Book rate of return has become a standard measure of company and industry performance, particularly for regulatory purposes. The choice of an accounting method that provides a book rate of return widely divergent from the actual internal rate of return of a firm can lead to misallocation of resources. This paper demonstrates that successful efforts accounting leads to just such a book rate of return. The book rate of return derived from successful efforts accounting is inferior to that derived from full cost accounting as a measure of internal rate of return and is more likely to differ from the internal rate of return by a high order of magnitude.

This paper makes use of techniques described by Solomon (1971) and formalized by Stauffer (1972) to relate the book rate of return of a firm to its internal rate of return. The internal rate of return is independent of the method of bookkeeping; therefore, it is possible to compare it to the book rate of return that would result if the same company used successful efforts or full cost accounting.

This firm is assumed to be growing at the steady rate of g and is composed of a series of investments offering the same rate of return and having the same economic life. Using these assumptions, the internal rate of return of an investment is expressed in terms of the investment's cost, its cash flows, and economic life. Similarly, for any financial accounting technique the resulting return can be expressed in terms of the same cash flows, investments, and depreciation rates. Stauffer used this methodology to estimate the internal rate of return of pharmaceutical companies once their book rate of return was measured. This paper uses the inverse process; an internal rate of return of a hypothetical petroleum company is assumed to be known and its book rate of return for both the successful efforts and full cost reporting methods is computed.

This paper does not fully describe the investment behavior of a firm but rather distills the important elements of investment and examines the relationships between economic rate of return and the returns derived from the two accounting measures.

Internal Rate of Return of an Investment

The firm begins by making an initial investment, $\gamma$, composed of successful exploration expenses, $\alpha$, plus unsuccessful exploration expenses, $\beta$. The proportion of unsuccessful to successful exploration expenses is assumed to be constant over time. Thus, $\gamma = \alpha+\beta$.

The cash flow generated from the successful exploration in any year may be expressed as $hK(t)$, and will be assumed to last N years. $K(t)$ is the cash-flow profile, $\{K(t), N\}$. A 1 year lead between exploration and receipt of the first cash flow is assumed; however, this restriction can easily be relaxed and does not affect the substance of the analysis. All outlays for a given investment are assumed to occur at the same time, i.e., 1-year before the cash flow begins. The present value of outlays is the initial investment, $\gamma$. The internal rate of return is defined as the discount rate that equates the present value of the cash flows with the cost of the investment. Equating the present value of outlay and cash flows, the internal rate of return can be found:

$$\text{Cost of Investment} = \sum_{1}^{N} \frac{hK(t)}{(1+r)^t} = h \sum_{1}^{N} \frac{K(t)}{(1+r)^t}$$

where:

$K(t)$ = cash flow per dollar of investment
$h$ = a constant relating cash flow to the size of the investment

r = internal rate of return[1]
N = economic life of asset

let k(r) represent the Laplace transformation of K(t), $\sum_{1}^{N} \frac{K(t)}{(1+r)^t}$,

then

$$hk(r) = h \sum_{1}^{N} \frac{K(t)}{(1+r)^t}.$$

The r in equation (1) represents the internal rate of return earned by investment in new drilling operations of the firm in any year.

$$\gamma = \alpha + \beta = hk(r) \qquad (1)$$

Accounting Rate of Return of the Firm

The accounting rate of return of an all equity firm is defined as follows:[2]

$$\text{Accounting Rate of Return} = \frac{\text{Net income}}{\text{Net Assets}}$$

Full Cost Accounting

Under the full cost accounting approach, income is defined as cash flow less amortization of exploration expenses. Net assets are composed of the capitalized exploration expenses less the portion that has been amortized.

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1 An investment has a unique internal rate of return if the initial cash flows are followed by net cash inflows.

2 The introduction of debt does not materially change the results.

Total cash flow of the firm at any time is composed of the individual cash flows received from each existing investment. For a firm with a constant growth rate of investment, g, the investment made two periods ago is smaller than the investment made one period ago by the factor (1+g). The cash flows have the same relationship. The cash flow of the firm at time can be expressed as

$$\text{Cash flow } (\tau) = \left[hk(1) + \frac{hK(2)}{1+g} + \frac{hK(3)}{(1+g)^2} + \ldots + \frac{hK(N)}{(1+g)^{N-1}}\right](1+g)^{\tau}$$

$$= (1+g)^{\tau} \sum_{1}^{N} h \frac{K(t)}{(1+g)^{t-1}}$$

$$= (1+g)^{\tau+1} \sum_{1}^{N} h \frac{K(t)}{(1+g)^{t}}$$

$$= (1+g)^{\tau+1}\, hk(g)$$

where:

N = economic life of asset

g = growth of investment

k(g) = The Laplace transformation of K(t), $\sum_{1}^{N} \frac{K(t)}{(1+g)^{t}}$

$\tau$ = The age of the firm $\geq$ N

Since all of the firms' investments have the same cash-flow profile, K(1) is the cash flow per dollar invested, received in the first year from any investment. Similarly, K(2) is the cash flow per dollar invested, received in the second year from any investment.

The total amortization expense of the firm at any time $\tau$ is equal to the sum of the amortization expense of each existing project. Letting D(t) represent the amortization expense of a project of age t, the total amorization expense may be written as:

$$\text{Total Amortization Expense } (\tau) = \left[\gamma D(1)+\gamma\frac{D(2)}{1+g}+\gamma\frac{D(3)}{(1+g)}2+\ldots+\gamma\frac{D(N)}{(1+g)}N-1\right](1+g)^{\tau}$$

$$= (1+g)^{\tau+1}\gamma\sum_{1}^{N}\frac{D(t)}{(1+g)^{t}}$$

$$= (1+g)^{\tau+1}\ \gamma d(g)$$

where:

D(t) = amortization expense of project at age t

N = economic life of asset

g = growth rate of investment

$$d(g) = \Sigma\ \frac{D(t)}{(1+g)^{t}}$$

Net income at any time $\tau$ is therefore equal to cash flow minus depreciation:

$$\text{Net income}_{(\tau)} = [(1+g)\ hk(g) - (1+g)\ \gamma d(g)](1+g)^{\tau}$$

Total assets at time $\tau$ equals total gross assets (the sum of gross investment of each investment) less total accumulated depreciation (the sum of the accumulated amortization of each investment):

$$\text{Total assets}_{(\tau)} = \frac{(1+g)^{\tau+1}}{g} \gamma [1-(1+g)\, d(g)]$$

The accounting rate of return, RFC, under the full cost method--income divided by net assets--is equal to:

$$RFC_{(\tau)} = \frac{[(1+g)\, hk(g) - (1+g)\, \gamma d(g)]\, (1+g)^{\tau}}{\frac{(1+g)^{\tau+1}}{g} \gamma [1-(1+g)\, d(g)]} = \frac{hk(g) - \gamma d(g)}{\frac{\gamma}{g}[1-(1+g)\, d(g)]} \qquad (2)$$

Note that any accounting rate of return is independent of the age of the firm as long as the firm has been in operation at least N periods.

Equation (1), the equation for the internal rate of return, can be solved for h. Substituting for h in eq. (2), the full cost accounting rate of return can be expressed in terms of the internal rate of return:

$$RFC = \frac{\gamma \frac{k(g)}{k(r)} - \gamma\, d(g)}{\frac{\gamma}{g}\, [1-(1+g)\, d(g)]} = \frac{\frac{k(g)}{k(r)} - d(g)}{\frac{1}{g}[1-(1+g)\, d(g)]} \qquad (3)$$

Equation (3) represents the accounting rate of return that would occur if the firm kept its book on a full cost basis.

Successful Efforts Accounting

Under successful efforts accounting, dry-hole expenses are deducted from cash flow in computing income. The only expenses amortized are those of successful exploration. Under successful efforts accounting net income equals cash flow, $(1+g)\ hk(g)$, less dry-hole expense, $\beta$, less amortization of existing capitalized assets, $(1+g)\ \alpha d(g)$:

$$\text{Net income}_{(\tau)} = [(1+g)\ hk(g) - \beta - (1+g)\ \alpha d(g)](1+g)^{\tau}$$

As only expenses for successful wells are amortized under successful efforts accounting, net assets under this method equals $\frac{\alpha}{\gamma}$ of full cost accounting net assets.

$$\text{Net assets}_{(\tau)} = \frac{(1+g)}{g}\ \alpha[1-(1+g)\ d(g)]\ (1+g)^{\tau}$$

The accounting rate of return with successful efforts accounting, RSE, is

$$RSE = \frac{(1+g)[hk(g) - \beta - (1+g)\ \alpha d(g)]}{\frac{(1+g)}{g}\ \alpha[1-(1+g)\ d(g)]}\ \frac{(1+g)^{\tau}}{(1+g)^{\tau}}$$

$$= \frac{hk(g) - \frac{\beta}{1+g} - \alpha d(g)}{\frac{\alpha}{g}[1-(1+g)\ d(g)]} \qquad (4)$$

Substituting for h, RSE becomes

$$RSE = \frac{\gamma\frac{k(g)}{k(r)} - \frac{\beta}{(1+g)} - \alpha d(g)}{\frac{\alpha}{g}[1-(1+g)\ d(g)]}$$

but $\gamma = \alpha + \beta$

substituting for $\gamma$

$$RSE = \frac{\alpha\ \frac{k(g)}{k(r)} + \beta\ \frac{k(g)}{k(r)} - \frac{\beta}{1+g} - \alpha d(g)}{\frac{\alpha}{g}[1-(1+g)\ d(g)]}$$

$$= RFC + \frac{\frac{\beta}{\alpha}[\frac{k(g)}{k(r)} - \frac{1}{1+g}]}{\frac{1}{g}[1-(1+g)\ d(g)]} \qquad (5)$$

Equation (5) represents the accounting rate of return that would occur if the firm kept its books on a successful efforts basis, and is equal to the full cost rate of return plus a second term. The sign of the second term is determined by how fast the firm is growing relative to its internal rate of return, i.e., the sign of $(1+g)k(g)-k(r)$.[3] Generally, when the internal rate of return exceeds the rate of growth, successful efforts will provide a higher accounting rate of return than full cost accounting. Conversely, when the internal rate of return is less than the rate of growth of investment, successful efforts will provide a lower accounting rate of return.

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[3] When beginning of year values are used, the (1+g) term does not appear. The full cost and successful efforts returns would therefore be equal when the growth rate equals the internal rate of return.

The magnitude of the second term is determined by the ratio of dry holes to successful explorations. The greater the success rate of a firm, the less effect the choice of accounting technique has on its accounting rate of return.

## Income Tax Effects

### After Tax Return

The after-tax return for these industries is complicated by the ability to expense for tax purposes certain costs of successful wells, such as intangible drilling costs, not expensed for book purposes. The after-tax model assumes that all expenses of unsuccessful wells are expensed for tax purposes, as well as a portion of costs of successful wells, $\mu$. Equating the present value of the outlays and after-tax cash flows, the after-tax internal rate of return can be found by solving equation (6) for r.

$$\gamma=(1-t)\left[hk(r) - \frac{\beta}{1+r} - \frac{\alpha}{1+r} - (1-\mu)\alpha D^T(r)\right] + \frac{\beta}{1+r}\frac{\mu\alpha}{1+r} + (1-\mu)\alpha D^T(r)$$

$$= hk(r)(1-T) + \frac{\beta T}{1+r} + \frac{\alpha\mu T}{1+r} + (1-\mu)\alpha\ TD^T(r) \qquad (6)$$

where:

$\alpha$ = proportion of year's expenses that lead to successful operations

$\beta$ = proportion of year's expenses for unsuccessful operations

$\mu$ = percent of drilling costs of successful ventures expensed in first year

$D^T(r)$ = present value of tax depreciation schedule discounted at r

$k(r)$ = present value of before-tax cash flow discounted at r

$h$ = scalar

After-Tax Full Cost Return

It is a simple task to convert the before-tax full cost returns developed in eq. (2) to an after-tax basis. The full cost method does not expense capital costs for book purposes; therefore the after-tax full cost return, $RFC^T$, is one minus the tax rate times the before-tax return derived in eq. (2):

$$RFC^T = \frac{[hk(g) - \gamma d(g)][1-T]}{\frac{\gamma}{g}[1-(1+g)\ d(g)]} \tag{7}$$

Solving for h in equation (6) we obtain:

$$h = \frac{\gamma - \frac{\beta T}{1+r} - \frac{\alpha T \mu}{1+r} - (1-\mu)\ \alpha T D^T(r)}{k(r)\ (1-T)} \tag{8}$$

Substituting for h in equation (7) yields:

$$RFC^T = \frac{\left[\gamma - \frac{\beta T}{1+r} - \frac{\alpha T \mu}{1+r} - (1-\mu)\ \alpha T D^T(r)\right]\frac{k(g)}{k(r)} - \gamma d(g)\ (1-T)}{\frac{\gamma}{g}[1-(1+g)\ d(g)]}$$

$$RFC^T = \frac{\left[1 - \frac{\beta}{\gamma}\frac{T}{1+r} - \frac{\alpha}{\gamma}\frac{T\mu}{(1+r)} - (1-\mu)\ \frac{\alpha}{\gamma} T D^T(r)\right]\frac{k(g)}{k(r)} - d(g)\ (1-T)}{\frac{1}{g}[1-(1+g)\ d(g)]} \tag{9}$$

After-Tax Successful Efforts Returns

All costs associated with unsuccessful wells are expensed, and those costs associated with successful wells are capitalized. The after-tax successful efforts return, $RSE^T$, is one minus the tax rate times the before-tax return derived in eq. (4).

$$RSE^T = \frac{[hk(g) - \frac{\beta}{1+g} - \alpha d(g)][1-T]}{\frac{\gamma}{g}[1-(1+g)\ d(g)]} \qquad (10)$$

Substituting for h from eq. (8),

$$RSE^T = \frac{[1 - \frac{\beta}{\alpha} - \frac{\beta}{\alpha}\frac{T}{(1+r)} - \frac{\mu T}{1+r} - (1-\mu)\ \alpha T D^T(r)]\frac{k(g)}{k(r)} - \frac{\beta}{\alpha}\frac{(1-T)}{(1+g)} - d(g)(1-T)}{\frac{1}{g}[1-(1+g)\ d(g)]}$$

By rearranging terms the successful efforts book return can be expressed in terms of the full cost return.

$$RSE^T = RFC^T + \frac{\beta}{\alpha}\frac{[1 - \frac{\beta}{\gamma}\frac{T}{(1+r)} - \frac{\alpha}{\gamma}\frac{\mu T}{(1+r)} - (1-\mu)\frac{\alpha}{\gamma} D^T(r)]\frac{k(g)}{k(r)} - \frac{(1-T)}{(1+g)}}{\frac{1}{g}[1-(1+g)\ d(g)]}$$

The differences between the no-tax case and the after-tax case are due to the level of income tax and the tax savings from any costs that would not normally be expensed for book purposes but are expensed for tax purposes.

Whether the after-tax full cost or the successful efforts book return is greater than the economic return is determined, as in the no-tax case, by the relative magnitude of the economic rate of return and the growth rate, and in addition the proportion of costs that would normally be capitalized but are expensed for tax purposes.

What Method is Closer to the True Economic Rate of Return?

Having derived equations describing the full cost and successful efforts accounting rates of return in terms of the underlying economic rate of return, we may simulate the books of a single firm for both accounting methods using a wide range of

assumptions. Simulations were run varying growth rate between 2 and 30 percent, well life between 10 and 40 years, internal rate of return between 10 and 20 percent, proportion of intangible drilling expenses between 0 and 100 percent, and the ratio of dry holes to successful wells between 1 in 10 and 0 in 1. A series of graphs is presented demonstrating the relationship among the three rates of return.

Figure I shows the before-tax case with the following assumptions: the ratio of dry holes to successful drilling is three to one; cash flows from successful wells decline linearly; the internal rate of return is 10 percent; and well life is 20 years. Depreciation-and-amortization is a form of usage depreciation and declines linearly over the life of the assets. The vertical axis represents rates of return and the horizontal axis represents the firm's growth rate. The gently sloping line represents the full cost rate of return, at different levels of firm growth, of a firm whose economic rate of return is 10 percent. The steeply sloping line represents the rate of return the same firm would experience from keeping its books on a successful efforts basis.

On a before-tax basis the full cost return is both closer to the economic rate of return and diverges less from it than the successful efforts method. The difference in variability is great; the range of the full cost return is between 10 and 12 percent, while the range of the successful efforts return is between 49 and -29 percent.

FIGURE I

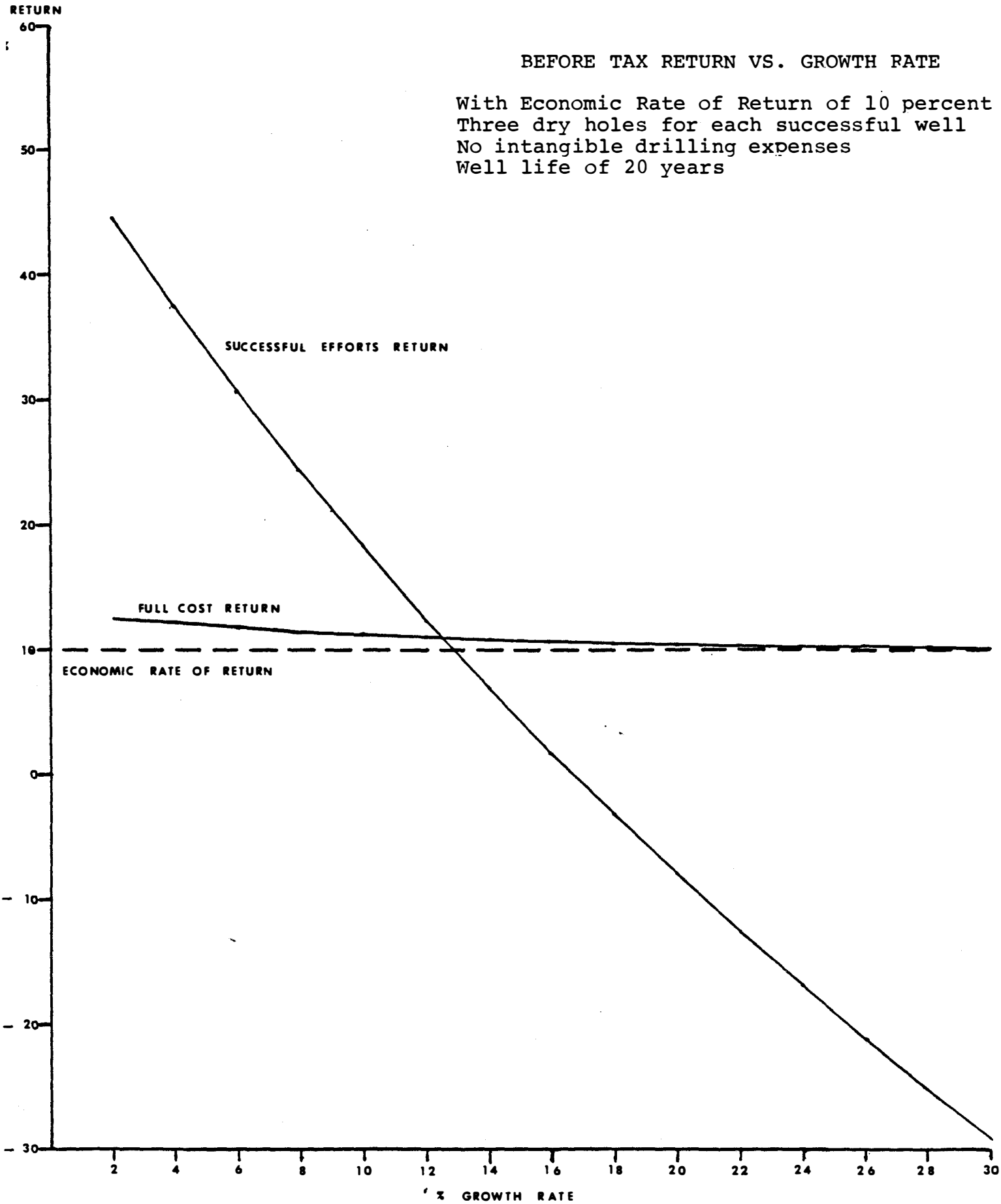

RETURN
60
50
40
30
20
10
0
– 10
– 20
– 30
BEFORE TAX RETURN VS. GROWTH RATE
With Economic Rate of Return of 10 percent
Three dry holes for each successful well
No intangible drilling expenses
Well life of 20 years
SUCCESSFUL EFFORTS RETURN
FULL COST RETURN
ECONOMIC RATE OF RETURN
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
% GROWTH RATE

Figure II presents the results for the same set of assumptions as figure I, but on an after-tax basis where no intangible drilling expenses are taken. The tax rate is 50 percent. Again, the full cost return is closer to the 10-percent internal rate of return and the successful efforts return is much more volatile, varying from 32.44 percent to -6.51 percent.

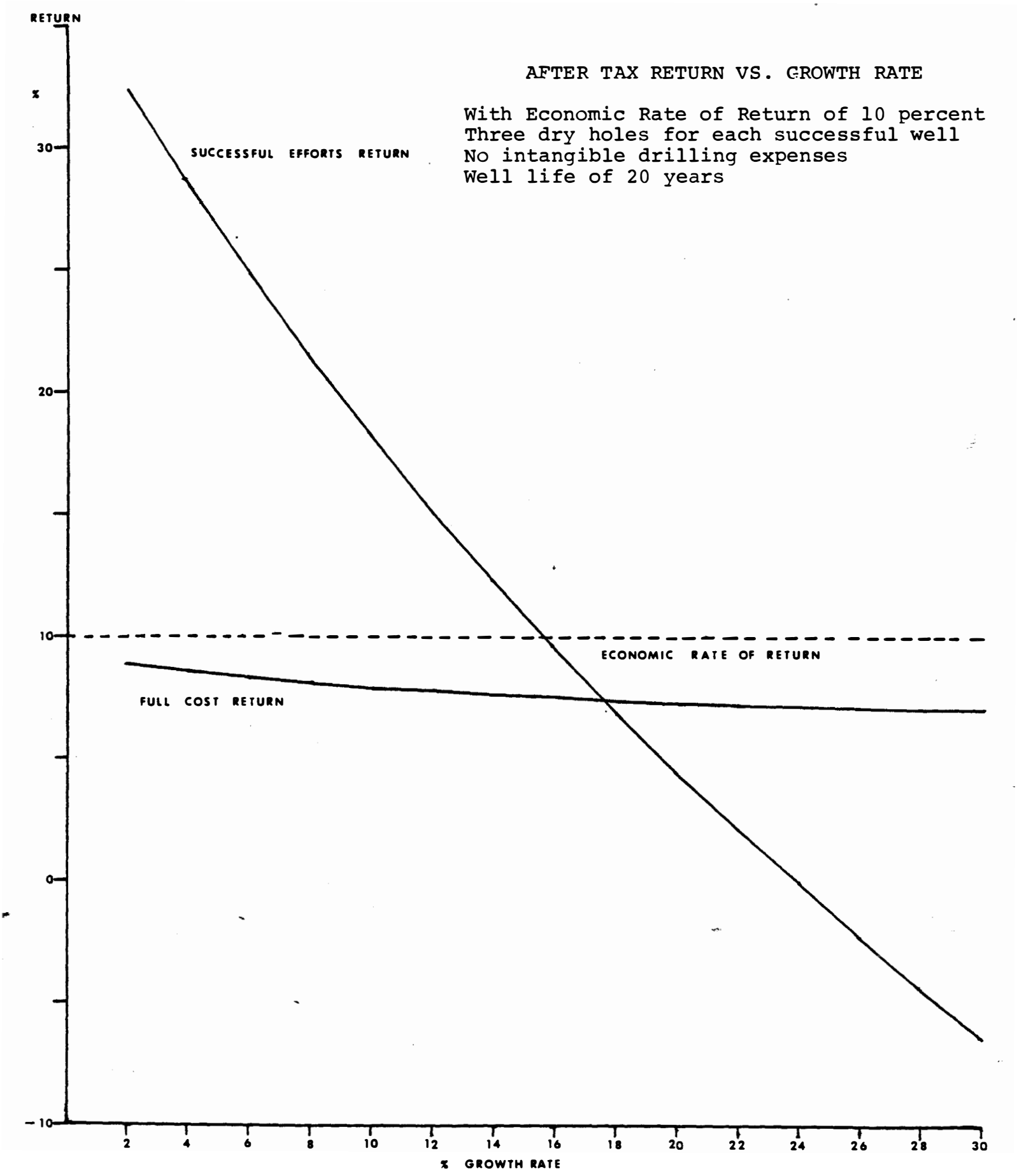
Figure III expands the previous case to include intangible drilling expenses of 50 percent of the costs associated with successful wells. The full cost method again provides a better estimate of the internal rate of return and the successful effort return is again more volatile, varying from 29.92 percent to -8.51 percent.

Figure IV changes the asset lifetime of the previous case to 40 years. The findings are similar to that of the previous figures; the full cost return is much more stable.

The results of other simulations conform to those presented in these graphs.

Figures II-IV show that given the assumptions used, on an after-tax basis the full cost book return is always below the economic rate of return. The simulations found a few instances of the full cost book return above the economic rate of return, at very low growth rates, but in general the full cost return was below the economic rate of return. The implication is that full cost accounting is likely to lead to an underestimate of a firm's actual rate of return. Figures II-IV also show that the

FIGURE II


AFTER TAX RETURN VS. GROWTH RATE
With Economic Rate of Return of 10 percent
Three dry holes for each successful well
No intangible drilling expenses
Well life of 20 years
RETURN
%
30
20
10
0
-10
SUCCESSFUL EFFORTS RETURN
ECONOMIC RATE OF RETURN
FULL COST RETURN
2
4
6
8
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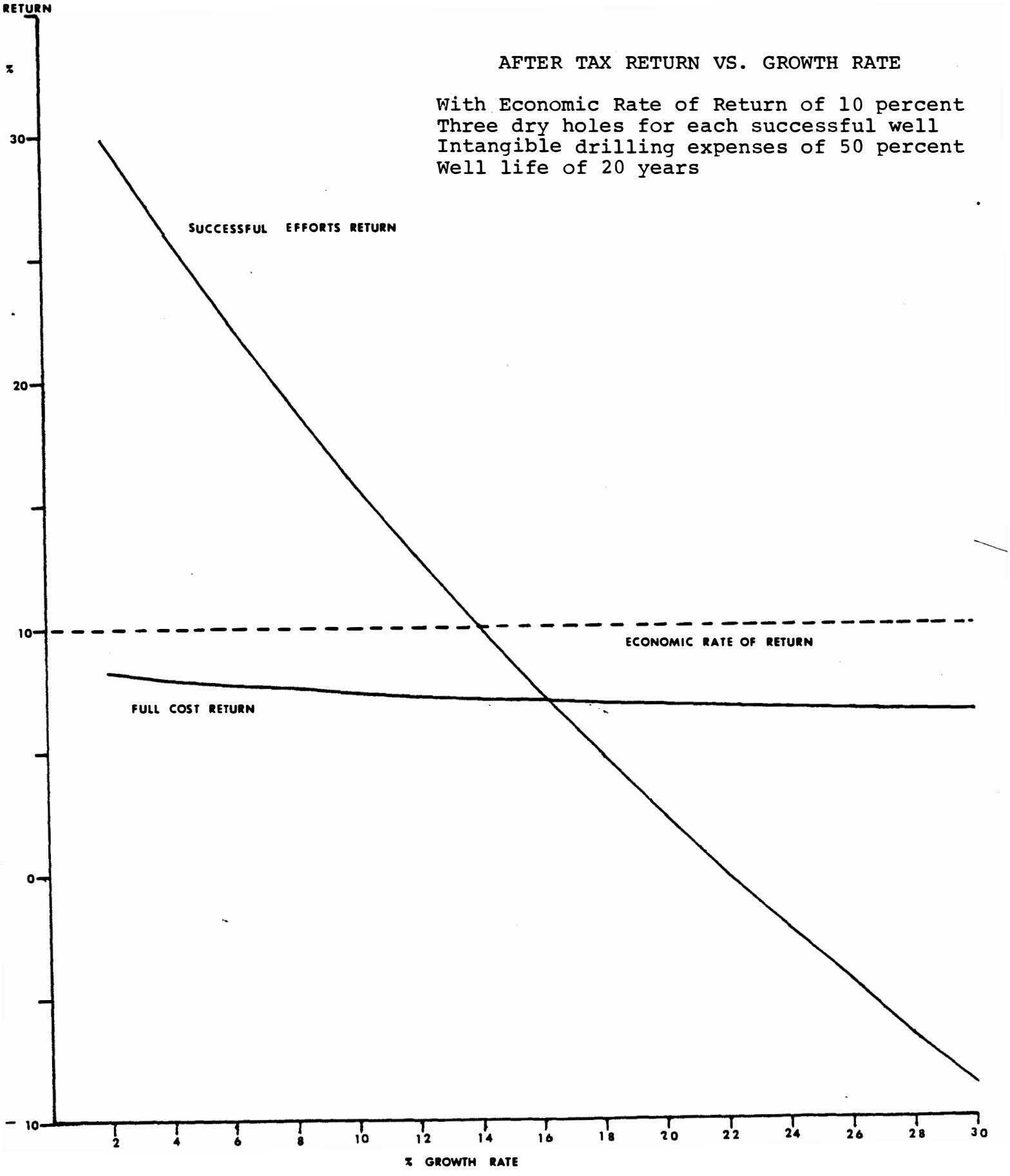
12
14
16
18
20
22
24
26
28
30
% GROWTH RATE

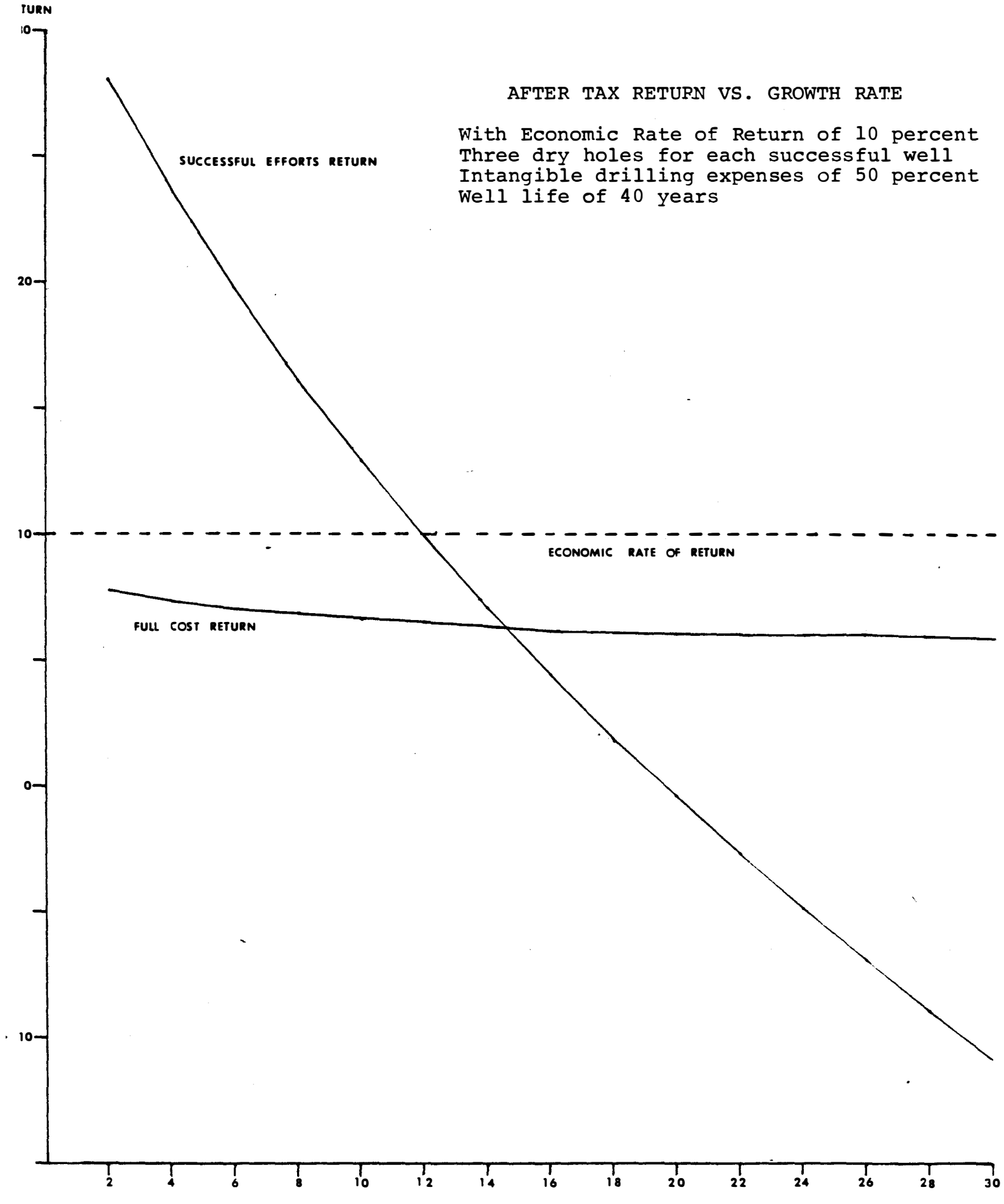
FIGURE III




AFTER TAX RETURN VS. GROWTH RATE

With Economic Rate of Return of 10 percent
Three dry holes for each successful well
Intangible drilling expenses of 50 percent
Well life of 20 years

FIGURE IV


TURN
10
20
10
0
10
AFTER TAX RETURN VS. GROWTH RATE
With Economic Rate of Return of 10 percent
Three dry holes for each successful well
Intangible drilling expenses of 50 percent
Well life of 40 years
SUCCESSFUL EFFORTS RETURN
ECONOMIC RATE OF RETURN
FULL COST RETURN
2
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% GROWTH RATE

successful efforts book return is generally above the economic rate of return for lower growth rate, and below for higher growth rates; however, the rate of growth at which the switch occurs is not clearly defined. The implications for successful efforts accounting that can be drawn from these findings are not as strong as in the full cost case; nevertheless there is a tendency for successful efforts accounting to overestimate economic return at low growth rates and to underestimate at higher growth rates.

## Conclusion

This paper has developed a model to portray the books of an oil company with a known internal rate of return, on both full cost and successful efforts bases. Computer simulations were performed varying each parameter--growth rate, rate of dry holes, asset lifetime, percent intangible drilling expenses, and internal rate of return. A series of simulations was presented showing the return derived from both sets of books, varying the growth rate and assuming parameter values similar to those experienced by oil companies. The results are dramatic. The book return of the successful efforts method is volatile, particularly with respect to growth and dry-hole rates, while the full cost method provides a consistently closer measure of the internal rate of return. The major characteristics of a firm that uses successful efforts accounting that would result in a book return greatly different from the firm's internal rate of return would be one that experiences an average of more than two dry holes for each successful well and has a low or moderate growth rate (roughly less than 10 percent) or a very high growth rate (roughly greater than 20 percent). Most firms fall into this category.

The Securities and Exchange Commission has correctly rejected the FASB recommendation that successful efforts accounting be adopted as the industry standard and instead has proposed a reserve recognition accounting (standard) for some time in the future. However, until the reserve recognition accounting

standard is developed, firms are free to report on a successful efforts basis.

The analysis presented here indicates that anyone trying to measure the profitability of a firm using successful efforts accounting may be greatly misled, and further, anyone comparing the profitability of firms using the different accounting methods will encounter serious problems of noncomparability.

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