OIL PRODUCING COUNTRIES' DISCOUNT RATES

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ABSTRACT

The small LDCs which own the great bulk of oil resources are rational agents and calculate with short horizons and high discount rates. They have pre-commitments to spend much (or even more than all) of their incomes, hence behave like highly leveraged corporations. They are also undiversified, hence the risk factors are set not by covariance with a diversified portfolio or sources of income, but rather by the variance of the oil income stream itself. Political risk is additional. High discount rates act both to raise and lower the depletion rate, so the net effect is indeterminate without knowledge of costs, not considered here. High discount rates sharply lower the effective elasticity of demand, and lead to a cartel policy of "take the money and run."

OIL PRODUCING COUNTRIES' DISCOUNT RATES

1. Introduction

The great bulk of world oil resources and reserves are owned by a few small less-developed countries (LDCs). To make the best use of assets, they must choose between near-term and farther-off costs and benefits. This requires a set of appropriate discount rates.

The rates may be implicit, never stated as such. If a party is willing to give up a dollar today for two dollars expected in 14 years, he may not realize that he is using a 5 percent discount rate, any more than the party unwilling to wait even four years is aware that he is using more than 20 percent. Both parties are like the man who talked prose for 40 years without knowing it was prose. Their actions may reveal their preferences more accurately than could their words.

We are particularly interested in two areas of choice. (1) The optimal rate of reserve depletion, which determines the timing and scale of investment. The owners must decide at what point the present value of an additional barrel left in the ground exceeds the price (for a competitor) or the marginal revenue (for a monopoly).

(The unqualified statement that "oil in the ground is worth more than money in the bank" logically implies that the

optimal depletion rate is zero. It has been a very influential dogma.)

Today the government-owner usually makes the investment-production decisions directly. However, other nations negotiate with private companies (usually foreign) to find and develop oil. They need to know both their own and the companies' discount rates in order to make the deal best for themselves. [Lessard Paddock and Blitzer 1984] have pointed out that both parties benefit by assigning risks to the side better able to bear them. There seems to be limited but increasing recognition of this principle [McPherson & Palmer 1984]. We aim at some rough measure of the risk discrepancy.

(2) Elasticity of demand. Since some oil producers are organized in a cartel, they must consider demand in order to choose the optimal price-output combination. Consumption reacts to price with a considerable lag. The decision to raise prices must incorporate two assumptions: at what rate the sales loss from higher prices comes about, reducing income in later years, and at what rate to discount that lower income. Similarly with a proposed lower price.

To speak of "the rate" of discount is of course to oversimplify. To every risk class there corresponds a discount rate. An oil company invests among other things in trucks, which can be moved freely and easily resold; in drilling equipment,

which is moved from well to well at considerable expense and can only be resold in a narrow market at highly variable prices; and in exploration wells in remote areas, which are literally sunk costs. The three risk classes require three discount rates. However, this paper is not concerned with the family of rates within the firm, but rather with the difference between two groups of firms, private versus public.

We first summarize the estimates of discount rates applicable to private parties in developed countries with diversified capital markets. We next indicate the factors which would tend to make the producing nations' discount rates higher or lower than the private rate. We arrive at LDC discount rates which are much higher than those of private firms in developed economies. We consider some of the possible objections to our findings, and conclude with some very limited conclusions about the effect on depletion rates and oil prices.

2. Private Oil and Gas Producers' Discount Rates

[TABLE I HERE]

Table I presents some recent estimates of the discount rates, or cost of capital, of private firms producing crude oil and natural gas in the United States and Canada. Because the industry is so international, these rates apply to any large private firm in the industrial world.

There is some variation, as is to be expected. In my view, the Baldwin-Mason-Ruback estimate is too high because it is based on only one year. It is statistically robust because it is based on a large enough sample to represent 1979 conditions, but the year 1979 is not a good sample of the recent past.

A very brief review of elementary finance theory is necessary to see how we will go from the private discount rate to the rate at which a government should discount its oil and gas revenues.

The usual formulation is: D = RF + Beta(RM - RF), where D is the expected discount rate, RF the expected risk-free rate, and RM the expected return on a diversified portfolio of assets. Historical series are entered for RF and RM as the best approximations. Beta is the measure of covariance between the market rate RM and the return on the particular asset in question, estimated by least-squares regression. As just seen, any two estimates of D will vary, depending upon the observations composing RM and RF.

The premium over the risk-free rate is a return for risk, conceived as the undiversifiable variability of the gains from operating the venture to which the investors' funds are committed. The variability is unknown because the future is unknown, but is expected to be much like the past. The chances

of gaining or losing by holding and operating the asset an additional year are measured by the fluctuations in the past.

Past fluctuations are measured by the standard deviation of past gains and losses. But the risk measure Beta reflects not the variability of the asset itself, but the variability which that asset contributes to the "market portfolio", the whole portfolio of assets owned by or available to investors. The distinction between variance and covariance will be of particular importance.

If there is perfect covariance between the given asset's income and the market portfolio's income, the asset neither adds to nor subtracts from the risk of holding the portfolio, Beta is unity, and the risk premium for the asset is that for the market generally.

If the asset's earnings fluctuate with the gains of the whole portfolio, but more widely, then it adds something to risk; if less widely, it diminishes risk. Or if the asset's earnings fluctuate out of harmony with the rest of the market portfolio, then it tends to stabilize the portfolio's earnings, and diminish risk. In such instances, Beta is less than unity.

The asset might seem very risky in isolation, if we knew only its variance. But its interaction with the market portfolio might be such as to make its incremental risk very low, and the discount rate should reflect this. Conceivably, the asset's

earnings might even fluctuate inversely to the portfolio's. The asset might be worth taking on as a diversifier even when there were expected losses not gains. Because of the covariance, the discount rate on the asset in question might be zero, or even negative.

The Beta on a corporation is measured in two stages. First, the gains to holding a share of corporate stock are measured against the market portfolio, and an equity Beta computed. This is adjusted or unlevered (usually simply multiplied) by the ratio of equity to total equity-plus-debt of the firm in question, to derive an asset Beta.

The reason for this adjustment is that the equity Beta incorporates not only the business risk in holding the asset, but also the financial risk of leveraging. When there are obligations such as debts or leases, part of the stream of net revenues is pre-committed. The residual, revenues minus pre-fixed contractual payments, is the more volatile stream determining risk and return to the shareholder. (This assumes that the debt is riskless to the creditor, which may not be quite true. See Table I above, note explaining the Paddock estimates.)

The stock market does not include all other assets an owner might hold, or his other sources of income, although those others may be highly correlated with the stock market. The use of a stock market Beta may overstate variability to some degree,

though there is no reason in theory why it must. ([Stambaugh 1982] concludes it does not.)

The usual assumption is that any individual investor can diversify against the market portfolio. Hence the differences in risk between any two assets or projects depend only on the characteristics of the two assets. We will soon be compelled to depart from this assumption.

3. Preliminary observations about nation-owners

There has long been controversy over the use of private discount rates to determine the "social discount rate" which is to govern the investment decisions of public bodies. But we do not address this question. We seek only to know at what rate to discount the flow of revenues from petroleum-producing assets, in order to calculate a present value of the flow. Then it is comparable with any other flow, from an existing or proposed asset. [Compare Lind (1982)]

The risk premium does not depend on the time preference of the discounter.[1] Risk, unlike beauty, is not in the eye of the beholder; like the mountain, it is simply there. The greater the risk, the lower the present value of a given flow.

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[1] Strictly speaking, the riskless rate summarizes the pure rate of time preference of the various individuals in the same way as a market price sums up their tastes.

Owners' needs, and attitudes to risk, govern their choices of assets. "If you can't stand the heat, get out of the kitchen." If the assets held are too risky for a given owner's taste or needs, they should be exchanged for lower-yield lower-risk holdings. A nation-state may be more or less risk-averse than a private firm or household. But a given bundle of assets comprising an oil company presents the same risk to one or the other--unless their portfolios are radically different (of which more below).

3.1 Cartel nations are rational

A common misconception is that the OPEC nations are arm-waving wild men, nuts, incapable of making rational policy. At worst this is mere prejudice; at best it is simply gratuitous and unfounded.

Internal OPEC documents rarely get into the public press, but those which do are revealing: for example, the 1980 report of the OPEC long-term strategy committee (summarized in [PIW 1980]), or a paper submitted by Iran to an OPEC committee meeting. [PIW 1983] One may disagree with what is said, but the arguments are respectable and certainly the tone is calm.

Kaddafi, Khomeini, and others less flamboyant, are bloody-minded, full of hate, see the United States as the Great Satan, etc. But whatever their goals, the more revenues the better to advance them. Some, for a time, may overlook this.

The "moderate" Bani-Sadr (who had an economics degree) allowed much of the Iranian oil industry to be ruined, possibly because he really believed it was not "needed". His more ferocious successors have acted much more rationally. Their minds were concentrated by the Iraqi attack, and the need for money to buy arms. Hence they settled claims with the United States, and moved swiftly to carry out their agreement. "This curious blend of Holy War against the Great Satan and business-as-usual with his bankers is typical of the paradox that is Khomeini's Iran." [Smith 1984]

Of course, wishful illusions may influence risk perception. Especially around 1980, there was supposed to be less risk in oil or gas because prices would not fluctuate, only rise onward and upward, forever and ever. Political bodies are learning the lesson a little more slowly and painfully than private. Our purpose is to ascertain the reality toward which they are trending.

4. Forces tending to lower government-owners' discount rates

Governments, especially OPEC governments, should in some respects discount at a lower rate than U. S. companies.

4.1 There is nearly always much less geological risk than in the United States, and sometimes hardly any. Deposits are typically larger and not exhausted as soon, hence there need be

less probing of the unknown. There has never been much true exploration in Saudi Arabia, for example, because, although it always pays to find cheaper oil, it cannot be much cheaper. Of 50 known oil fields, only 15 are currently operated. [AAPG 1981, 1982, 1983] [Oil & Gas Journal 1984]

4.2 There is no risk of unfavorable government action to reduce profits, since the nation-owner is sovereign.

However, these two risk reductions are relatively small because geological and political variations are largely uncorrelated with general market changes. Hence they serve as diversifiers, and add relatively little to the riskiness of the hypothetical portfolio. Accordingly, their absence does not much diminish risk.

4.3 A more complex issue is that of fluctuations in revenues. Let us defer discussion of one component of revenues, i. e. sales volume, and consider first the net revenue per unit sold: price less unit cost.

Unit cost in the OPEC nations is usually only a minor or even negligible fraction of U. S. cost. [Adelman 1986a, 1986b] Since unit net revenue is a residual, the lower the cost, the less the fluctuations.[2]

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[2] The variability of net profit margins is much reduced in the United States by the so-called Windfall Profits Tax, which is really an excise tax on the difference between the market price and a base price. Thus the government takes most of a price increase and bears most of a price decrease. The tax was an

In normal times, of the sort we have not seen since 1973, and are not likely to see again soon, price fluctuations would be correlated positively with the general market. Hence the lower net revenue fluctuations for a lower-cost producer would be a net risk reduction, possibly an important one.

However, there are two modifications.

4.3.1 One is the cartel itself. Far from bringing stability--the usual dogma--it has greatly increased price fluctuations and risk.

4.3.2 The price movements have been mostly contra-cyclical, because oil is so large an industry that large price increases hurt world economic growth, and price decreases help. This was true after 1973, and again after 1978. The brisk recovery in North America and the slower one in Europe and Asia since 1982 have coincided with major price decreases. The collapse in early 1986 has seemed favorable to economic growth.

Since higher oil prices and much higher profits have coincided with lower profits elsewhere, fluctuating oil prices have been a diversifier for private owners.

But for the cartel nations, price fluctuations have not been exogenous events, but rather the result of their own actions. Hence it would be fallacious to argue that the offsets

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important earnings stabilizer until the price collapse of 1985-1986.

to oil price increases, acting as a diversifier, have been beneficial to these nations.

However, the chances of another price explosion seem to be less than previously, and even if one again happened, there seems to be much less room for a profitable increase. Hence the contra-cyclical nature of oil profits may have disappeared, or at least lessened, and the lower costs of the producing countries may now be an appreciable stabilizer.

Or, what points to the same conclusion derived from option theory, the less the expected future variability, the less the value of the option held by a high-cost producer, who hopes for a windfall gain some day. But a low-cost producer remains indifferent.

I would conclude, without trying to quantify the proposition, that the forces tending to reduce the exporting nations' discount rates are non-negligible, but minor.

5. Forces tending to raise exporter nations' discount rates

5.1 Amplified output fluctuations

Cartel oil has been the oil of last resort because its price is never lower and often higher than non-cartel oil. Cartelists produce only what they can sell, without undermining the price. Since late 1985, they have of course been striving

with all their might to make non-cartel producers share that responsibility for supporting the price. But so far (June 1986) they have not succeeded. Non-cartel producers have felt free to shade or reduce prices in order to maintain sales volume. They sell all they can produce, and take whatever price they can get. Nor can we doubt that if non-cartel producers agree with the cartel on production sharing, they will be quick to repudiate responsibility as soon as members or non-members cheat.

Accordingly, non-OPEC oil production has fluctuated very little this past decade. The United States was stable, other areas grew quite steadily. The cartel nations (OPEC plus Mexico after 1981) have absorbed all the fluctuations in oil output.

The cartel's gradual secular loss of markets due to the long-run effect of higher prices in curbing demand and stimulating supply is uncorrelated risk. But the variability of cartel sales has been largely an amplified version of changes in oil and energy consumption in response to general business conditions. It is correlated risk and non-diversifiable. On this count, cartel nations' oil income is much more risky than oil income generally.

5.2 The national "portfolio"

We turn now to a more pervasive difference between public and private owners. The basic assumption of the capital asset

pricing model, as pointed out earlier, is that a given asset is only a minor part of a broad portfolio. Or what comes to the same thing, the income from a given asset must be small in relation to all other sources of income.

5.2.1 Industrial countries

In the United States in 1982, oil and gas production net revenues were only 2.25 percent of the GNP; in Britain they were expected to peak at about 5 percent in 1984-5.[3]

The national or social discount rate on oil-gas properties owned or taxed by a large industrial country can therefore be no more than the 10-11 percent shown in Table I above. It can hardly be much less, because the income flow from the stock market portfolio is already so widely diversified that it closely approaches the maximum possible for any income flow. The social or national discount rate on petroleum extraction

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[3] According to the Survey of Current Business, July 1983 pp. 68-69, 1982 gross national product in current dollars was $3073 billion. Gross product in all mining was $116 billion. Oil and gas extraction accounted for 60 percent of net mining income (without capital consumption adjustment). Accordingly, we may estimate oil and gas extraction gross income at $69.6 billion. This is roughly corroborated by the Bureau of the Census, Annual Survey of Oil and Gas 1982, Table 5 ("net company interest statistics"). Total lease revenues from oil and gas sales were $103 billion. Subtracting $46 billion of capitalized expenditures, we have roughly $56 billion that might be called gross income to the factors. Since the Annual Survey is no longer published, it is not possible to update the comparison. For the U. K., see The Economist, June 9, 1984, p. 67.

cannot possibly be as low as the 5 percent used as the standard in British nationalized industries. [HMSO 1978, Rees 1979]

In smaller industrial countries, like Norway and the Netherlands, there is less diversification through the national income. There is, however, a perverse kind of diversification, even a contra-cyclical effect, which has become a cliché, the "Dutch disease". Oil or gas exports lead to an overvalued currency, which in turn reduces non-hydrocarbon exports. (This has been widely discussed. For a good brief account, see [Economist 1982].)

5.2.2 LDC owners

Once we get beyond the oil producers of the developed world, we confront a difference in degree so great it becomes one in kind.

All the OPEC producers, and to an important degree Mexico, are in the position of the individual or corporate person whose oil holdings are most of its holdings, and oil income most of its income.[4]

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[4] Diderik Lund has pointed out that with large-scale oil or gas production, the composition of the national portfolio changes. One might expect that the in-ground asset is exchanged for various above-ground assets. Thus the portfolio changes, the risk-weighted interest rate becomes endogenous, and an analytical solution of the sequential optimum depletion rate much more complex. I believe Lund is correct. If the presence of oil wealth makes the nation-owner more not less oil-dependent, the risk-adjusted rate is even higher than our simplified analysis would indicate.

Some of the oil producing nations have built up substantial holdings of foreign assets, but with the exception of Kuwait and Brunei, the income derived from them is only a small proportion of oil income. For example, in mid-1984, Saudi Arabia had about 100-120 billion of foreign assets. [WSJ 1984, Financial Times 1984] We take the lower estimate to allow for non-earning assets like Iraqi "debts". For comparability, we should impute to this amount the current 11 percent (real) rate of return on assets of corresponding risk, not the much lower rates on lower-risk securities, hence an annual yield of $9.6 - $13.2 billion. When the kingdom produced 8.5 million barrels daily (mbd) for sale at $34, total oil income was $104 billion (assuming production costs at 50 cents per barrel), and the oil percent was no less than 104/(104+13.2) or 89 percent. Since then, oil income has dropped precipitately, but so have foreign income-earning assets, which today are apparently no more than $55 billion. [WSJ 1986] The financial embarassment of the kingdom is shown by its failure to calculate and publish an annual budget for 1986.

The 1982 oil percent of GNP among the Persian Gulf producers lay between 65 (Saudi Arabia) and 70 (Kuwait), except in Iran, where in 1981 it was 40. For the largest non-Persian Gulf producers it is less: Algeria 32, Indonesia 16, Nigeria 26, Libya 40, Venezuela 18. [CIA, 1983]

But national income figures understate oil-dependence, because a large fraction of the non-oil industries and occupations are really oil-dependent. Either they are direct oil-service industries, or else they represent the spending of oil-derived incomes. With no oil income, they lose their reason for existence.

In a developed economy, the receivers of oil income have skills or property which can be switched from oil to non-oil activities, although the amount of non-oil income will presumably be less than the amount of previous oil-derived income.

But this is not true of the oil-producing LDCs. Even industries which look independent, e. g. which are exporters or import-substitutes, may be subsidized--a use of resources, not a source of income. Saudi Arabia exports wheat, but this is an expensive hobby, not farming income, since the government buys it from local farmers at seven times the world price. [WSJ 1984b]

The new refineries and petrochemical plants, now beginning large-scale exporting, are more than a hobby, less than a source of income. Worldwide, these industries are overbuilt and shrinking. Nobody who is free to choose is building refineries. Some are being sold at prices only a small fraction of construction costs.

The oil exporters' capital and operating costs are higher than their competitors'. Their crude oil costs, for a refining

or petrochemical operation, are no lower. The true opportunity cost of crude oil is its market value, since the alternative to processing the crude is selling it. This is strictly true for a competitive firm or an observant cartelist, who stays inside his production quota. For a cheating cartelist, this is not true. But given enough cheating the cartel disappears, and the statement is again true.

Whether the oil-based industries will in time be regarded as at least a means of education, or as merely "cathedrals in the desert", does not concern us here. They are small or negligible income-earners, hence non-diversifiers for oil production.

Indeed, the situation is even more extreme, in that oil development damages pre-existing industries more severely than in the developed countries. Nigeria is probably the outstanding example of oil revenues making a country even more oil dependent. Agricultural output has declined, and the towns have attracted a large parasitic population (no less so for being very poor) for whom the governments must provide food and other imported necessities at subsidized low prices. In a less extreme form, the same affliction holds of the other exporters. [World Bank 1981. Amuzegar 1982] Even when oil exports are a relatively small percentage of national income, they may be a very high percentage of imports. Mexico has become a well-known example.

As the then Secretary General of OPEC warned:

"[The] gains of oil-induced growth tend to increase rather than decrease the dependence...on the quantity and price of crude oil exports." [Attiga 1981]

A private person with a high but uncertain income from his one holding, who dislikes the high risk, could sell part of the holding, and buy other assets, to lower his total risk. But to sell part of their oil holdings is precisely what the exporting nations cannot do. It is politically impossible; indeed, utterly repugnant. After all, they only recently nationalized their respective oil industries. And even if they were willing to sell they would find few takers, who would offer insultingly low prices, because of the risk of later expropriation.

Hence each oil exporting nation is locked into its holding of the one asset which accounts for most of its income, or most of its foreign exchange earnings. They would quickly perish without the oil-derived purchasing power to buy foreign food, manufactured products, and services. Here is perhaps the most important single difference between private and public holdings.

5.2.3 Measuring additional risk for cartel nations

The increased risk in holding one asset is well illustrated by Pogue. He took the fluctuations of the whole stock market as unity. His sample of 18 industries taken as a group had an equity Beta of 1.03, not much greater than the market as a

whole. Then, allowing for leverage, he arrived at an asset Beta of only 0.81 for the whole group.

But if we assume that a holder held stock in only one industry, and was not free to diversify his portfolio, then the relevant variable is not the security's covariance with the market, but only the variance of the single industry. Every individual industry had a much larger standard deviation than did the whole market; on the average, it was 2.3 times as large. [Pogue, Exhibit GAP 2.]

The investor confined to one security, who cannot diversify even into individual holdings within the industry, is running an even greater risk.

5.3 Cartel nations as leveraged corporations

We remarked earlier that to arrive at the Beta for total assets, we must remove the effect of leveraging. But the oil producing nations are leveraged. They are like private companies with high levels of debt or high rentals, i. e., with large prior claims on their gross income. The governments tend, even more than private persons, to anticipate and overspend future income, saddle themselves with debts or other commitments. The greater the oil income, the more they leverage it.

The financial history of the OPEC nations is revealing. Even in the 1950s, when oil revenues were trifling by today's

standards, governments strongly complained that it was difficult to live with fluctuating incomes. The tension became intolerable in 1959, when some of the multinational oil companies responded to lower market prices by reducing the revenues per barrel. A direct result was the 1960 Baghdad meeting which launched OPEC. As the preamble put it: "any fluctuation in the price of petroleum necessarily affects the implementation of the Members' programmes". [Pergamon Press 1984] Of course, one could deal with fluctuations by saving a large fraction of one's current income and accumulate financial assets to use as a stabilizer. Neither then nor now did it seem like an available option.

Much higher revenues have not only increased oil dependence, but have also led to much greater commitments to spend oil revenues, and even anticipate them. In 1974, the current account surplus of the OPEC nations was $69 billion, several times any previous peak. By 1978, the surplus was gone; Saudi Arabia ran both a budget and foreign-exchange deficit. The reason for this massive turnabout was a surge in imports of goods and services, and in spending outside the respective countries. [IMF 1982, IMF 1986]

The discomfiture of the governments was strongly voiced in 1978. The then OPEC Secretary General warned that if OPEC exports stagnated there would be "political and economic disasters" in the OPEC nations because of revenue cutbacks and disap-

pointed expectations. [Jaidah 1978] There was nothing new or startling in this warning; it was generally accepted as true, leading to the correct expectation of a price increase coming in 1979, slack market or not.

The opportunity was taken in 1979-81, when despite the absence of any shortage--as is generally recognized today--prices were driven up to more than double, in real terms, by restricting output and panicking the market. The 1980 current account surplus was "only" $111 billion because imports chased up so fast. The surplus gave way to a deficit in two years, and the OPEC nations remain in deficit. Saudi Arabia is in deficit on both budget and current account. [IMF 1986, SAMA 1984]

Thus the OPEC and some non-OPEC exporters have managed to put themselves into the position of a highly leveraged corporation. If we adjust the risk premium without any allowance for un-leveraging--because the holder is in fact leveraged--the risk premium becomes 8*2.3, or 18.4 percent, and the total required return or cost of capital is then 20.4 percent. Some of these governments have made the analogy exact by going deeply into debt, but this is only the most extreme example.

5.3.1 Leveraging of mineral income in the XVI century

There is a historical precedent. King Philip II of Spain used the proceeds of a huge mining business (silver from Mexico and Peru) to take over a good sized business in ocean shipping

and wholesale groceries (the annexation of Portugal). In seeking power and glory, King Philip spent the combined proceeds--and more. He was the wealthiest monarch in Christendom, and went broke the most often. Accordingly, he paid increasingly high interest rates, because his creditors realized, sometimes a bit late, that the risk had been transferred to them. [Elliott 1963] [Braudel 1966]

5.3.2 Problems of adaptation to lower revenues

Nobody knows how much of these governments' outlays are irreducible. (For a careful examination, though now outdated, see [Moran 1978]. The corresponding numbers would be much higher today.)

Cutting the incomes and subsidies of various groups may threaten social unrest or revolution. We referred earlier to the grotesque subsidy to Saudi Arab wheat farming. It has proved impossible to eliminate, and extremely difficult even to reduce.

If some of the payments are untouchable, like a corporation's rental and interest payments, this concentrates the fluctuations on the remainder of the revenues, which fluctuate more than does the total. This vulnerability to fluctuations should make a rational owner put a high discount rate on future incomes.

5.4 Political instability

There is an additional source of risk, resulting from the inherent instability of most of these governments. Domestic opposition has no outlet but conspiracy and violence; they are also threatened by their neighbors.

Suppose we have been able to calculate, according to the capital asset pricing model, a risk adjusted rate of discount, call it i. It is not hard to show [Adelman 1982 pp. 59-60] that if there is a probability p that the owner of a mineral deposit will, within any given year, suffer a sudden complete and irrevocable loss of his property, the true discount rate r, adjusted for that risk, is:

$$r = (i+p)/(1-p) \qquad [1]$$

Suppose we believe there is a 50-50 chance of a ruling party or faction or junta or family being overthrown from inside or outside within 20 years. Then in any given year, there is a 3.4 percent chance of overthrow. If the discount rate, for ordinary business risk, is 20 percent, then the risk-adjusted rate is: r = (.20+.034)/(1-.034) = 24.2 percent.[5]

When calculating oil development costs in the 1960s, I assumed a 9 percent cost of capital in the United States, and 20

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[5] As in large matters, so in small. "Observers who knew [Iran] before the revolution say there is probably more [corruption] now. Before the revolution, those holding top jobs skimmed 2-3% off contracts. Now, since people frequently get sacked for political reasons, they have to make their money faster; so they take 10% or more." [Economist 1984]

percent for firms operating in the OPEC nations. [Adelman 1972, ch. 2] It did not occur to me that this discount rate (which, I was informed, was about what oil companies were using) was an implicit forecast of an even chance of expropriation within 7.2 years. That is:

$p=(r-i)/(1+r)=(.20-.09)/1.2=.092$, and $(1-.092)^{7.2} = .5$

If we take the year of forecast as 1966, that was not a bad guess.

5.4 Summary

If governments were subject only to the risks facing a producer of oil and gas in the United States, they should properly discount future income streams at about 10 percent, i.e. 2 percent riskless and 8 percent risk premium. (The capital market would furnish no equity funds at a lower rate.) If we conservatively assume that they have no control over at least one-fourth of their incomes, then they should add about two percent to the risk premium, and discount at about 12 percent. If we recognize that they cannot diversify income to any significant degree, the required rate goes sharply higher, probably above 20 percent. Recognizing the probability of a "short sharp shock" to the current regime requires another substantial boost. The total varies among nations, of course, but for the current regime in Saudi Arabia it must exceed 20 percent. For Kuwait it

is lower, since true non-oil income, derived from foreign investment, is higher in relation to oil income. For all others, it must be higher.

6. Some objections considered

The range of discount rates suggested here, from 8-11 percent in the USA to two-three times that much in the OPEC countries, will probably arouse some disagreement.

6.1 The "r percent rule"

One reason is the widely held belief in the "Hotelling paradigm or r percent rule" [Miller & Upton 1985], according to which minerals prices, less extraction costs, must inevitably rise at the relevant rate of interest. It would follow logically that future receipts (and, with some adjustment, future prices) should be discounted at a near-riskless rate. Certainly price appreciation at any risky rate is not of this world. Fifty years at 10 percent per year is an increase by a factor of 117; 100 years, by a factor of nearly 14,000.

The attempts to measure the Hotelling effect have assumed riskless discount rates, without however trying to justify them or discuss the actual risks of mineral operations, including petroleum. [Heal & Barrow 1981: U. K. Treasury bills] [Smith, V. K. 1981: prime commercial loans, high grade municipals, one-year corporate bonds, 30 year corporate bonds, and stock

exchange call loans.] [Devarajan & Fisher 1981: no reference to appropriate discount rates.] [Marshalla and Nesbitt 1986: a range of 2 to 6 percent]

In this paper, I will merely state without trying to justify a position. The failure of econometric verification of the price-increase paradigm is due neither to inadequate data nor inadequate econometricians. The Hotelling principle is correct: the discounted net return from extracting a mineral unit from a given deposit in any year must equal that in any other year, which in turn equals any return from a holding with equal risk. This is no truism; it is a basic insight into mineral economics. But the Hotelling principle does not require the paradigm of net prices rising at all, at any rate. Mineral scarcity is the uncertain fluctuating result of conflicting forces: diminishing returns versus increasing knowledge. Prices therefore rise and fall. Discount rates for the minerals industries, which incorporate price risk, should be--and are-- in the normal commercial range.

6.2 Optimal depletion rates

One can cite some respected names in support of the proposition that the higher the interest rate, or the greater the risk, the higher the optimal depletion rate and the faster the exhaustion of a mineral deposit; and vice versa. [Dasgupta and Heal 1979] [ICF 1979] [Kay and Mirlees 1975] [Nordhaus 1973]

[Pindyck 1978] [Posner 1972] [Solow 1974] As the ICF authors state (p. II-5): "If extractors become less fearful that their fields will be expropriated, it is no longer rational to pump as vigorously, much as if there were an unanticipated reduction in the interest rate."

But this idea is mistaken. A changed discount rate can raise or lower the optimal depletion rate. [Gordon 1966] [Adelman 1982] It is true that cet. par. a higher interest rate makes it less attractive to keep an asset in the ground, and favors increased extraction. It is also true that investment per unit of output rises with the rate of output, and with cumulative output, since one factor, the deposit, is fixed. But the higher interest rate makes the increasing investment per unit more expensive. The first effect promotes investment and output, the second depresses it.

Clearly, the relation between the discount rate and the optimal depletion rate is complex and depends on current and expected costs and prices. Let us take an extreme but realistic case, where cost--investment requirements per unit of capacity--is very low. Here the first effect tends to overbear the second. Hence the high discount rates of the LDC exporting nations should on the whole induce higher depletion rates--assuming they act as competitors. But this effect has been

dominated, of course, by the need to restrict output to maintain prices. We now turn to this aspect.

7. Exploitation of a monopoly position

We have shown elsewhere that if the reaction of consumption to a higher prices takes time, and the consumption reduction declines exponentially, then the relation between timeless elasticity E and present-value-weighted elasticity E' is as follows:

$$(P_a/P_b)^{E'} = (i/(c+i)) + (P_a/P_b)^{E} * (1-(i/(c+i))) \quad [2]$$

where P_a and P_b are prices before and after the change, i is the discount rate, and c is the exponential decay rate of the consumption effect. Table II gives some illustrative cases.

[T A B L E II H E R E]

Assume that demand elasticity for a product is unity. If the effect were felt immediately, or if the discount rate were zero, it would not pay a monopolist to raise the price. But if the delay has a half-life of e. g. seven years, then with a 10 percent discount rate the effective elasticity is only about -0.5, and with a 25 percent discount rate, elasticity is only -0.32. A 1 percent price increase would increase the discounted present value of revenues by 0.68 percent; a 1 percent decrease would lower revenues in the same proportion.

This, in my opinion, is the most important effect of higher

discount rates and shorter time horizons: a cartel gravitates toward a policy of "take the money and run".

8. Exporter country attitudes

It may be objected that even if high discount rates are correct in theory, and oil-exporting governments should in their own interest use them, yet they believe low discount rates are "right", and act accordingly.

This argument is often confused with another one: that revenues from oil sold today bring not wealth but "illth" to the nation: conspicuous waste, social disruption, etc. This argument assumes as a fact that more income is bad. If so, one should keep the oil in the ground whether it is worth much or little. The nation deliberately chooses a second-best. The best would be to produce the oil and invest the proceeds for the benefit of this and future generations. But one assumes it will not be well invested. Better therefore to keep it in the ground, where it has at least some value. Perhaps the policy will improve in the future.[6]

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[6] Michael C. Lynch has suggested that if E is called the percentage of income "not wasted", then the asset value is:

$$V(t) = E * P(n) * (1+i)n$$

where V(t) is the asset value at the present time, P(n) is the price received n years ago, and i the interest rate at which one might have invested it. But he points out that there is a hidden assumption, namely that the government will henceforth spend the money "wisely". Otherwise, the income from the reinvested asset will itself be "wasted" at the same rate. Then one faces the original problem: produce and sell the oil, or keep it.

On its premises, the argument is sound. The risk, which governs the present value of the flow of revenues, is not relevant. Of course, one man's "waste and corruption" is another man's delight. Moreover, an income corruptly gained, then reinvested abroad in productive assets, is a net gain to the economy, however unjustly distributed. Public or private investment in a money-losing enterprise which requires subsidized imports to keep functioning, is a running sore on the body politic, however fair, just, and reasonable is the division of the burden.

Returning to discount rates: certainly oil-exporting governments (and others) have long insisted that they consider far-off gains very close to present gains, and would therefore prefer to keep oil in the ground than put money in their purse.

But an unsupported statement by an interested party is not good evidence. These governments want consumers to believe that they are producing more than economic interest would indicate, or making a "sacrifice" for the sake of the world economy. Thus we owe them political or other favors to insure "access" to oil. Certainly the belief that our statesmen must and do assure "access" has been a foundation-dogma for U. S. policy-makers for well over a decade. [Kissinger, "Foreword", in [Ebinger 1982], a volume dedicated to the proposition that "access" is a major problem.]

No good reason has ever been given for assuming the dogma that exporting nations produce more oil and more revenues than they wish. Moreover, the surge of imports noted above, which twice turned massive OPEC surpluses into deficits, would be sufficient proof that these governments want more revenues not less to spend. Furthermore, during the repeated oil gluts since 1973, there have been repeated opportunities for Saudi Arabia and others with small populations to let others have the market, and keep their oil in the ground, as they say they yearn to do. Of course they have done no such foolish thing, but rather maneuvered and fought for the largest possible market share compatible with maintaining the price. Better to watch what they do than what they say.

But perhaps producers, including exporting governments, may simply be mistaken, impressed by fashionable Club-of-Rome hysteria, or more sober papers in various journals, or endless repetition by statesmen in the consuming countries, or just blindly following an un-examined rule.

This argument is not to be lightly dismissed. But it can only be tested, if at all, by an appeal to history. The difficulty is that an expected rise in price acts like a lower discount rate. Before 1982, the oil industry expected that prices were inexorably headed upward. [OGJ 1982, OGJ 1984] In this sense, the industry acted for a time as if their discount

rates were considerably lower than market rates. The oil exporting nations acted just like private parties, but they were much more vulnerable to price decreases--another way of saying their risks were greater.

9. Conclusion

Non-industrial oil exporting countries, as rational income-receivers and wealth-holders, should discount future oil revenues at rates much higher than private oil producers, in no case below 20 percent per year, and mostly above 25 percent.

We drew attention to the Blitzer-Lessard-Paddock paper suggesting that the discrepancy in price risk between oil companies and governments made it profitable for both sides to put the risk on the oil companies, and compensate them for taking it. If our argument is sound, the potential gains are indeed great.

The short horizons of the cartel nations favor large quick price boosts. But they also force some cartelists into breaking away and playing the reluctant price cutter in order to obtain immediate cash benefits, however short-sighted they know their actions to be.

TABLE I
ESTIMATES OF DISCOUNT RATES (REAL) FOR CRUDE OIL AND NATURAL GAS COMPANIES (in percent per year)

Estimator	Time Period	Riskless Rate	Asset Risk Factor (Beta)	Real Cost of Capital on: Equity	Assets
Terry & Hill	1953	n.a.	n. a.	n. a.	8
Eggleston	1964	n. a.	n. a.	n. a.	9
Pogue	1974-78	n. a.	1.070	13.1	11.2
Baldwin, Mason, & Ruback	1978-79	2.0	1.234	n. a.	12.9
Paddock	1960-82	2.0	n. a.	12.0	10.2
	1970-82	2.0	n. a.	11.8	10.0
DataMetrics	1972	0.5	1.12	11.9	9.6
	1982	0.5	1.02	13.3	9.3
Herold	1980s	n. a.	n. a.	n. a.	10-15-20
McPherson & Palmer	1980s	n. a.	n. a.	n. a.	15-20
Arthur Andersen & Co.	1980s	n. a.	n. a.	n. a.	10

[SOURCES: Terry & Hill, Eggleston, in M. A. Adelman, The World Petroleum Market (1972), pp. 53-54. Gerald A. Pogue, in U. S. Federal Energy Regulatory Commission, Williams Pipe Line Co., Docket Nos. OR79-1, et al, Verified Statement, Exhibit GAP-2. Carliss Y. Baldwin, Scott P. Mason, and Richard S. Ruback, "Cost of Capital for the Cold Lake Project", unpublished paper in MIT Center for Energy Policy Research-Sloan School ofManagement Workshop, Energy Project Evaluation, April 21-23, 1983. James L. Paddock, unpublished paper, 1984. Paddock also estimates long-term realized rather than expected returns, which reflect the significant losses to fixed-interest debt holders as average market yields rose: 8.3 and 8.0 percent, respectively. DataMetrics (G. Campbell Watkins), The Oil & Gas Investment Climate: Changes Over a Decade (Canadian Energy Research Institute, Study No. 20, June 1984, chapter 3; capital cost computed. John S. Herold, Inc., periodical appraisals. McPherson & Palmer, op. cit. Arthur Andersen & Co., Oil & Gas Reserve Disclosures (Survey of 300 Public Companies 1980-83 (published 1984).

TABLE I (cont.)
CALCULATION OF COST OF CAPITAL FROM WATKINS STUDY

	1972	1982
Asset beta	1.12	1.02
Equity beta	1.4	1.48
Real c.o.c.	11.9	13.3

Cost of Equity 1972= RF 1972 +Beta 1972 (M1972-RF1972)
11.9 =.5+ 1.4 (M1972-.5)
M1972= 8.643

Cost of Equity 1982= RF 1982 +Beta 1982 (M1982-RF1982)
13.3 =.5+ 1.48(M1982-.5)
M1982= 9.149

Cost of asset capital 1972= .5+1.12(8.64-.5)
= 9.617
Cost of asset capital 1982= .5+1.02(9.15-.5)
= 9.392

TABLE II. TIMELESS ELASTICITY AND
PRESENT-VALUE-WEIGHTED ELASTICITY

Definitions:

Q_b = quantity before price change

Q_a = quantity after price change

P_b = price before change

P_a = price after change

E = timeless elasticity of demand
E' = present-value-weighted elasticity of demand
i = risk-adjusted discount (interest) rate
h = half-life of effect of price change on quantity change
c = annual rate of exponential decay of effect of price change
e = exponential

Relations:

$$e^{-ch} = 0.5, \text{ hence } -ch = -.693, \; c = .693/h$$

$$(P_a/P_b)^{E'} = (1/(c+i)) = (P_a/P_b)^{E*\,(1-(i/(c+i)))}$$

Assumptions:

$P_a/P_b = 1.01$
$E = -1.0$

	h =	3	5	7
hence	c =	0.231	0.139	0.099

Values assumed	E'	Values assumed	E'
c = .231 i = .10	-0.697	c = .231 i = .25	-0.479
c = .139 i = .10	-.580	c = .139 i = .25	-0.327
c = .099 i = .1	-0.496	c = .099 i = .25	-0.322

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