THE CHANGING WORLD PETROLEUM MARKET; RESOURCES, RESERVES AND PRODUCTION

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Abstract

The structural changes in the international oil industry after 1973 led to elements of fundamental disequilibria in respect of the industry's organisation, economics and politics.

The initial post-'73 near-absolute power in the hands of the countries that happened to be oil exporters at the time survived for less than a decade. Both supply and demand side changes first restrained and more recently all but eliminated OPEC's control. Power in the system is once again more widely shared not only with other energy producing countries, but also with other actors (notably the major oil companies) and with consumers.

In economic terms, however, there is a residual expectation and/or acceptance of the validity of high oil prices, viz. of prices which remain significantly above oil's long run supply price (of, say, $10 per barrel in 1992 $). Higher prices paradoxically 'satisfy' both the needs of the exporters for revenues and of importers anxious to curb imported oil demand. Yet the achievement of these objectives makes the high prices unsustainable. In the absence of severe supply disruptions, continuing price weakness can be predicated with a 'more likely than not' price collapse accompanying the re-entry of Iraq to the market.

In political terms, fear of dependence on OPEC/Middle East remains important. Any sense of this recurring — as would certainly be the case in a world of competitive oil markets — will strongly stimulate the search for energy policies which give greater emphasis to supplies which are perceived to be more secure. Such security seems likely to be sought at a regional level so that relatively high cost energy producers will be accorded preference in significant markets (centred on the US, the major nations of Western Europe and the high growth economics of the Western Pacific Rim). In this changed energy sector structure, natural gas seems likely to provide much of the required additional supply so that it could soon become the world's number one energy source.

By contrast, a competitive oil market — inherently globally oriented — will keep oil as the single most important energy source for at least another generation as it will offer more vigorous price competition against the alternatives which have generally been favoured under recent conditions of high oil prices.

The Interesting, But Unimportant Issue of Global Oil Resources

Some fifteen years ago, at the time of the second oil price shock, when the fear of the near-future inevitability of a global oil crisis arising from the impending scarcity of oil gripped the western world and led to expectations of $100 per barrel oil, we published a modest book, with an immodest title, viz. The Future of Oil; World Oil Resources and Use. This sought to demonstrate the extremely low probability that any such supply crisis — and its accompanying high price for oil — would emerge even in the long-term. The 50% probability case showed the capability of oil supply growing exponentially at 1.9% per annum until about 2050 when output would peak at 70 billion barrels: to give an industry three times its 1979 size. (figure 1)

In the meantime the demand for oil has failed to grow at anything approaching that rate. Indeed, the 1980–93 average annual growth rate in use has been well under 0.5%. Even if one excludes the period 1980–85 when oil demand declined, the rate of growth since then has only been 1.1% per annum. At that slow expansion rate in oil use, the 5000 billion barrels of conventional and non-conventional oil resources assumed

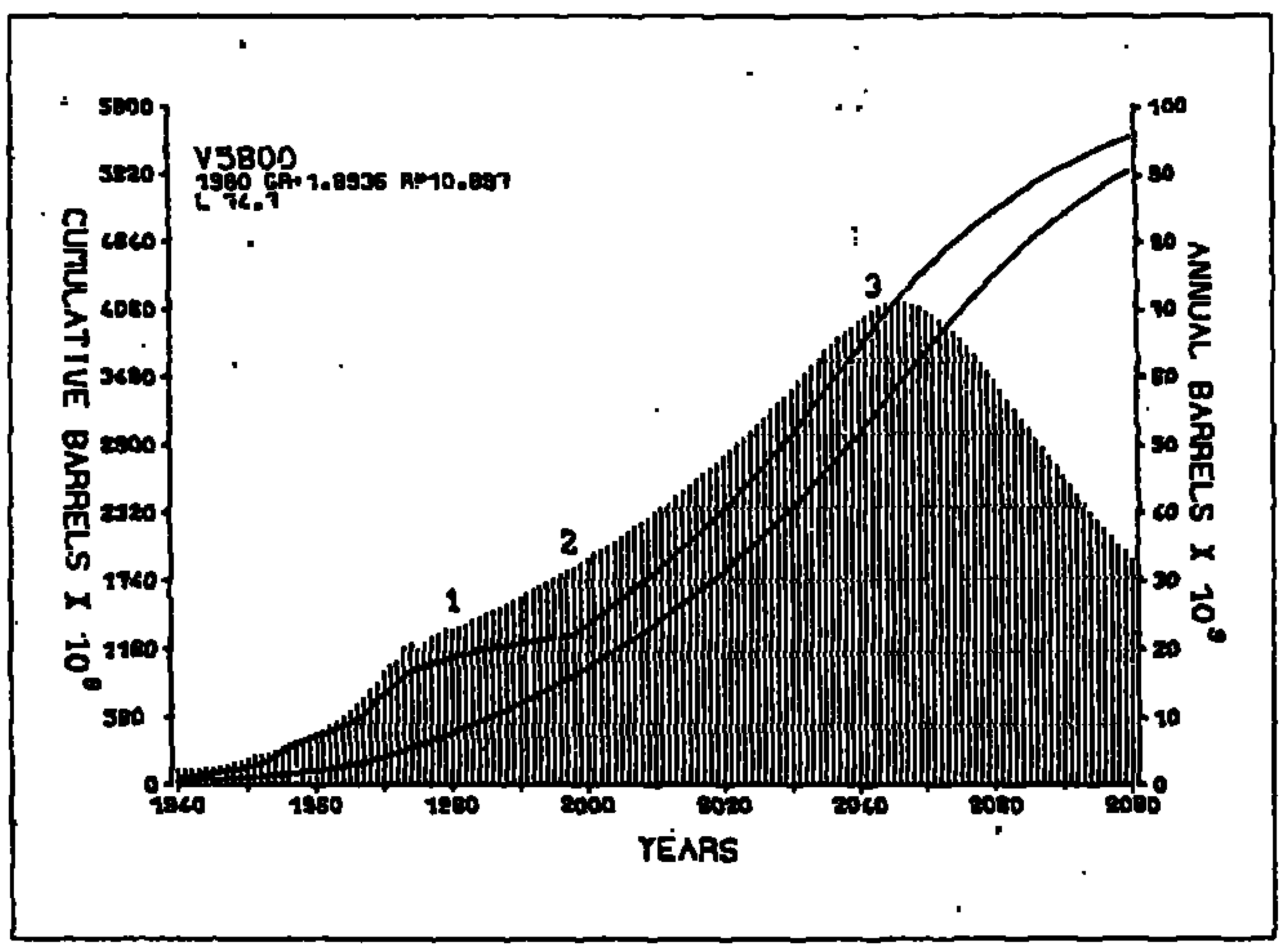

Fig. 1. A simulation of the future of oil : the 50% probability case. This is the case with a 5800 x 10^9 barrel resource base; a 1.9% growth in the demand for oil; and an upper limit of 75 x 10^9 barrels of gross annual additions to reserves. The production profile is shown by the sequence of vertical lines at one year intervals (from P.R. Odell and K.E. Rosing; The Future of Oil, Kogan Page, London, 2nd Edition, 1983).

in the 50% probability case as defined above, would support the industry's development for another 100 years.

In the late 1970s/early 1980s, there remained some doubts as to whether the potential size of the world's conventional oil base could be as big as 3000 billion barrels. Nevertheless, evidence of the previous 40 years' growth in the estimates of ultimate conventional oil resources demonstrated a statistically significant correlation between the date and the size of such estimates, such that extrapolation of the trend appeared not to be unreasonable (given the absence of any indication of a near future cessation of either the growth of knowledge of conventional oil occurrences or of the oil industry's ability to increase recovery rates). The trend's extrapolation (figure 2) implied that a 3000 billion barrel oil resource base would emerge by the late 1980s or early 1990s. The most recent update of the estimates shows that this has, indeed, now become the modal expectation. Complementing that, the existence of a minimum of 3000 billion barrels of non-conventional oil is not in doubt, such that one may reasonably assume its initial availability as producible oil from about 2000, and its ability thereafter increasingly to supplement the supply of conventional oil as this rises to a peak sometime after 2020 (figure 3).

The recent re-emergence of some fears for the future of oil in terms of the inability of resources to sustain increasing production thus remains unjustified by the reality of the world's potential oil wealth; especially in the context of a now generally expected much more modest rate of increase in oil use. In the late 1970s, the then recent history of a near 30-year-long period of an average 7.5% per annum rate of growth in oil use still played a powerful role in determining attitudes to the longevity of oil resources. Today, even those who argue that the last 15 years of an average near zero growth rate in oil use, or the past eight years at only 1.1% per annum, will prove to be an aberration, soon to be ended by continued high rates of growth in the increasingly important industrialising countries, do not anticipate a global average annual rate of growth as high as 2.5%. Others argue for a global industry which will continue to expand much more slowly; at no more than 1.5% per year. In either case, however, the issue of the adequacy of global oil resources as a constraint on the required levels of oil production remains unimportant through until the mid-21st century at the earliest. It is perhaps the now general recognition of this prospect which serves to explain why the earlier vigorous controversy over the question has all but disappeared within the industry.

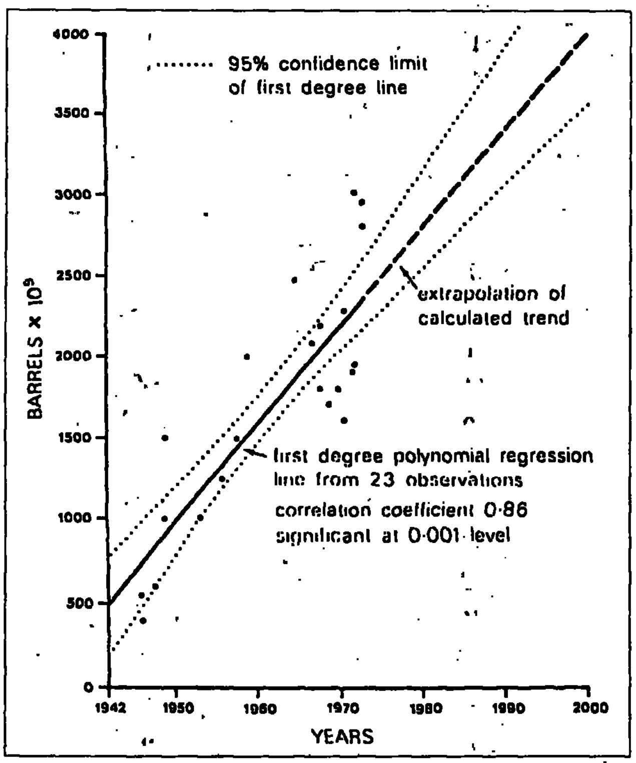

Fig. 2. Historical estimates of the world's ultimate conventional oil resources: with an extrapolation of the calculated trend from 1975 to 2000.

The Adequacy of Additions to Reserves: an Issue of Some Importance

The relationship between annual additions to reserves and annual production has long been a crucial variable in the continuing contemplation of the oil industry's performance and prospects in the United States; and similarly in the evaluation of the performance of individual companies. This is hardly surprising for an oil industry of such relative antiquity (compared with the rest of the world); and an industry, moreover, which, within the context of a unique legal framework and a pattern of organisation, has had an intensity of exploration, appraisal and development which is at least an order of magnitude greater than anywhere else in the world. These historical elements, coupled with a high intensity of indigenous oil use in the US, have produced the need and the willingness to work with a reserves to production ratio at, or close to, its lowest possible value of about 10 years for decades.

As these conditions do not apply elsewhere, it is hardly surprising that the United States' predisposition to give central attention to reserves/additions questions does not have a parallel in any other significant oil-producing country in the world, let alone at the level of the global industry. The little comment there has been on the relationship of reserves additions to production seems, however, to have been mainly based on an inappropriate extrapolation of US experience, with even senior industry spokesmen commenting on what they describe as the failure of the volumes of new discoveries of oil to keep pace with volumes of oil used and/or on the implications of how many years are alleged to have passed since the last giant oil field was discovered. Whether or not such statements are valid is indeterminate, in the absence of an agreed world-wide system of declaring reserves split

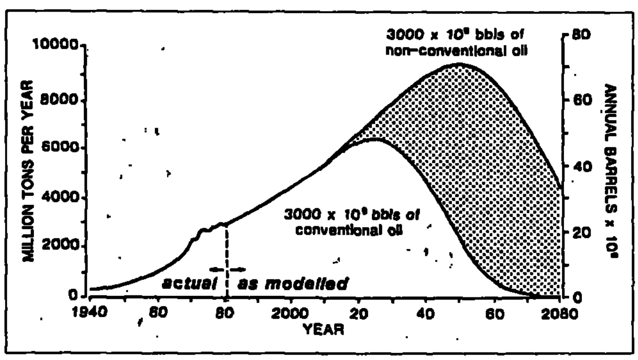

Fig. 3. A simulation of the sequential depletion of 3000 x 10^9 barrels of non-conventional oil under specified growth rates in demand and limits on annual additions to reserves (from Odell and Rosing, see figure 1 for reference).

between new discoveries, field extensions and improved recovery rates. The diversity of types of ownership in the world, compared with the uniquely all-private system of ownership in the US, together with the existence of contrasting systems whereby governments monitor and record (or fail to record) the data in general terms, let alone in terms of details of discoveries and their subsequent performance, prevents any instant and accurate appraisal of what is happening to global reserves.

What data there is, however, suggests that concern for the issue of global additions to reserves is entirely misplaced. Given the global oil industry's lack of maturity compared with the US, the much lower motivation to exploit new reserves as quickly and as intensively as in the US and the much more generous reserves to production ratios, then new discoveries are generally much less significant in the reserves' development process. Instead, the simple overriding impact on reserves, arising from the long-continuing exploitation of the whole set of fields, from the oldest to the newest, is of the essence. The results are, moreover, generally neither presented systematically in terms of types of reserves, nor even recalculated on an annual or regular basis. What is left to examine is thus little more than the aggregated net changes to reserves; after the intervening period's production of the pre-existing declaration of reserves.

As a consequence of these considerations, annual estimates of global oil reserves are necessarily subject to significant variations and these are not necessarily related to what has happened during the year, in respect of the totality of exploration and development efforts. The annual variability in gross additions to global reserves can be clearly seen in table 1. Short-term analysis of the data is inappropriate. Viewed over the whole period, however, the contrast between total gross additions to reserves (over 878 billion barrels) and the total amount produced (used) (just over 439 billion barrels) indicates formidable overall success by the global oil industry in adding reserves only a little short of double the amount of oil used since 1970. In spite of the succession of traumas in the oil market over the 24-year period, the processes of reserves discovery and development have proceeded in a way which justifies the conclusion that the world is running into oil, rather than out of it.

The incidence of reserves additions, however, seems to have little correlation with the changing condition of the global oil industry over the period. For example, the dispossession of the major international oil companies by the newly created state companies in most of the OPEC countries since the mid-1970s is not reflected in the reserves additions data. Nor is there an apparent correlation between prices and reserves growth. The raw data seen in table 1 hint at these anomalies,

Table 1. Proven reserves, reserves/production ratio, oil production and net growth/decline in reserves over the 20-year period from 1973 (in barrels x 10^9).

Proven reserves at the beginning of year (R/P ratio in years, in brackets)		Production of oil in year	Gross additions to reserves in year	Net growth (+) or decline (-) in reserves in year
1973	577 (29.9)	21.2	35	+14
4	591 (27.9)	21.2	32	+11
5	602 (28.4)	20.2	31	+11
6	613 (30.3)	21.9	4	-18
7	595 (27.2)	22.6	16	-7
8	588 (26.0)	22.9	45	+22
9	610 (26.6)	23.7	22	-2
1980	608 (25.7)	22.8	34	+11
1	619 (27.1)	21.3	67	+46
2	665 (31.2)	20.1	30	+10
3	675 (33.6)	20.0	21	+1
4	676 (33.8)	21.1	44	+23
5	699 (33.1)	20.5	30	+9
6	708 (34.5)	21.4	67	+46
7	753 (35.2)	21.9	113	+91
8	844 (38.5)	22.8	99	+76
9	920 (40.3)	23.5	72	+48
1990	968 (41.2)	23.8	40	+16
1	975 (43.1)	22.6	30	+7
2	997 (41.8)	23.9	46	+22
Total 1973–92		**439.4**	**878**	**+439**

Sources: Reserves' developments based on data from the annual survey of world oil reserves in the Oil and Gas Journal, 1973–93; from World Oil, 1973–92 and from De Golyer and MacNaughton's Annual Survey of the Oil Industry, 1975–83. Annual production data from the Petroleum Economist, 1974–1993.

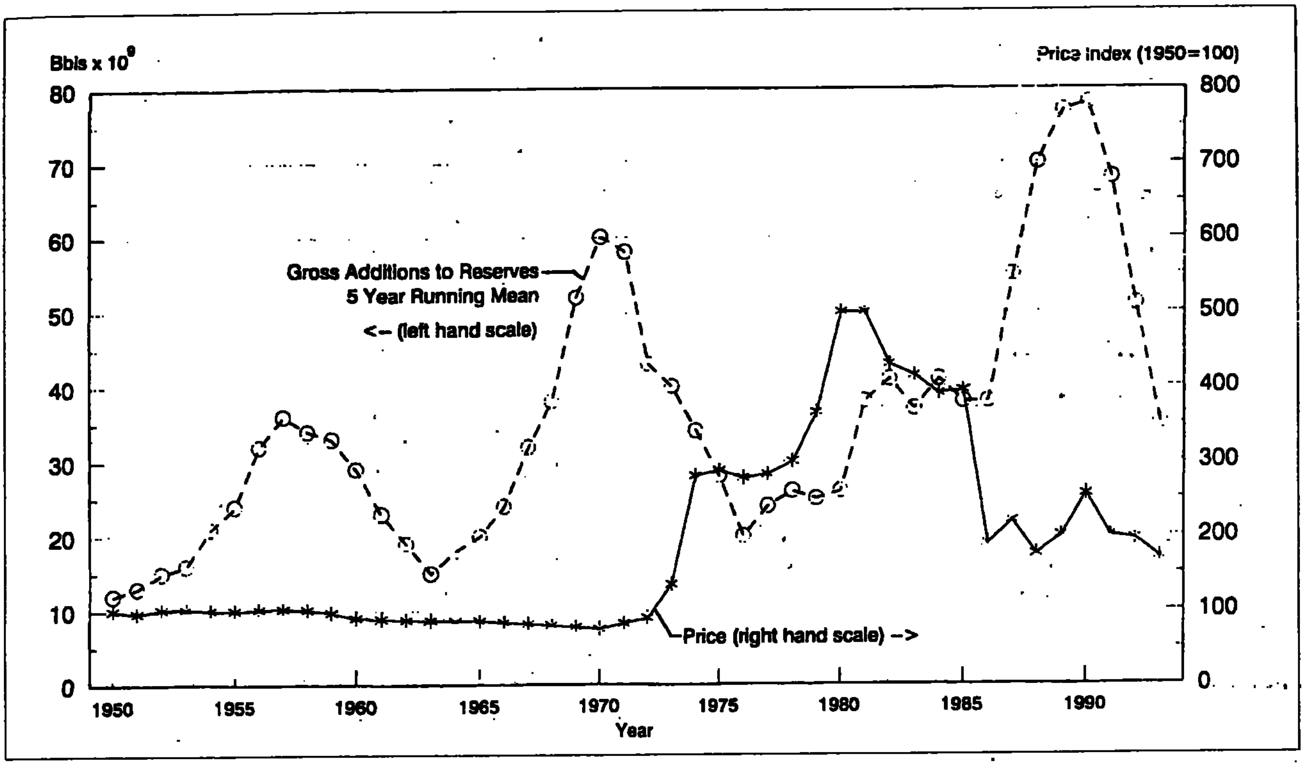

Fig. 4. The 5-year running mean of gross additions to reserves, 1950–1992 and of the price of crude oil indexed to the price in 1950 (in 1992 $ values).

but in figure 4, in which the reserves additions data since 1950 are smoothed, through the calculation and presentation of a 5-year running mean (so as to reduce the impact of the yearly variations in the reporting system), one sees more clearly the difficulty there is in relating the evolution of reserves to the changing structure of the industry and to the oil price.

In the early 1970s the low reserves additions can perhaps be correlated with the uncertainties faced by the then dominant international oil companies in the run-up to the first oil crisis and the immediate aftermath of that event. But their replacement as the decision takers on exploration and development activities by the inexperienced state companies of the OPEC countries was not marked by a continuing period of low additions to reserves: as might well have been expected, given the loss of expertise and of the access to investment funds involved in the change. On the contrary, since 1976 a continuing success appears to have attended the global industry's efforts. Unless, of course, as a number of analysts had suggested in earlier years, there had, indeed, been a persistent understatement of reserves previously discovered by the international oil companies for reasons related to their wishes not to declare themselves too successful, for fear of further intervention in their concessions. Subsequently, some of the very high reserves additions also appear to have been motivated by the idea that OPEC should quota production in relation to declared reserves.

Movements in the real price of oil (1950=100) are also shown in this graph. The sharply contrasting pattern of price changes, on the one hand, and of reserves additions, on the other, now becomes quite explicit. The late 1950s/early 1960s dip in the otherwise strong upward trends in reserves development between 1950 and 1970 is not explicable in terms of the movements in the oil price which, over the years concerned, simply continued its inexorable loss of value. On the other hand, the early 1970s strong increase in price was accompanied by a steep decline in reserves additions. The strong upturn in reserves did not materialise until the highest prices of 1979/81 were already past. Since then reserves volumes have continued to advance, in spite of more or less continuously falling prices since 1982.

In the absence of an apparent explanation for the phenomenon of reserves addition related to industry structure and/or price, one has to conclude that geological and political factors, rather than economic and managerial, have principally been involved in determining the global reserves' development process. This possibility can best be tested on a national or a regional basis as this is the geographical scale on which such factors operate. This is done in the following section of this paper: but first, it is appropriate to define why the US must be excluded from the analysis. There, as already indicated, the reserves development process has been constantly motivated by short-term demand considerations, with an industry objective of ensuring the replacement of oil used in a continuing situation of a minimum reserves to production ratio. The situation is thus quite different from that in the rest of the world.

The Geography of Reserves Development: an Issue of Great Importance

The under-exploration and limited exploitation effort (as measured by the number of wells drilled) is graphically portrayed in figure 5. This shows the relationship, on a regional basis, between exploration/development activity, on the one hand, and the geographical extent of actual and potentially petroliferous areas, on the other. The United States' situation constitutes the basis for comparison and, in

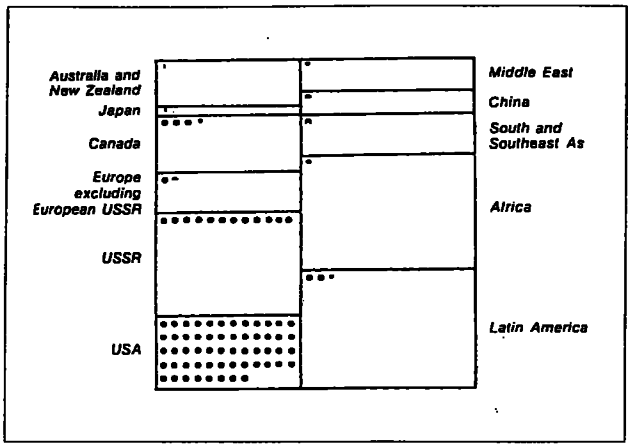

Fig. 5. The regional distribution of the world's potentially petroliferous areas shown in relation to the world total. Within each region the number of exploration and development wells drilled to 1975 is shown. Each full circle represents 50 000 wells.

this context, it appears that no other part of the world has been more than "scratched" in the search for oil.

This is even true for the Middle East, where approximately two-thirds of the world's reserves are concentrated, so that almost any additional drilling there has a high probability of either finding new oil-fields or extended reserves from existing fields. Thus, since 1973, in spite of a less than systematic, continuing and intensive exploration and field development process in the region, remaining proven reserves of oil have increased from 350 to 625 billion barrels; even though production over the 20-year period has totalled more than 125 billion barrels. These data indicate an average annual gross additions to reserves of 20 billion barrels, which, in round figures, is only a little short of the global average annual use of oil over the same period. Viewed in narrowly economic terms, 85% or more of the Middle East's proven oil reserves are irrelevant; they simply have no net present value.

Elsewhere in the world (outside North America and parts of the former Soviet Union), the areas of maturity in respect of oil exploitation are very limited: essentially to a few locations such as the Gulf coastal strip of Mexico, the periphery of Lake Maracaibo in Venezuela, parts of Indonesia and some small petroliferous zones in Europe. In each of these, the industry dates back to the 19th or the early 20th century. Otherwise, most upstream petroleum activities date only from the past 25 years or so, related principally to the motivation for exploration and exploitation created by the post-1970 rise in prices. In a few petroliferous areas, where access to appropriate technology, managerial know-how and investment has not been a problem, progress in upstream oil activities has been rapid in response to the highly profitable opportunities created by oil priced, in real terms, at four to seven times its 1970 value. Notable among such regions in the industrialised countries, are the North Sea, Canada and parts of Australasia. In spite of the fact that these are also major oil-consuming areas, so giving a high motivation for discovered oil to be brought quickly into production so that output over the last 5 years was almost three times greater than in the five year period from 1973 to 1977, the areas' remaining proven reserves have, nevertheless, been generally more than maintained since 1973. Gross additions to reserves over the 20-year period total over 36 billion barrels. The significant petroliferous regions that have been discovered have usually contained large (even giant) fields and, in response to an intensive search and exploitation effort, they have become important elements in the world's upstream oil industry. Though well behind the Middle East (and other OPEC members) in terms of the size of their proven reserves, the exploitation of their reserves has provided many companies with a welcome diversification of their production activities.

For this group of countries it is self-evident that political, as well as the favourable geological, considerations have been influential in their recent petroleum exploitation history. In essence, they have all had political regimes which have been favourable to oil companies' aspirations: in terms of strong, stable and recognisably fair governments with respect to the industry's investments. The countries' petroleum exploration and exploitation regimes — in terms of concessions or contractual arrangements and of tax rules and rates — have generally generated enough confidence amongst the oil companies to persuade them to make large-scale investments. In most cases, moreover, they were, as indicated, already countries with oil-intensive economies so that there was, if need be, the prospect for the immediate disposal of any locally found oil into the local or regional market. Collectively their indigenous (or regional) oil consumption of more than 110 billion barrels since 1973 has provided more than adequate markets for the 37 billion barrels of oil produced in the countries concerned.

For such countries the success of post-1973 upstream petroleum development is, with hindsight, hardly surprising. Nevertheless, the scale of the developments were not always foreseen. Notable amongst the highly pessimistic interpretations of the prospects, by both companies and governments, were those for the North Sea oil province; the extent and exploitation of which is shown in figure 6. Even after the first oil price shock raised net unit revenues to levels which justified much increased investments; and even though the latter then, in turn, led to large additional discoveries and to technologically advanced production systems, there remained an unwillingness to accept the clear evidence of the high up-side potential which the region's petro-geology indicated — in terms of field size, recovery rates and high percentage success rates for continuing exploration.

As a result, the North Sea's oil prospects were generally presented as unlikely to contribute anything more than a modest small addition to Europe's oil supplies. At best, it was argued, there might perhaps be reserves enough to meet the region's additional requirements for oil for a limited period of time. Such views then led to policy reactions which reflected fears for near-future reserves exhaustion. Thus, exploration and/or depletion constraints were introduced, so threatening the expansion of production in the short term and the continuity of reserves additions in the longer term.

In spite of these negative aspects of the history of the North Sea, the overwhelming attraction, in both economic and political terms, of North Sea oil and gas to virtually all of the world's largest private oil companies (combined with the positive impact of the state oil enterprises of Norway and the UK, as well as those of other European companies) eventually led to an exploration and development effort of such a magnitude that its results swamped the pessimism in a plethora of new finds of major significance, by more cost effective technologies for their development, from higher recovery rates than expected from most of the fields, from the growing ability to exploit reservoir extensions and nearby fields, through the original investments in production platform complemented by sub-sea completion facilities, and by the falling real costs of servicing the fields and of transporting the oil to the onshore terminals.

In the context of such a formidable range of positive geological and technological factors, neither the fall in oil prices from 1981, nor even their collapse in 1986, did more than create temporary short-term hiccups in the increasing levels of production. Indeed, in the medium term, the price falls motivated the companies to achieve cost reductions so as to maintain economic viability against the lower unit revenues. Moreover, because of the progressive nature of the tax

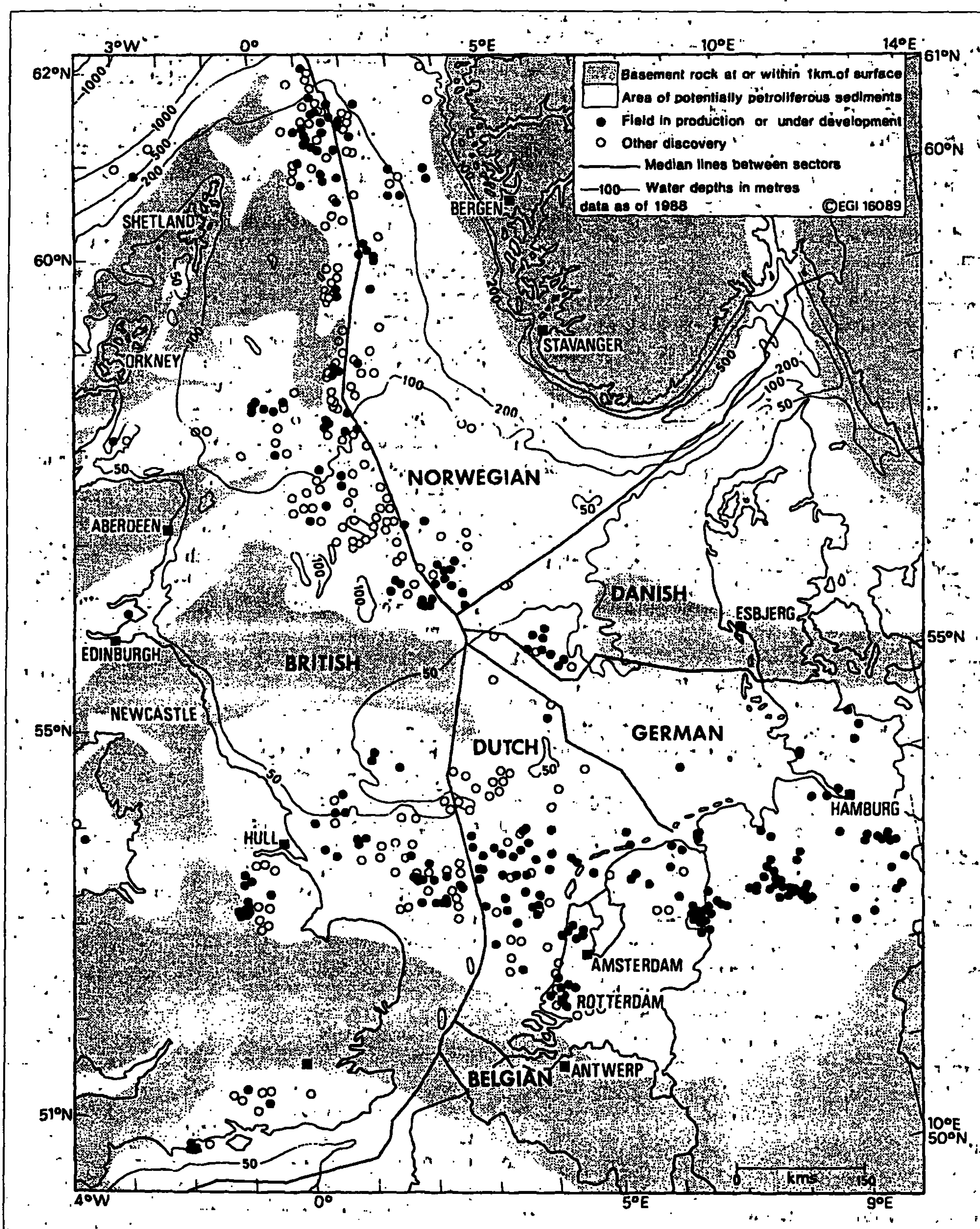

Fig. 6. The North Sea oil province.

regimes which Norway and Britain had imposed, the fall in revenues generated by declining prices, mainly impacted on the governments' tax-takes, rather than on the companies' profits. Finally, in the more stringent economic climate created by lower prices, the governments took steps to modify their tax regimes, so as to make them less onerous for most companies and thus maintain the latter's interest in continued investment.

As a result, the North Sea oil province has come through to the early 1990s generally unscathed by an oil price which is now back, in real terms, to less than its pre-1979 level. Indeed, in late 1993, Norway and Britain, together producing more than 5 million b/d, became the world's fifth and sixth largest non-OPEC producers; and ahead of all member countries of OPEC, except Saudi Arabia, Iran and Venezuela. Moreover, The Netherlands and Britain are the world's fourth and fifth largest natural gas producers, and together with Norway and Denmark, supply over 200 Bcm (20 000 mcfd) to the rapidly expanding West European gas markets. Similarly, though quantitatively less important, with most of the other newly developed oil provinces that lie within the same category as the North Sea in geological and political terms, rapid expansion in the decade of rising prices has been followed by consolidation and more modest growth since the mid-1980s.

Meanwhile, there is a larger set of countries in which post-1973 incentives to find and develop oil resources have had a significant impact on global production patterns and on reducing dependence on OPEC oil. This set consists of the developing countries outside OPEC. Prior to 1973 these countries, increasingly and eventually heavily orientated to oil use for energising their economic growth, were largely dependent for their supplies on crude imported mainly from the OPEC countries; with the oil bought either in government-to-government deals or, more usually, through the supply systems of the international oil companies. Their own upstream oil industries' development had been thwarted by the low prices for internationally traded crude, (which undermined the viability of investment in indigenous oil) and/or by their non-acceptance of the international oil companies as concessionaires for oil exploration and exploitation.

The post-1973 oil price rises in the context of their heavy dependence on imported oil and their international indebtedness, coupled with adverse balance of payments situations, necessitated a change in attitudes and policies towards indigenous oil development potential. Their own considerable petroliferous potential had been under-evaluated — given the alternative more rewarding opportunities for the oil industry's investment in the OPEC countries — but for many of them there was a high probability that indigenous oil could be found and produced given appropriate policies. These necessarily related to the ways in which sufficient expertise and investment could be attracted to get effective exploration programmes established.

In a number of the countries, state oil companies succeeded in accelerating and expanding their exploration and development activities as governments allowed them to retain profits for investment and/or permitted oil to be priced realistically. In many others, however, governments improved the terms of concessions or contracts for oil exploration and production by private foreign oil companies. As a result reserves in existing oil provinces have been built up and other areas of oil potential were successfully explored. Table 2 indicates the achievements in respect of increased oil reserves, increased production and a reduction in dependence on imports over the 20-year period, 1973–1993.

Production, meanwhile, increased threefold, from 3.5 to 10.5 million b/d, while oil consumption merely doubled. In 1973 the countries' net imports of oil were 2.8 million b/d, equal to 75.5% of indigenous production and to 44.3% of oil use. In 1992 imports were down to only 1.7 million b/d, equal to only 15.9% of indigenous production and 14% of oil use. The achievement had been relatively greater still in 1987 (when net imports were down to only 0.6 million b/d), but the deterioration in the relationship between production and use over the past five years reflects almost exclusively the recent much increased rate of growth in oil use in the rapidly expanding economies of the Western Pacific Rim and South East Asia. In this region three of the most important economies, viz. South Korea, Taiwan and Hong Kong have no oil production and, in any event, they have now achieved such strong economies (unlike most of the rest of the non-OPEC developing countries) that increasing oil imports are not a burden. It is important to note that the deterioration does not reflect any significant reduction in the expansion of the indigenous oil production effort amongst the developing countries which have potential; their collective output has continued to grow at up to 5% per annum.

Similarly, as also shown in table 2, these countries have achieved a development of proven reserves equal to the degree required to sustain the increase in production noted above. Their proven reserves in 1973 totalled only some 35 billion barrels. Cumulative production since then has been over 50 billion barrels, but nevertheless, their proven reserves are now estimated at some 95 billion barrels, indicating gross reserves additions over the 20-year period of almost 125 billion barrels. The reserves to production ratio has thus been maintained at about 25 years, in spite of the three times greater production in 1992 compared with 1973.

With few exceptions, the developing countries outside OPEC still have oil industries which are in the earliest stages of development. The extent and intensity of exploration has, to date, been modest so that there is a very low probability that they are even approaching their peak production potential. They do, of course, have to maintain their motivation to continue to expand as oil producers, but this seems highly likely, even in conditions of relatively low oil prices, as their external economic relationships remain generally weak and especially exposed to balance of payments problems. Given these conditions the shadow-prices for their oil imports are well above the presently low international market price for oil.

Viewed in now somewhat outdated politico-economic terms, the remaining group of countries which have a significant part of the world's proven oil reserves portfolio is that of the formerly centrally planned economies, viz. *first*, the former Soviet Union and its dependencies in Eastern Europe and *second*, China. In 1973 this set of countries was estimated to account for about 37% of non-Middle East proven reserves (viz. over 100 billion barrels), though note that this estimate probably tended to overstate the share because of differences between western and eastern definitions of reserves. These countries' share of total non-Middle East production at that time was, however, much lower, at only about 25%. They were in 1973 thus relatively better off in respect of oil supply

Table 2. Oil reserves, production and use and import dependence in the non-OPEC developing countries, 1973–1992.

Year	Reserves at Jan 1. (bill.bbls)	Production (mill. b/d)	Reserves/ Production Ratio (years)	Use (mill. b/d)	Net Oil Imports (mill. b/d)	Imports as % of Prod %	Imports as % of Use %
1973	35.3	3.50	27.4	6.28	2.78	79.4	44.2
1974	35.0	3.44	27.9	6.46	3.02	87.8	46.7
1975	36.0	3.76	26.1	6.42	2.66	70.7	41.4
1976	35.2	3.94	26.9	6.72	2.78	70.6	41.4
1977	44.9	4.18	23.0	7.00	2.82	67.5	40.3
1978	44.5	4.46	27.3	7.30	2.84	63.7	38.9
1979	47.5	5.14	25.3	7.60	2.36	47.9	32.4
1980	57.1	5.70	27.4	7.98	2.28	40.0	28.5
1981	71.5	6.34	30.9	8.06	1.72	27.1	21.3
1982	83.0	7.00	32.3	8.48	1.48	21.1	17.5
1983	78.1	7.36	29.0	8.52	1.16	15.8	13.6
1984	82.0	7.88	28.4	8.82	0.94	11.9	10.6
1985	82.0	8.24	27.1	9.04	0.80	9.7	8.8
1986	89.0	8.25	29.5	8.94	0.69	8.2	7.6
1987	86.9	8.68	27.4	9.30	0.62	7.1	6.7
1988	96.4	9.02	29.2	9.96	0.94	10.4	9.4
1989	98.6	9.54	28.3	10.52	0.98	10.3	9.3
1990	90.5	9.98	24.8	10.98	1.00	10.0	9.1
1991	91.3	10.32	24.2	11.52	0.80	11.6	10.4
1992	92.2	10.54	24.9	12.26	1.72	16.3	14.0

Sources: Oil and Gas Journal Annual Worldwide Reserves Report, 1972–1992 and British Petroleum's Annual Review of World Oil (Energy) 1973–1992

potential than other regions of high and increasing oil demand.

Since then, however, their position has quickly deteriorated. By 1980 their share of non-Middle East reserves was already down to 30%, while their share of production was up to 34%. Their proven reserves had, in absolute terms, fallen to a little over 86 billion barrels. By 1987, when oil production in the USSR and Eastern Europe peaked, their reserves had further declined to a little under 80 billion barrels while production had increased to almost 16 million b/d. By this time their share of non-Middle Eastern reserves was down to under 24%, while their share of production remained at about 34%. The reserves to production ratio, of a set of countries which had elevated self-sufficiency in oil to the status of a principal planning objective, has thus fallen to only 13.6 years, compared with 29.9 years in 1973. Doubts already expressed some years earlier by outside analysts concerning the ability of the USSR's reserves — and, even more important, its annual rate of reserves' discovery — to sustain the country's production policies now became very evident. But 1987 turned out to be the peak year of production (after half a decade of increasingly desperate attempts to keep production above 12 million b/d). Since then, initially for reasons related directly to physical and economic parameters, but from 1989 also to political issues arising out of the difficulties and subsequent collapse of the traditional Soviet regime, output has fallen year by year. By 1992 it was down to only 73% of its 1989 level and had fallen to under 25% of the global total outside the Middle East. Meanwhile, declared proven reserves have stabilised at just over 80 billion barrels so that, given the decline in production, the R/P ratio is now back up to about 20 years.

For the former Soviet Union, in particular, even with the reduced rate of production levels in recent years, remaining proven reserves have been reduced by about 2 billion barrels. This appears to indicate that the oil industry has only survived the last five years of difficulty as well as it has by living in part off its accumulated capital (in the form of previously discovered reserves). In the short-term, the deteriorating reserves position is not perhaps of great consequence in setting production limits as these are more immediately related to the continuing decline in oil use (which has fallen by over 20% since 1987) and to the ability or otherwise of the industry to cope with the shortage of essential equipment; or even to pay the work force. The trend in reserves does, however, have important implications for the medium-term ability of the oil industries of the post-Soviet republics to restore production to the higher levels of previous years, once the initial problems of the traumatic political changes have been overcome. Herein lies one of the less positive aspects of the prospects for global oil supplies for the rest of the 1990s.

Meanwhile, China is becoming relatively more important compared with the Soviet Union and its successor states. Its oil use, production and reserves have all continued to increase since 1973, but its long-standing export surplus has gradually been whittled away by an increase in the rate of consumption, consequent upon more rapid economic growth in recent years, greater than the increase in annual production. Nevertheless, China has succeeded in maintaining annual additions to reserves in excess of production and it still has a relatively high reserves to production ratio of more than 22 years. Geological opportunities and the political will to avoid becoming a significant oil importer suggest that Chinese policies towards the international oil industry will be adjusted, as necessary, to ensure the continuing expansion of production and of reserves' discovery through the 1990s: though probably not quickly enough to avoid the country becoming a small net importer of oil in the middle of the decade.

The Prospects for Global Oil Supplies to 2010

The Middle East's massive oil resources, ultimately discoverable reserves, proven reserves and annual additions to reserves are essentially irrelevant to the region's most likely required contribution to global oil supply, in the context of oil priced at more than $15 per barrel as a result of OPEC's controls on its members' production levels.

Since 1973 the Middle East's remaining proven reserves have virtually doubled (from 350 to 662 billion barrels) in spite of a cumulative output over the 20 years of more than 125 billion barrels. Current proven reserves, measured against an annual output of more than 18 million b/d, indicate a reserves to production ratio of 100 years; compared with an R/P ratio in 1973 of only 45 years. Thus, even with the highly improbable prospect of no further additions to reserves from existing fields in the region, nor any new discoveries whatsoever; and further assuming an annual increase in production at the same rate as in the period 1986-93 (viz. 4.9%), it would take well over a decade merely to bring down the R/P ratio to its 1973 value. As the industry in the Middle East is hardly likely to take an exploration and development "holiday" for the next ten years, such an early return even to the generous reserves/ production ratio position of 1973 is out of the question. The real supply side restraint, in such an undemanding demand-side scenario for Middle East oil, is the availability of timely and adequate investment for the near 50% increase in production capacity required over the period. Even this constraint, however, appears to be unrealistic, in that a sustainable annual increase in supply from the Middle East at an average near 5% per annum in a world in which oil use is increasing at less than 2% per annum implies limitations on supplies from elsewhere which would be politically unacceptable.

Indeed, with a continuing low global oil use growth outlook, there seem likely to be only modest increases in the residual need for Middle East oil in those parts of the world where, as shown in the preceding section, there are likely to be steadily rising supplies available from indigenous or regional production. Quantitatively, the non-OPEC developing countries are the most significant in this respect, in terms of both production potential and oil use. Their collective output has, as already indicated, now exceeded 10.5 million b/d. Of the existing main producers, only India has failed to maintain the expansion of its upstream oil industry, mainly as a result of inappropriate policies which have given inadequate encouragement for exploration and development even for its own state oil enterprise, let alone for private foreign investment. For every other major non-OPEC developing country producer, the continuation of appropriate exploration and exploitation policies appears likely to ensure continuing development which is not only sufficient to offset the impact of the depletion of existing producing fields, but also to provide for growth in production. For those countries where the industry has been kept in the state sector, positive cash flows created by previous upstream oil industry successes serve to diminish earlier bottlenecks to expansion caused by external financing requirements. In most other countries contractual and fiscal regimes attractive enough to foreign oil investments have been put in place.

In addition, there are clear indications that a number of countries which have been minor producers to date will become much larger producers over the next five years. This is the result of recent highly successful exploration in areas of significant potential and of newly implemented policies for encouraging oil developments. The additional potential larger producers include Colombia and Argentina in Latin America, Yemen in the Middle East, Vietnam and Papua New Guinea in Asia and a number of countries in West Africa.

Taken together, the increases from most of the existing large producers plus the initially significant production from the newly developed fields in a number of other developing countries will keep the overall total production moving slowly up. The increase does not, however, seem likely in the short term to be sufficient to prevent the continuing rise in net imports by this group of countries (as shown already, net imports have been rising from 1987). Thus, dependence on OPEC supplies will increase from its present low level of 14% of oil use, but it seems unlikely to become a flood, as balance of payments and other constraints on oil imports would once again come into play to counterbalance such a development. Such economic considerations would, moreover, complement political considerations which also serve to inhibit the re-emergence of oil import dependence.

Moreover, the possible emergence of two, or even three, non-OPEC developing countries as much larger producers of oil over the decade cannot be excluded. This would have the effect of reversing the trend towards more net imports. Colombia and Vietnam are probably the best candidates to fulfil such a role; the former because of the imminent large-scale exploitation of the giant Cusiana field by BP, in the context of a slowly improving political and security situation in the country; and the latter as a result of the large number of significant offshore finds already made by the wide range of companies which already have commercial interests in their development. Moreover, US companies will shortly be added to this range as the location of the country in the epicentre of increasing global oil demand and the positive oil regime under which exploration and development in Vietnam is now encouraged overcome the political problems which have, to date, made their participation impossible. As in previous decades, supply-side surprises in the 1990s seem much more likely to be favourable, rather than unfavourable. They could, indeed, be critical in establishing new fundamentals for market developments in both Latin America and the Western Pacific Rim in the second half of the decade.

The second most important quantitative supply side element for the 1990s, in the context of the oil price (in real terms) remaining above $18 per barrel, is the prospect for the North Sea and other nearby northwest European offshore areas. As already described, under conditions of a falling oil price the productivity of investment rose sharply in the late 1980s/ early 1990s. This encouraged the continued search for, and the development of, new capacity; a development which has recently been reflected in a near 20% increase in production in the course of 1993. In the context of a near stable demand for oil in Europe, this has led to a renewed upward trend in the contribution of indigenous oil to total supply. It now stands at almost 40%, the highest ever. Even with prices declining still further, to a low of $15 per barrel, the expansion of northwest European output is likely to continue to edge up, with surprises more likely to be up-side, rather than down-side, as the prospects both for important field extensions and new discoveries remain good. Meanwhile, the demand for oil in Europe will remain close to present levels as consumer prices rise in response to governments' additional taxation on oil products for a combination of environmental and revenue-needs reasons.

Elsewhere in the world, the uncertainties in the US and the former Soviet Union seem likely to cancel each other out in terms of their net effects on the world market. Production in the former will drift slowly down, so necessitating a rising demand for imports of the order of an additional 200 000 b/d per year. This increase in the net US import requirement happens to be of the same order of magnitude as the prospective annual growth in Russian (and other former Soviet Republics') oil exports in the second half of the decade, resulting not only from the initial commitments of private foreign investment and of western development aid to the former Soviet oil industry, but also from the expected continuing decline in domestic demand for oil as efficiencies in energy use are generated through higher prices and improved technologies.

Table 3 summarises the impact to 2010 of the foregoing interpretation of the outlook for oil supplies' development; on the assumption that prices will be maintained at above $15 per barrel through OPEC production quotas and in the absence of significant structural change in the organisation of the industry over this period. The post-1996 relatively slowly growing volumetric contribution by the present members of OPEC to global oil supply represents the residual amount of oil required to clear the market in the context of an average annual increase in oil demand of under 1%; based on an assumption that the real prices of oil products to consumers in most parts of the world will continue to rise from a combination of increasing real costs in the downstream sector of the industry and of increasing taxation on oil products for environmental and other reasons. Enhanced competition for oil from natural gas in many parts of the world will also serve to constrain the rate of growth in oil use. There is, of course, also an assumption that OPEC as an organisation will continue in existence with its present members and that it will quickly revert to its pre-June 1993 policy of constraining supplies, so as to maintain prices.

An Alternative Prospect

Faced with the prospect of little better than a stagnant market at a price which rises little, if at all, in real terms for the next twenty years, OPEC's members could, however, decide to take action to expand the demand for their oil. OPEC oil does, after all, constitute over three-quarters of the world's known reserves. Most of these reserves are, moreover, lower cost to produce than almost any alternative supplies. Such action would, however, involve not only deep price cutting, but also very large and early investment in capacity expansion so that, even if this were politically acceptable to all OPEC's members, it could still be economically difficult for many of the countries concerned. In essence, it would separate out the Gulf members from the rest (with the possible exception of Libya and Venezuela). It would thus, on the one hand, undermine the solidarity of the organisation while, on the other, it would raise the spectre amongst the world's oil importing countries of renewed heavy dependence, for an economically vital commodity, on the oil exporting countries of the Middle East.

In many respects the development would represent a return to the pre-1973 situation, when both Western Europe and Japan, as well as many developing countries, became dependent on the Middle East for upwards of 90% of their oil needs. It would likely even necessitate the major re-involvement of the major multi-national oil corporations in respect of the investment, expertise and managerial input which the Middle East producers would have to have in

Table 3. Global oil supplies 1995–97, 2000 and 2010 (in millions of b/d).

	Estimated Actuals 1993	1994	1995	Forecasts for 1996	1997	2000	2010
World Total	64.7	65.2	66.2	67.1	67.7	69.1	75.4
FSU, Eastern Europe and China	11.2	10.8	11.3	11.6	12.0	12.8	16.2
Internal Use	9.7	9.4	9.5	9.6	9.8	10.3	13.2
Net Exports	1.5	1.4	1.8	2.0	2.2	2.5	3.0
OPEC's Present Members	26.8	27.4	27.9	28.3	28.6	28.9	29.4
Rest of World	26.7	27.0	27.0	27.2	27.1	27.4	29.8
US/Canada	10.7	10.4	10.2	10.1	9.9	9.7	9.5
Rest of OECD	5.5	5.7	5.8	5.8	5.8	5.8	5.5
Other LDCs	10.5	10.9	11.0	11.3	11.4	12.0	14.8
Total Supply to Market Economies	55.0	55.8	56.7	57.5	57.9	59.0	62.2

Source: Estimated Actuals for 1993 based on BP's Statistical Review of World Energy, 1993. Forecasts are the author's own.

order to secure the required major expansion to their upstream oil industries. Indeed, such large-scale input of these production factors seems unlikely to be available to the countries concerned in any other way. Certainly, the combination of the companies' know-how and financial strength with the limitless (in practice) oil reserves of the region would provide a powerful combination in economic terms for the re-establishment of international oil as a significant growth industry: and could thus effectively undermine the validity of the more modest long-term prospects for it, as indicated above. Such an alternative prospect would, however, pose questions as to the acceptability of its consequences elsewhere in the world and could thus lead to reactions which would serve to undermine its viability.

Apart from a powerful political concern in importing countries over a prospective development in which Middle East supplies once again come to dominate the oil market — and which, in itself, would probably generate sufficient fears whereby protective steps were taken to reduce the threatened exposure to dependence — there would also be reactions related to economic considerations by other energy/oil-producing countries. First, there would seem likely to be actions designed to safeguard the future of indigenous energy-supply industries in many countries as a means of maintaining a lower level of energy import dependence. Second, the non-Gulf member countries of OPEC, finding the viability of their own oil industries in danger (compare the decline of the oil industry of Venezuela in the 1960s when it was out-competed by Middle East oil) and thus facing potentially severe adverse effects on their economies, would be obliged to seek alternative alliances and relationships which reflected those concerns.

In these circumstances, the stage would be set for a potential regionalisation of the global oil industry based on a perception of mutual economic and political interests between contiguous or proximate exporters and importers. The most important elements of such a regionalisation of the oil market would be the adherence of the non-Middle East major oil-exporting countries (both former OPEC members and those countries which never became members of the organisation, in spite of the importance of their oil exports, for example, Mexico and Egypt) to energy-trading blocs built around the three geographical groupings of OECD countries, viz. North America, Western Europe and Japan/Australasia. A possible 'shape' for the blocs and the location within them of oil exporters and potential exporters is shown in figure 7.

Precursors to such a regionalisation of a hitherto global market already exist in the more general politico-economic policies which are already at work in efforts to sustain and develop such regional geographical linkages. First, there is the North American Free Trade Area which Mexico, an important non-OPEC producer and exporter, has recently joined. The oil-exporting countries of northern South America seem unlikely to find their membership of that organisation an unacceptable proposition, providing they could secure unfettered and preferential access to the US oil market. Second, in the Far East, both ASEAN and Japanese policy makers are already discussing an intensification of regional economic relationships in general. Within such a development, intra-regional trade in oil (plus gas and coal) would fit very nicely, so that appropriate terms and conditions of energy trade within the region could be readily negotiable. Third, for Europe, links with the successor states of the Soviet Union, with their potential for larger scale oil (and, even larger scale, gas) exports, are already being established. This is partly under the influence of a self-evident mutuality of interests in oil and gas and partly in the institutional context of, for example, the developing European Energy Charter Organisation, the Baltic Cooperation initiative and the operations of the European Bank. North (and even West) Africa's close association with this regional grouping is already an important component in the oil and gas exports of the area's OPEC members, viz. Algeria, Libya and Nigeria.

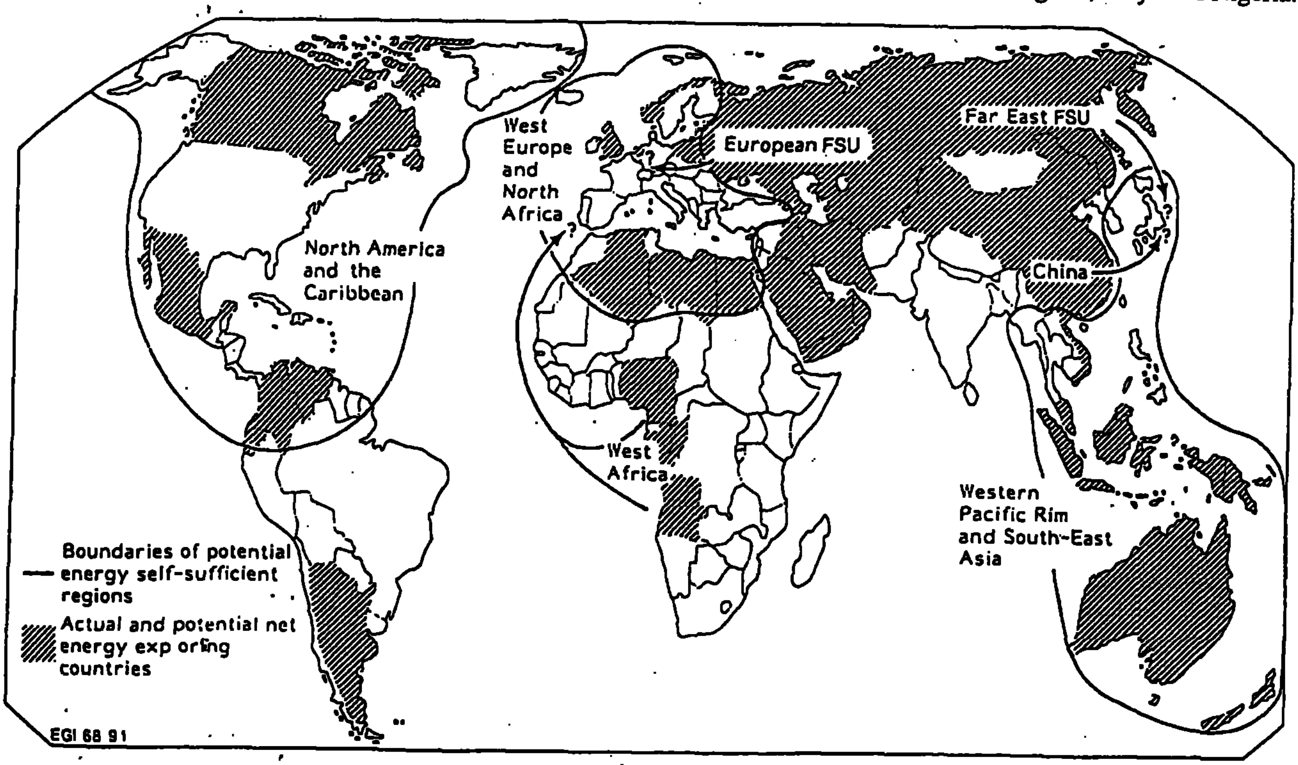

Fig. 7. The prospective regionalisation of world oil markets.

These could be further expanded, both from the point of view of the additional resources' exploitation prospects it would generate and of the significant impact it would have on potential new infrastructure developments, such as a greatly extended pipeline system extending from North and West Africa across the Mediterranean to the countries for southern Europe. This prospect for a set of regionalised oil markets thus appears to offer an alternative to the more widely presented view which suggests the inevitability of the re-establishment of a world oil industry based on the combination of large additional volumes of oil supplied from the Middle East with the cooperation of the international oil corporations. In other words, the prime motivation to seek such regionalisation would be the fears of aggressive policies by the oil-rich and low-cost Middle East exporters. Such fears and the reactions they generate could thus be seen as a tempering influence on the Middle East oil states' potentially powerful reaction to the limitations they necessarily face on the expansion prospects for their oil industries if they fail to act competitively.

The more open question is whether the rest of the world will choose to seek to regionalise its energy supply/demand relationships without such a positive motivation arising from actions of the Middle East producers. It could still happen, simply because those producers are, in any case, perceived to be securing too large a share of the slowly growing international oil market to the disadvantage of non-Middle East OPEC and non-OPEC producers. In these circumstances the latter might seek protection in regional arrangements. It could also emerge if new destabilising events in the Middle East yet again disrupt, or threaten to disrupt, oil supplies and prices. This would likely result in an even more positive effort by major importing and consuming countries to minimise their dependence on the Middle East by maximising their energy-trading relationships with their nearer neighbours; so offering deals and long-term prospects which the latter would find difficult to refuse.

There are, in other words, a number of ways in the period to 2010, in which the Middle East core of OPEC could face difficulties should it seek to become an increasingly important supplier of oil to the very slowly expanding world oil market. The expansion and diffusion of production in oil-rich, and potentially oil-rich, countries in other parts of the world, in formal or informal relationships with neighbours or near-neighbours whose oil requirements could be served at real prices little or no higher than today's levels, does offer a possible alternative future structure for the world's petroleum market.

Author

PETER ODELL graduated with First Class Honours in geography from the University of Birmingham in 1951, from which he also received his PhD in 1954. He also has a Master's degree in International Relations from the Fletcher School of Law and Diplomacy in the United States. After service with the R.A.F. he worked for Shell International Petroleum Company in its economics division in London. In 1961 he was appointed Lecturer in Geography at the London School of Economics. He was promoted to senior lecturer in 1966 and in 1968 was invited to take the Chair in Economic Geography at the Netherlands School of Economics, now part of the Erasmus University, Rotterdam where he was also Director of the Economic Geography Institute until 1981. He was then appointed the Director of the University's Centre for International Energy Studies (EURICES) and in 1982 was nominated to a Special Chair in this field of study in the Faculty of Economics. He retired from his posts in the University at the end of 1990 and now has the title of Professor Emeritus. Since 1983 he has held an appointment as Visiting Professor at the London School of Economics. He was a Professor at the College of Europe in Bruges from 1984–1990. He has been a Member of the Royal Institute for International Affairs in London and a Fellow of the U.K. Institute of Petroleum for many years. He was the founding-chairman of the Benelux Branch of the International Association for Energy Economics in 1983 and remained a member of the Board until 1989. He was nominated as a Council member of the I.A.E.E. itself for 1990. In 1982 he was elected a Fellow of the Royal Society of Arts. He has been a member of the Editorial Boards of the Journal of Energy Policy since 1973, of the International Journal of Energy Research since 1983 and of the Energy Journal since 1985. He was European Editor of the latter from 1986 to 1990. He is a member of the Scientific Advisory Committee for Energia (L'Editrice dell' Automobile, Roma).

His research interests have been mainly in the economics of resources, especially energy resources on which he has been active for over 30 years. During this period he has published widely in this field, including many books. In addition he has contributed more than 250 articles and papers etc. to many books and to a wide range of academic, professional and technical journals. In 1975 he was invited to give the annual Lord Stamp Memorial Lecture in Economics at the University of London; in 1978 he was a Canadian Council Fellow at the University of Toronto; in 1979 he gave the annual lecture to the Scottish Economic Society; in 1980/81 he was a visiting scholar in the Faculty of Science at the University of Southampton; in 1982 he gave the Wilkinson lecture at the University of Reading; in 1984 he was a scholar-in-residence at the Rockefeller Study Centre in Bellagio, Italy; in May/June 1987, the Director of the Joint London School of Economics/Erasmus University Rotterdam Summer School on the International Oil and Gas Industry; in September 1987, an academic visitor at the Fridtjof Nansen Institute in Oslo; the Killam Visiting Fellow at the University of Calgary for the Fall Term 1989; and in 1991 he was awarded the International Association for Energy Economics annual prize for "outstanding contributions to the field of energy economics and its literature" and the Centenary Medal of the Royal Scottish Geographical Society in 1993. He has also presented papers and lectured on energy topics at many universities, to industrial, commercial and political groups and institutions, and to numerous conferences throughout Europe, as well as in the United States and Canada, India, China, Australia, New Zealand and a number of countries of the Caribbean and Latin America. Over the years he has contributed to many television and radio programmes on international energy affairs.

In 1977/8 he was a special adviser to the United Kingdom Department of Energy where he prepared a report since published under the title British Oil Policy: A Radical Alternative (Kogan Page, London, 1980). He has also advised other governments, organisations, and other institutions and companies on international energy questions.