North Sea oil and gas—costs and benefits

This article examines the implications for the future of the UK onshore economy of the development and exploitation of oil and gas reserves in the North Sea, expanding the analysis in the Governor's Ashridge Lecture of November 1980.[1]

Part I discusses the size of the reserves and the cost of their exploitation. It presents estimates of real flows for the last decade, during which the UK has become roughly self-sufficient in oil, and illustrative projections to the mid-1980s, when the UK will probably be a net oil exporter. Two main conclusions are:

- *in real terms it has cost substantially more to develop North Sea oil than it cost to import oil before the first oil shock; but*
- *the cost has been less than the cost of importing oil at current (or expected future) prices.*

Part II addresses some broader issues. The present value of the economic rents arising from the oil and gas fields could be of roughly the same magnitude as current annual GNP. The effect on economic welfare is best measured by seeing how much can be consumed while not impoverishing future generations—perhaps between 3% and 6% of GNP compared with a situation where the UK had no indigenous oil.

Internationally, higher oil prices transfer income to oil producers from oil consumers, who have to pay more for oil. They are likely to have to 'industrialise' so as to export more industrial output to oil producers. The UK, being both an oil producer and an oil consumer, is largely spared this need.

It has sometimes been argued that the UK is better off for North Sea oil and for this reason will need to 'de-industrialise'; and that the recent very high exchange rate is the mechanism by which market forces were bringing this about. The present article argues that, with oil costing at least as much real resources as in the past, the UK had no need on this count to contract its industrial sector; and that the strength of sterling must be seen as largely due to other factors (eg the asset preferences of oil exporters or high UK interest rates).

Since oil reserves should be viewed as a wasting capital asset, prudence would require the investment of sufficient of the revenues to maintain the real value of the capital; by 1985, the portion to be invested at home or abroad on this criterion could be substantial. Achievement of greater domestic investment on these grounds cannot, however, be separated from the more general need to achieve fuller utilisation of productive capacity, which would itself be likely to bring greater investment.

I The scale of the North Sea endowment

The course of oil and gas production

Some idea of the importance of North Sea production for the UK can be gained from examining trends in the share of different fuels in UK energy consumption, and in their production. There has been a dramatic rise in the production of indigenous oil and gas in the last ten years, from 5% of UK consumption of fuels in 1970 to about 60% in 1981 (Chart 1). Dependence on net imports of oil (about 100 million tonnes in 1970) was eliminated between 1980 and 1981. The UK became a net oil exporter in 1981, and is likely to continue to be a net fuel exporter for a number of years, on the basis of recent official oil production forecasts. These forecasts[2] are subject to substantial uncertainty, and the range of profiles of net exports in Chart 1[3] indicates the

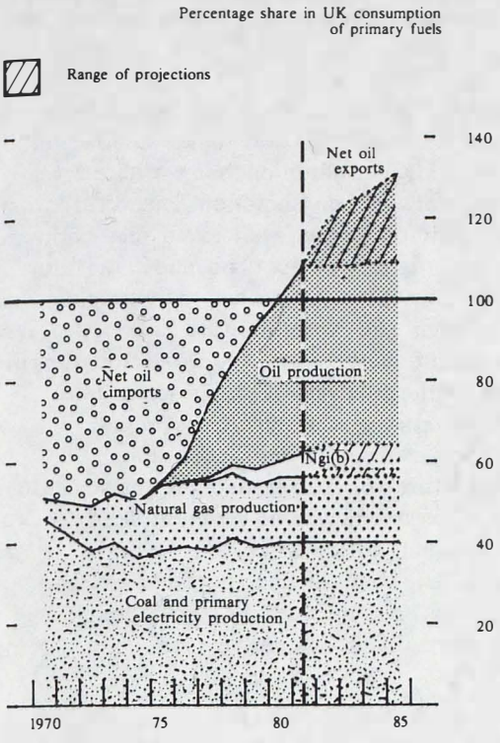
(1) See the December 1980 *Bulletin*, page 449.

(2) Production forecasts were contained in a parliamentary written answer on 4 March 1982 published in *Hansard* vol 19 no 70.

(3) Illustrative projections of a range of magnitudes are used in this and subsequent charts and tables. The projections of North Sea magnitudes are Bank estimates made in the light of private projections publicly available, including those of Wood Mackenzie & Co. who provided additional assistance for which the Bank is indebted. All projections of this kind are inevitably subject to considerable margins of error.

The uncertainties are particularly large in the forecast of future oil production. Chart 4 indicates the uncertainties reflected in the forecasts published by the Department of Energy. A number of stylised assumptions are made about other economic magnitudes: the most important are that the real price of North Sea oil in the UK remains constant from 1982 at a level equivalent to about £138 per tonne in 1982, and that modest output growth and the continuing effects of high real oil prices on oil demand lead to a constant level of domestic oil consumption. The oil price assumption incorporates a modest allowance for a weakening of the oil price from its level at the start of 1982, and would probably, on average, be consistent with modest growth in the world economy over the period to the mid-1980s. The substantial uncertainties are recognised by showing the projections as ranges.

Chart 1
UK energy consumption and production[a]



(a) Bank estimates for 1981, and illustrative projections for 1982–85.
(b) Net gas imports.

potential margins of error. But even the combination of relatively low production and relatively high consumption is likely to leave a modest net surplus for export. The contribution of indigenous gas is also important: although the UK is not self-sufficient in gas, domestic production had risen to cover perhaps 16% of total fuel needs in 1981.

Although on balance a modest oil exporter, the UK remains both an exporter and an importer. About half of production in 1980 was exported, and there were substantial imports of crude, largely from the Middle East. This is because North Sea oil is lighter and lower in sulphur content than typical Middle East crude, and UK refineries are most economically run on a mix of crude oils. The UK will probably remain a substantial international trader in oil in the years to come.

The special characteristics of typical North Sea oil mean that it is possible to extract more high-value products such as motor spirit from it than from typical Middle East crude; and its lower sulphur content makes it cheaper to process. As a result, North Sea oil commands a quality premium, varying with market conditions, over the average barrel of oil traded on world markets.

Although production of North Sea oil and gas is now large in UK terms, it amounted to only about 3% of world production in 1980. In comparison with other Western European countries, however, the UK is a substantial oil producer.

How big are the reserves?

There are two major difficulties in calculating how much the UK can hope to extract from its oil and gas reserves. The first is the geological assessment of the amount of oil or gas present in a structure that has been discovered; the second relates to the technical and economic uncertainties that make it hazardous to estimate how much of the reserve will actually be recovered. The assessment of recoverable reserves will, for instance, depend to some extent on the real net price that the producer can obtain for the oil after the Government has collected royalties and taxes. And there should be an allowance for production from any future discoveries.

The uncertainties are indeed large. The Department of Energy's estimate of reserves at the end of 1980 for oil and gas yet to be produced is constructed as shown in Table A. The lower limit of 1.1 billion tonnes of oil consists of reserves which are virtually certain to be technically and economically producible. The upper limit allows 1.8 billion tonnes for future discoveries, 0.6 billion tonnes of reserves with more than a 50% chance of production, and 0.6 billion tonnes with a significant, but less than a 50%, chance of production.

The Department of Energy view of proven reserves from existing discoveries in licensed areas has changed little over the last five years (Chart 2): and their estimate of total reserves from existing licences, including possible and probable reserves, was broadly stable from 1973–77, with some downward revision in 1978. At the end of 1975—the last year of substantial growth in assessed reserves—the Department's estimate of all reserves ranged from 2.3–3.2 billion tonnes, with about 1.4 billion in the proven category.

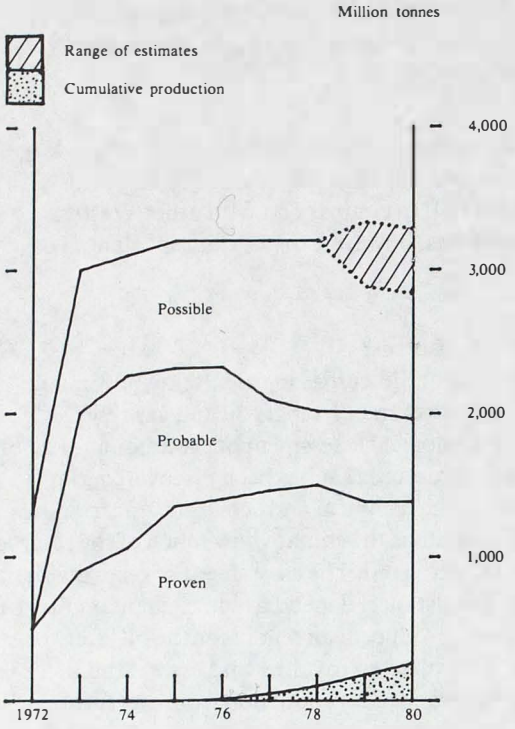
Table A
Oil and gas reserves

	UK reserves(a)					Proven world reserves(b)	
	In present discoveries			In future discoveries	Total(c)		Total
	Proven	Probable	Possible				
	Millions of tonnes (oil equivalent for gas)					*Years at 1980 consumption rates*	
Oil	1,100	600	600	800–1,800	1,100–4,100	15–50	25–30
Gas	..	..	..	..	1,000–1,900	25–45	about 50

.. not available.

(a) Department of Energy estimates at end-1980.
(b) Based on oil industry estimates.
(c) The upper end of the range shown includes all possible reserves, including some with a significant but less than 50% chance of being technically and economically producible.

Chart 2
Official estimates of North Sea oil reserves[a]



(a) Original reserves from existing discoveries in licensed areas only. The dates shown are those when the estimates were made.

Allowing for production in the intervening years, little has been added to proven reserves since 1975. And despite a recent upturn, exploration and appraisal drilling has fallen away from the peak levels reached around 1975, although this may be as much a result as a cause of low additions to reserves. It would appear therefore that there has been little reason to revise estimated reserves substantially in the last few years and these figures may be used with cautious confidence.

It appears, also taking industry estimates into account, that the UK is likely to have enough reserves of gas and oil to last, at current rates of consumption, for at least fifteen, and perhaps for as much as fifty years. The world as a whole has enough proven reserves of oil to last for twenty-five to thirty years at current rates of consumption. Students of the economic history of natural resources will not find this surprising, in that it ceases to become worthwhile to seek, or even to claim, reserves of minerals when there are large reserves already proven and under development, unless the new reserves can be exploited more cheaply than those in current or prospective production. And some geologists have argued that this has, in historical fact, persistently led to a level of world reserves little above, or below, twenty-five years at the then current rates of consumption. This is not to imply that geological realism would suggest that the UK on its own can always be economically self-sufficient in oil at whatever the world oil price happens to be; but there are dangers in exaggerating the imminence of exhaustion. And, looking twenty years ahead, the UK may find itself in as strong a position with respect to energy by virtue of its enormous coal reserves as it now does by virtue of its oil and gas.

Although the size of North Sea reserves is difficult to assess with any certainty, they are probably somewhat lower in relation to present UK consumption than world reserves in relation to present world consumption. The world as a whole must, by definition, be self-sufficient in oil—both today, at the currently ruling price of oil, and in the future. This future self-sufficiency will be achieved by simultaneous adjustment of current and expected future oil prices, consumption and production rates, all revised from time to time in the light of the discovery of fresh reserves and technical advances. In economic terms, the present value of future world oil consumption equals the present value of future world oil production; and since UK reserves appear to be a somewhat lower multiple of UK consumption than world reserves are of world consumption, the UK seems likely to be rather less than self-sufficient in this present value sense, even though a probable net exporter of oil for some years to come.

The cost of developing the North Sea

The costs of finding, developing and exploiting a field in the North Sea fall into three broad categories:

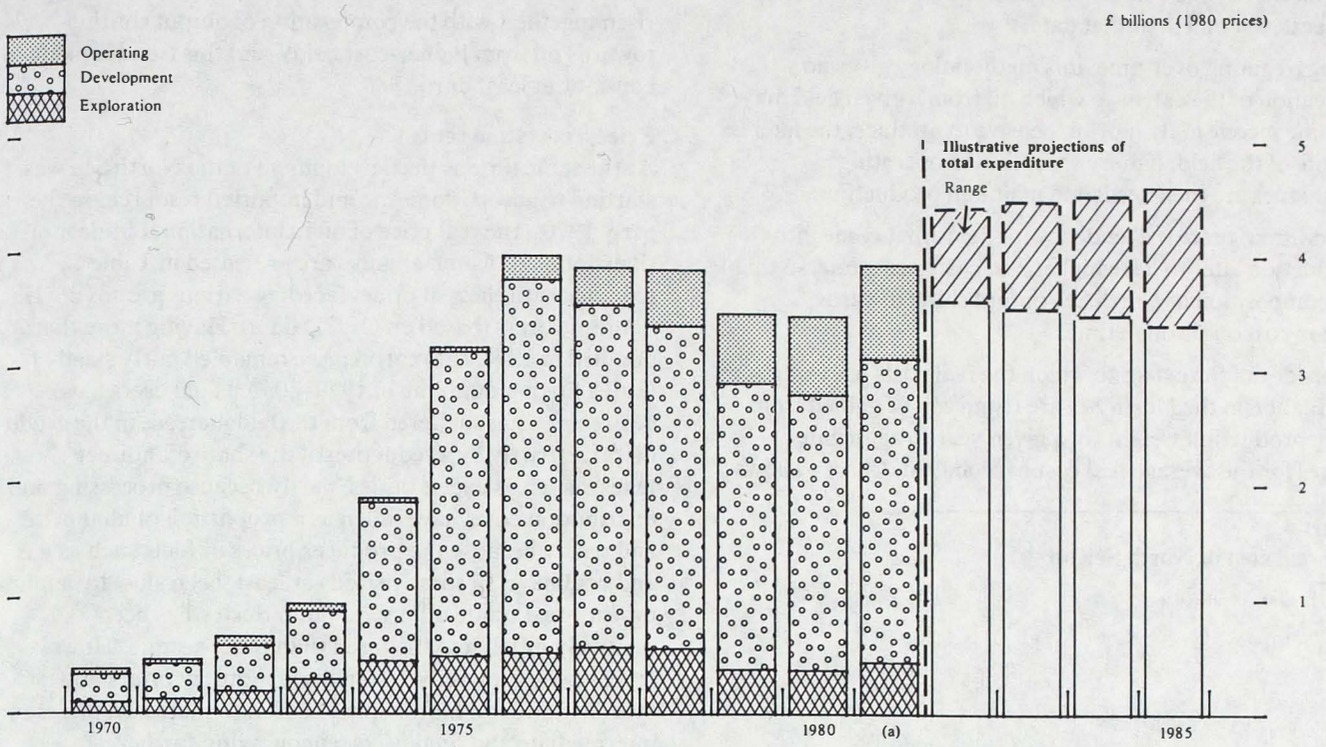
- Exploration and appraisal.
- Capital cost of development—production platforms, terminals, pipe-lines etc.
- Operating costs—the day-to-day costs of staffing, maintenance and materials associated with oil production.

Chart 3 shows expenditure on exploration, development and operation since 1970. The figures cover *all* energy-related activity in the North Sea—including Southern Basin gas—and are transformed to 1980 values using a deflator[1] for investment in the North Sea. The sums involved have indeed been large: they have grown to around £3½ billion annually, or almost 2% of GDP[2] in 1980, mostly accounted for by development, but with an important and fast-growing element of operating costs. From 1965–80, the total investment may have been £21 billion in 1980 prices, with a further £4 billion spent on exploration. The oil industry has estimated that perhaps a further £55 billion (in 1980 prices) will be spent in total over the next fifteen years, with capital expenditure accounting for some £40 billion. The total expenditure envisaged is equivalent to more than a quarter of GDP in 1980, and the capital expenditure is rather more than equal to gross domestic fixed capital formation in the UK in that year.

But by no means all of the resources used in the North Sea were provided directly by the UK. Imports of goods plus net imports of services[3] covered nearly all the initial

(1) The same deflator is used to reach values at 1980 prices for all magnitudes in this article.
(2) GDP measures UK output rather than UK income, and is thus a more relevant standard of comparison than GNP when calls on resources are considered.
(3) Services include such items as the hire of drilling rigs. Exports of catering and labour services to foreign operators in UK waters are deducted, to avoid double counting.

Chart 3
Real resources in the North Sea



(a) Bank estimates for 1981.

expenditures. The proportion fell to around half in the early years of heavy development, and dropped further in the three more recent years to about 15% in 1980. The real resources provided directly by the UK for the North Sea sector have risen correspondingly, from a trivial amount in 1970 to about £3 billion in 1980, and may remain at about this level in real terms to 1985. Imports of goods and services have to be paid for: ultimately, if not immediately, the UK will have to provide real resources to its foreign creditors. In fact, much of the North Sea programme has been financed by overseas investment; and capital inflows have, on average, been just about sufficient (see Table B) to pay for imports of goods and services.

As has been discussed, the cost of North Sea output is, together with the price of oil, a critical feature in assessing the size of North Sea reserves. It is also important in estimating the value in economic terms of these reserves, and of the oil and gas produced now and in the future—that is, in estimating how much better off the UK is as a result of having North Sea oil and gas, a question which is central to discussion of the economics of North Sea output.

The allocation of the field *lifetime* costs to production can be formalised as follows. All costs are converted into constant money terms by dividing them by an index of relevant prices, and their present value calculated at some reference date, using an appropriate discount rate. In this way, the total stream of costs of the field over its lifetime—perhaps twenty years—can be reduced to a single cash sum in the reference year. A similar procedure is followed to convert production (in tonnes, say) to a present value equivalent in the reference year. The real resource cost of a tonne from the field in question is then the present value of all costs divided by the present value equivalent of all production.

This calculation has been made for oil fields under production or under development, to get an average estimate for each category (data for Southern Basin gas fields are not available). The discount rate is set at 10%, which may seem a little high; but it reflects the high real rates of return current in the oil industry worldwide.

Since both costs and production are assessed with the same discount rate, the estimate is unlikely to be particularly sensitive to the precise choice of number. In 1980 prices

Table B
UK Continental Shelf: imports and overseas inward investment[a]

£ millions

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Imports of goods and net imports of services	70	100	120	160	330	820	1,180	1,230	730	610	610	700[b]
Overseas investment	..	..	..	60	230	950	1,140	1,500	790	690	770	1,550

.. not available.

(a) Further details and definitions can be found in Chapter 9 of *United Kingdom Balance of Payments, 1981 edition* (the 'Pink' Book), published by HMSO.
(b) Estimate.

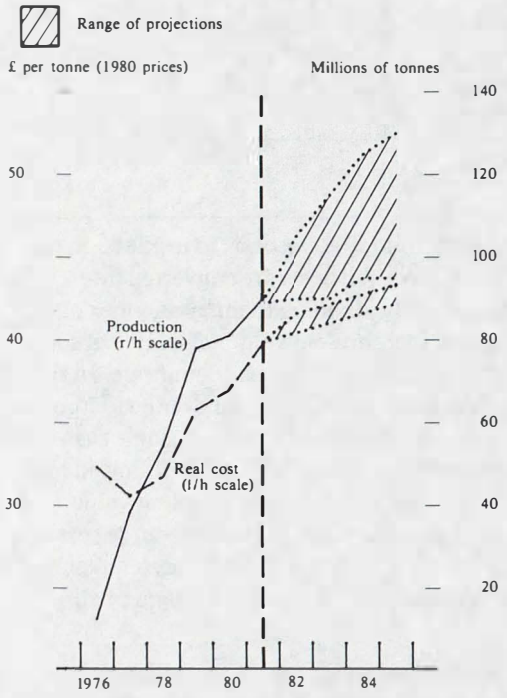
these costs amounted to about £35 per tonne for fields in production by the end of 1980, and to about £45 for fields under development at that date.

By aggregating over time, this methodology gives no indication of the extent to which oil from a given field may become increasingly more expensive to produce, the later in the life of the field, if more complicated operating techniques are then needed to maintain production.

In addition, there is a tendency for fields that come into production later to have higher real costs per tonne, so that the composition of North Sea output shifts towards higher-cost oil through time.

Some idea of the extent to which the real costs of average production in the North Sea are rising can be gained from using production weights in a given year to aggregate figures for the average real cost in each field. Chart 4 shows how this measure has evolved since oil production started in 1975. Production and the real unit cost of production have risen together, with the composition of output shifting towards oil from higher-cost fields, and this trend is likely to continue at least until 1985.

Chart 4
The real cost of North Sea oil[a]



(a) Bank estimates for 1981, and illustrative projections for 1982–85.

Prices, costs and rents

At the same time as the development of the North Sea was starting to absorb domestic and imported resources in the early 1970s, the real price of oil in international trade more than doubled. Annual figures are presented in Table C, together with the real prices faced by various groups of UK domestic users (based on OECD data). Having more than doubled in 1974, the real oil price remained fairly steady until a further doubling in 1979–80. All final users have been somewhat sheltered from the real increase in the crude oil price, partly by a reduction of the share of indirect taxes[1] such as excise duties, partly because processing and distribution costs have fallen as a proportion of final prices, and partly because the producer prices of fuels such as gas and coal have, in some periods at least, been slow to catch up with real crude oil prices: but industry has been relatively much less sheltered than other sectors. However, recent policy towards nationalised industry prices and specific duties on motor spirit has led to increased prices to intermediate and final users, encouraging further economies in energy use.

The price paid for UK oil imports from 1970 to 1977 and the premium price commanded by North Sea oil from 1976 are shown in Chart 5, together with the average cost of North Sea oil (derived as explained above). Although field-based cost estimates are not available for the earlier years, the chart suggests that, prior to the first OPEC price rise, cost and price might have been very similar. Since the early 1970s, however, the world oil price has exceeded the cost by a substantial margin. The same is true of gas. Plainly there are rents to be earned in the North Sea, even if a static real oil price is assumed for the years to come.

A proper estimate of the present value of these rents could in principle be made if good forecasts of the oil price and of production throughout the lifetime of all North Sea fields were available, and if an appropriate social discount rate

Table C
Oil prices

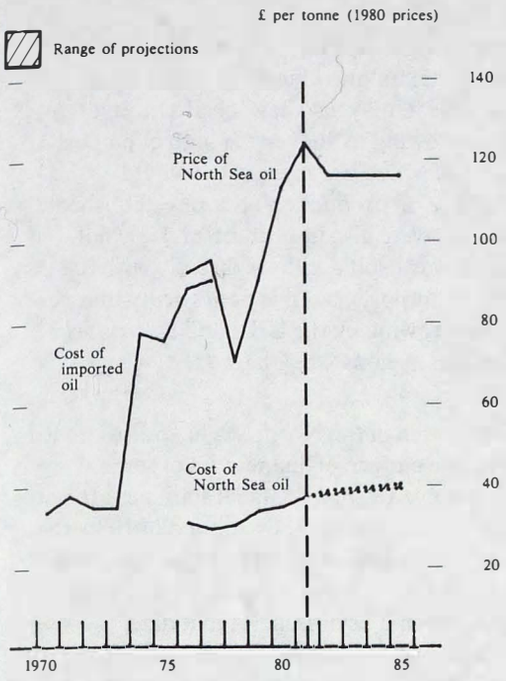
	1973	1974	1975	1976	1977	1978	1979	1980	1981
World price									
Nominal ($ per barrel)	3.50	9.60	10.70	11.60	12.50	12.70	18.80	31.20	34.30
" (£ per tonne)	10.70	30.80	36.10	48.20	53.70	49.60	66.40	100.50	127.00
Real(a) (1973 = 1)	1.0	2.28	2.25	2.43	2.41	2.15	2.82	4.19	4.88(b)
Real domestic final prices by sector(c) (1973 = 1)									
Residential/commercial(d)	1.0	1.07	1.11	1.16	1.16	1.13	1.15	1.21	..
Industry(e)	1.0	1.33	1.42	1.46	1.53	1.49	1.56	1.68	..
Transport(e)	1.0	1.28	1.45	1.33	1.19	1.03	1.22	1.32	..

.. not available.

(a) Deflated by the dollar price of world exports of manufactures (UN index).
(b) Bank estimate.
(c) Based on OECD data.
(d) Deflated by the consumer price index.
(e) Deflated by the wholesale price index.

(1) Specific taxes on hydrocarbon oils, for example, have fallen from 2.2% of GDP in 1973 to 1.5% in 1980.

Chart 5
The real price and cost of North Sea oil[a]



(a) Bank estimates for 1981, and illustrative projections for 1982–85.

could be agreed; in practice, there are severe difficulties in this calculation. A simple estimate may be made by assuming that the excess of the oil price over the costs of extraction grows at a compound rate equal to the appropriate discount rate, so that the UK is indifferent, on those grounds at least, to the timing of oil production. Then the present value of the economic rent involved in each tonne of North Sea reserves is simply the price in today's money less the average real cost of extraction in today's money. For the twenty-five fields in production or under development, the average real cost of all production after 1980 is about £40 per tonne in 1980 prices, and the operators estimated that remaining recoverable reserves at the end of 1980 amounted to about 1.2 billion tonnes. Taking the 1980 oil price of about £110 per tonne, the rent amounts to about £85 billion in 1980 prices, or about 45% of GNP in that year. This would take no account of reserves in fields not yet under development—perhaps as much as another 2 billion tonnes of oil—or of Southern Basin gas, for which the calculation is not technically possible.

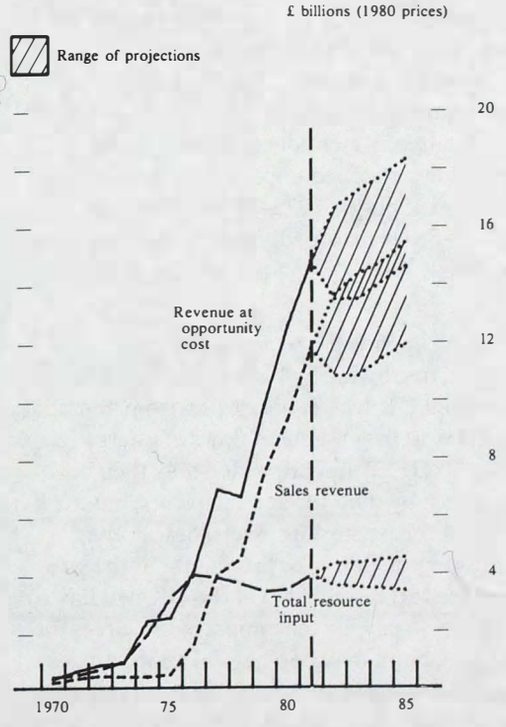
However, the cash flow corresponding to these rents arises with a profile through time that is far from smooth. Chart 6 shows some measures in constant prices of revenues and of costs in the whole North Sea. 'Sales revenue' represents the value of all sales of oil and gas from the North Sea. While North Sea oil is sold at world prices, much North Sea gas is sold by producers at a price substantially below that ruling internationally. In valuing North Sea output, and given the significant share of cheap Southern Basin gas, it might be appropriate to value gas[1] at a price which reflects its thermal equivalence to oil.[2] The upper line on the chart shows the importance of this distinction after the oil price rises of 1973–74. Even over the next five years, measured sales revenue may considerably understate the economic value of North Sea output.

As would be expected, sales revenue from the North Sea as a whole did not start to cover current and capital costs until 1978, when substantial quantities of oil began to flow. Thereafter, the surplus became large, and could comfortably exceed £10 billion (in 1980 prices) in 1985. The surplus of sales revenue over total North Sea costs is a measure of the cash flow accruing to North Sea companies, from which taxes, interest, profits due abroad and dividends have to be paid. The cash surpluses arising in the North Sea are large both in actuality and in prospect: for 1980 they amounted to over 2½% of GNP at market prices, with substantial rises to come.

The role of the capital markets

Chart 3 showed the total commitment of resources, both domestic and imported, to the development of the North Sea. The high levels reached in the mid-1970s coincided with a period in which, prior to North Sea coming on stream, the UK's oil import bill was also at a peak. The net cost, at 1980 prices, of the UK's oil imports is shown in Chart 7. It reflects such factors as the rising world oil price; the 20% fall in UK consumption from 1974 to 1980, partly in response to higher consumer prices; and rising UK production. The chart also shows the combined

Chart 6
Real revenue and costs[a]

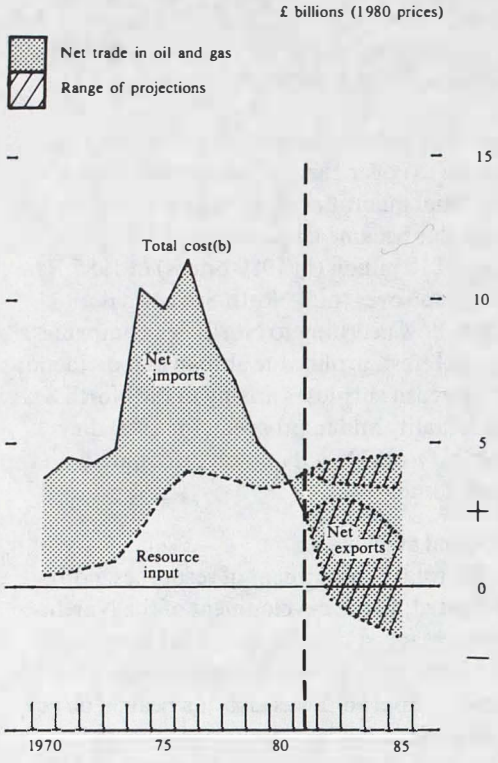


(a) Bank estimates for 1981, and illustrative projections for 1982–85.

(1) To the extent that gas prices to the consumer are lower than would be warranted by the world price of oil, it is the consumer who takes this part of the benefit from the North Sea. Where the British Gas Corporation or the Treasury takes the benefit—as is increasingly the case as the consumer price of gas rises in real terms—the outcome is a reduction in the public sector's financing needs.

(2) Since the first oil shock, the price of internationally-traded gas has been below this level, because of difficulties of transport and storage.

Chart 7
Real cost of oil and gas[a]



(a) Bank estimates for 1981, and illustrative projections for 1982–85.
(b) The total cost of oil and gas is the sum of spending on net imports of oil and gas and of spending on exploration, development and production in the North Sea.

expenditures on North Sea development ('resource input') and oil imports. In the absence of recourse to the world capital markets, the massive temporary rise in resources required for these purposes, which amounted to over 5% of GDP in 1976 (the peak year), would have had to be found by cutting resources devoted to other forms of consumption and investment. As already mentioned, and shown in Table B, capital inflows matched imports of inputs fairly closely; indeed, over the period 1973–81 total inflows related to the North Sea were broadly similar in size to cumulative imports.

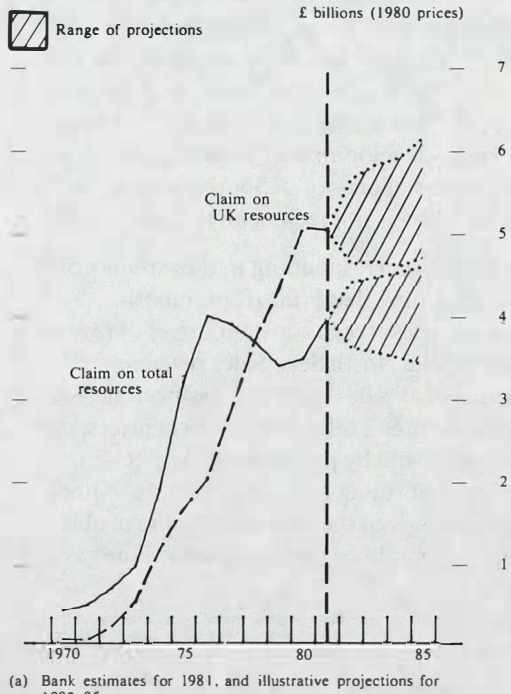
These inflows (which include the retained profits of overseas companies, borrowing by North Sea companies in foreign currency from UK banks, borrowing from abroad, and trade credits) result in subsequent flows of interest, profits and dividends (IPD) abroad, which may then be spent on British goods by their foreign recipients, but may equally be used to purchase sterling assets, or for other purposes. It is thus impossible to be precise about the size and the timing of the real resources that the UK will have to transfer to foreigners to pay for the import of resources for use in the North Sea; but it may be a helpful approximation to suppose that real resources are transferred abroad as the IPD payments are made. In that case, it is possible to derive a measure of the claim on UK resources represented by the North Sea: in the early 1970s, it was the costs incurred in the North Sea *less* imports of goods and services for use there; and throughout this decade, it will comprise, in addition, a substantial element of IPD outflows. Chart 8 demonstrates how the use of capital markets in this way has postponed the demands of the North Sea on UK resources.

The desire to smooth other resource uses, which partly accounts for the capital inflows identified as financing North Sea development, may also have been a motive behind overseas borrowing to finance the high oil import bill of the mid-1970s, which it was expected would disappear as domestic oil production became established. Other considerations were also important, and it is not feasible to associate any capital inflows directly with the need to pay for these imports, but it is noteworthy that new foreign currency borrowing by the UK public sector also reached a peak in these years—see Chart 9.

Domestic resources used in the North Sea have also needed to be financed and the pattern of financing is of some interest. Unfortunately, detailed financial statistics are not available, particularly before 1977. By the end of 1980, the domestic resources employed in the North Sea had cost a total of over £10.5 billion in current prices, with foreigners having spent an additional £6 billion. At that date, cumulative development expenditure in current prices was over £12 billion—about two thirds of the total expenditure. The stock of identified external finance for North Sea companies was about £5½ billion (see Table D), the bulk of it being from abroad. The tentative conclusion is that most of North Sea activity is currently financed from retained profits (including depreciation provisions) and from borrowing. In addition, there was some move to repay identified borrowing from abroard in 1979 and 1980 as production and revenues increased sharply.

The pattern of domestic and foreign financing, together with the North Sea tax regime, determines the claims of the

Chart 8
The real cost of the North Sea[a]



(a) Bank estimates for 1981, and illustrative projections for 1982–85.

Chart 9
Public sector foreign currency borrowing

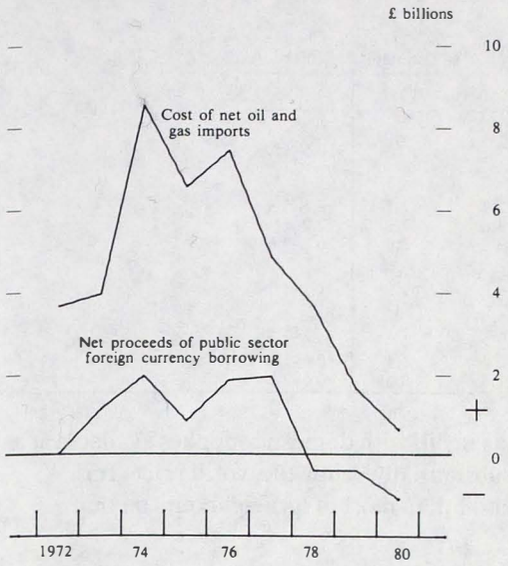


Table D
External financing of the North Sea[a]

£ billions; amounts outstanding

	1977	1978	1979	1980
Financing requirement	**4.6**	**6.3**	**7.2**	**8.0**
Foreign finance				
Eurocurrency lending by UK banks	1.0	1.0	0.9	1.1
Subscription to equity or loan capital by overseas associate or parent	0.3	0.6	0.6	0.8
Identified borrowing from abroad	1.1	1.1	0.8	—
Undistributed profits of foreign-owned North Sea companies	0.2	0.5	1.2	2.3
Identified foreign finance	2.6	3.2	3.5	4.2
Unidentified foreign finance[b]	1.3	1.4	1.8	1.9
Total foreign finance	**3.8**	**4.6**	**5.3**	**6.1**
Domestic finance				
Sterling lending by UK banks	0.6	0.8	0.9	0.8
Equity issues in the UK	0.2	0.3	0.3	0.3
Unidentified domestic finance (residual)	—	0.6	0.7	0.8
Total domestic finance	**0.8**	**1.7**	**1.9**	**1.9**

(a) Many items in the table are constructed on the assumption that flows in the early 1970s were negligible. For this and other reasons, the estimates must be regarded as highly tentative.

(b) This row is the residual that makes total foreign finance equal to cumulated capital account flows since statistics began in the early 1970s.

different parties on North Sea cash flows. Table E presents estimates of actual and forecast cash flows (in 1980 prices) from the North Sea from 1972–81, and a projection for 1985, bringing together the estimates of revenues (line 1), direct costs (lines 2 and 8) and IPD outflows abroad and to the UK (line 6) referred to earlier.

It is of some interest to consider the positions of the UK company sector in the North Sea and of the foreign sector in the light of the substantial tax take (see Table F, line 4). It is expected that the tax take may rise from almost 40% of sales revenue in 1980 to as much as 55% by 1985, largely because of the exhaustion of capital allowances built up in the years of heavy development. Table F also provides separate estimates of cash flow for North Sea licensees and the foreign sector, using inward direct investment in the North Sea as foreigners' financial input, rather than the previous resource measure, net imports. The figures confirm the large share of the cash surplus in the North Sea accounted for by taxes.

Clearly, then, the benefits of the North Sea accrue in great measure to the Government. In 1980, tax revenues from this source amounted to more than 4% of total receipts from taxes, and by 1985 this may more than double. But even after this taxation, North Sea cash flow is not a trivial proportion of UK industrial and commercial company gross after-tax profits, and it is expected to increase sharply in the next few years. Pre-tax, North Sea licensees earned about one third of all gross trading profits, net of stock appreciation, in the UK in 1980.

The North Sea will also continue to have substantial effects on the balance of payments. Starting from official production estimates and forecasts, a measure of the UK's net oil and gas exports in constant prices is calculated in Table G; direct investment in the North Sea *less* imports of goods and services for use in the North Sea (line 4) is to be added, and IPD outflows from the North Sea (line 5) subtracted, to reach an estimate of the financing needed across the exchanges in respect of oil and gas (line 6). This financing requirement changed little in current prices from 1974, in the wake of the first oil price rise, to 1980: in 1980

Table E
North Sea cash flows: licensees

£ billions at 1980 prices

	1972	1973	1974	1975	1976	1977	1978	1979	1980	Estimate 1981	Projection 1985
Revenues											
1 Total sales revenues from oil and gas	0.4	0.4	0.4	0.5	1.6	4.0	4.5	7.6	9.5	11.9	12–16.4
Costs											
2 Exploration, operating and other current costs	0.2	0.3	0.4	0.5	0.7	0.9	0.8	0.9	1.1	1.5	1.8–2.2
3 Royalties and licence fees	0.1	0.1	—	—	0.1	0.4	0.4	0.6	1.2	1.2	1.2–1.6
4 **Gross trading profits** (1 – 2 – 3)	0.1	0.1	—	−0.1	0.7	2.7	3.3	6.0	7.3	9.2	9–12.6
Less											
5 Corporation tax, PRT and special petroleum duty	—	—	—	—	—	—	0.4	1.2	2.3	4.3	5–8
6 Payments of ipd abroad and interest on sterling borrowing	—	—	0.1	0.1	0.1	0.9	1.1	1.7	2.3	2.1	1.7–2.7
7 **North Sea sector savings** (4 – 5 – 6)	0.1	—	−0.1	−0.2	0.6	1.8	1.8	3.1	2.7	2.6	1.5–2.5
8 Gross fixed capital formation	0.4	0.6	1.3	2.7	3.6	3.3	3.1	2.5	2.4	2.6	1.8–2.2
9 **North Sea financial surplus/deficit** (7 – 8)	−0.3	−0.6	−1.4	−2.8	−3.0	−1.5	−1.3	0.6	0.3	—	−0.7–0.7

Table F
North Sea cash flows: UK and overseas
£ billions at 1980 prices

	1973	1974	1975	1976	1977	1978	1979	1980	Estimate 1981	Projection 1985
Licensees in the North Sea										
1 Revenues *less* ipd due abroad	0.4	0.4	0.5	1.5	3.1	3.5	5.9	7.3	10.0	10.5–13.9
2 Current costs and capital formation *less* direct investment by foreign sector	0.7	1.2	1.4	2.3	1.9	2.8	2.6	2.7	2.7	2.5–3.3
3 Cash surplus (1 – 2)	−0.3	−0.8	−0.9	−0.8	1.2	0.7	3.3	4.6	7.3	7.2–11.4
4 Tax take	0.1	—	—	0.1	0.4	0.8	1.9	3.4	5.6	6.2–9.6
5 UK post-tax cashflow gross of interest payable to the UK (3 – 4)	−0.4	−0.8	−0.9	−0.9	0.8	−0.1	1.4	1.2	1.7	1.0–1.8
Foreign sector										
6 Ipd receipts	—	—	—	—	0.9	1.0	1.7	2.2	1.9	1.5–2.5
7 Direct investment in UKCS	0.2	0.5	1.8	2.0	2.3	1.1	0.8	0.8	1.4	0.9–1.3
8 Foreign cashflow	−0.2	−0.5	−1.8	−2.0	−1.4	−0.1	0.9	1.4	0.5	0.6–1.2

prices it has shrunk from almost £9 billion to about £3 billion, and is likely to move into modest surplus by 1985.

Line 1 gives an estimate of the foreign currency finance that would have been required for oil and gas consumption, if no North Sea output had been available. This assumes that the UK's economic history and prospects would have been otherwise unchanged, and that gas would have been available from abroad at as low a price as that paid for some North Sea gas. Adding the oil and gas financing balance (line 6) gives a simplified estimate of the balance of payments benefits of developing the North Sea (line 7). These are already large—about £7.5 billion in 1980, when the total measured current account surplus may have been £3 billion—and they may grow substantially in real terms by 1985. This calculation should, however, be taken as no more than indicative of the large orders of magnitude involved.

Oil and gas in the national accounts

The significance of North Sea production depends on whether it does lead, either directly or through the opportunities it offers, to greater income and consumption in the UK. In one sense the benefits are obvious and large. The UK is clearly likely to be better off on account of North Sea oil and gas than it would have been if, like most other industrialised countries, it had needed to buy the bulk of its oil and gas from abroad. Those countries have suffered a substantial loss in income through having to pay much higher prices for imported fuels in recent years—as did the UK in the mid-1970s: but the UK is now in rough balance on trade in oil, with domestic supplies available at a resource cost substantially below the world price. It is therefore better off than most of its neighbours on that account.

But for many purposes the important economic question is whether the UK is better off than in the past on account of domestic oil production, and it is natural to turn to the national accounts for an answer. The national accounts are designed to measure domestic output, income and expenditure, rather than a more general concept like economic welfare, or consumption in the broadest sense. Even the measurement of domestic output presents difficulties, since in each year the physical output of a range of different goods is added together using the set of relative prices which ruled in some base year. Normally, it makes little difference which base year is selected: but where both the output of a particular good and its relative price change rapidly, the particular choice of base year can produce somewhat different estimates of the growth of national output. UK oil is just such a good.

The CSO provides estimates of net output in the industries extracting petroleum and natural gas (MLH 104), which can be used to calculate output growth in the whole economy at the relative prices of 1975 and of 1980, if relative price changes elsewhere in the economy are ignored. The CSO has estimated, on simplified assumptions, that the use of 1980 prices rather than 1975 prices might add less than 1% to total recorded output growth from 1975 to 1980. This difference is smaller than the

Table G
The North Sea and the balance of payments
£ billions at 1980 prices

	1973	1974	1975	1976	1977	1978	1979	1980	Estimate 1981	Projection 1985
1 Domestic use of crude oil and gas	4.3	8.9	7.0	9.0	8.8	8.0	9.2	10.1	10.1	9.6–10.6
2 Production of crude oil and gas	0.4	0.4	0.5	1.6	4.0	4.5	7.6	9.5	11.9	12–16.4
3 Revenues from net exports of oil and gas (2 – 1)	−3.9	−8.5	−6.5	−7.4	−4.8	−3.5	−1.6	−0.6	1.8	1.4–6.8
4 Direct investment in North Sea *less* imports of goods and services for UKCS	−0.3	−0.3	0.2	—	0.4	0.1	0.1	0.2	0.8	0–1
5 Ipd outflow	—	—	—	—	0.9	1.0	1.7	2.2	1.9	1.5–2.5
6 Oil and gas balance for financing (3 + 4 – 5)	−4.2	−8.8	−6.3	−7.4	−5.3	−4.4	−3.2	−2.6	0.7	0–5
7 Notional balance of payments saving (2 + 4 – 5)	0.1	0.1	0.7	1.6	3.5	3.6	6.0	7.5	10.8	10.5–15

considerations suggested earlier might indicate, and the statistical difficulties in constructing an indicator of net output in MLH 104 are perhaps severe enough to justify an alternative procedure. In particular, the conventional treatment values gas at the price at which producers sold it to the British Gas Corporation as sole buyer, rather than at the price it might have fetched if it could have been sold abroad. Because royalties are related to the level of sales, they are treated as a tax on expenditure, rather than on income, although being neither charged on imports nor remitted on exports of oil, they fall exclusively on factor incomes in MLH 104. The appendix to this article discusses these difficulties, and suggests an alternative measure which might be used, with caution, to estimate the contribution of oil and gas to national output. The alternative measure indicates that moving from a 1975 to a 1980 base for oil and gas increases the estimate of total output growth from 1975 to 1980 by nearly 2%, and that making an allowance for royalties and valuing gas at world prices could together add about $1\frac{1}{2}$% to the estimated level of GDP in 1980.

The appendix also examines real national disposable income (RNDI) in the light of oil and gas. RNDI measures the volume of final goods and services for which national output could be exchanged, by adding to changes in measured output any changes in final resource utilisation made possible by changes in the terms of trade, and net flows of interest, profits and dividends, and current transfers from abroad. Oil has had an important influence on the terms of trade by improving the UK's real exchange rate, measured in terms of (say) manufactures: and the exploitation of North Sea oil has led to substantial outflows in the invisibles account. From 1973–76, the UK lost real income through the terms of trade as a result of the first round of oil price rises, offset to some extent by economies in oil consumption and rising gas production. In subsequent years, oil and gas added substantially to output (at 1975 market prices), and produced further shifts in the composition of trade as progress was made towards rough balance in oil. By the time of the second round of world oil price rises, the UK was sheltered from the terms of trade losses suffered by oil importing countries. Overall, the UK lost RNDI in the mid-1970s as a result of the first round of oil price rises, but made good the losses when substantial domestic output of oil became a reality.

The terms of trade effect captures movements in relative prices in so far as they affect the transformation of domestic output into foreign output through international trade, but there is no allowance for the effects of changing relative prices on the real value of *domestic* output consumed *in the UK*. Some have argued that it is appropriate to recognise the effect of higher real oil prices in raising the real value of oil in national income year by year by more than the rise in its output volume would indicate, and have argued that measures of domestic output should be appropriately modified. This would indeed be a useful concept, if it were desired to measure the value of domestic output on world markets when exchanged entirely for non-oil goods: and would prove helpful where a country does indeed export the bulk of its oil production, as most OPEC countries do. But in this case, the terms of trade calculation involved in the estimate of RNDI would provide the necessary adjustments to living standards on account of rising real oil prices.

Where a country has no net trade in oil, however, it is not appropriate to make this adjustment. Suppose that such a country were faced with a rise in the real price of oil, but that all production costs, reflecting unchanged technology, were unaffected. Then domestic oil consumers would economise somewhat on oil, and the excess production would be exported, with extra imports of other goods as a counterpart. Welfare in the country would be improved to a small extent, because there would have been a voluntary shift, in response to changed relative prices, away from oil consumption towards the consumption of other goods. The improvement would be small, and measured by a terms of trade gain in RNDI: there would be no welfare improvement corresponding to the increase in price of the smaller quantity of oil consumed, since economic welfare depends only on the quantity and composition of the goods chosen for consumption, and not on the relative prices which motivated that choice.

How, then, has the UK's economic welfare changed, from the days before the first round of oil price rises, to its present position of oil self-sufficiency at a high real oil price? Using the figures underlying Chart 8, in 1970–72 the UK devoted an average of less than 2% of its GDP to producing goods for export in exchange for oil. In 1980 the proportion of GDP accounted for by real resources used in the production of oil and gas had grown substantially, to about 3%, although the volume of oil and gas consumed had grown *less* than real output. Some of this represented investment in future production; but the real resource cost of oil produced in the North Sea in 1980 was about £35 per tonne (in 1980 prices), whereas before 1973–74 imported oil cost about £23 per tonne (also in 1980 prices). The UK is thus devoting more real resources to oil and gas now than it did then. The UK's real disposable income has been reduced more by international oil price rises than it was improved by the discovery and development of the North Sea. Thus the combined events of the 1970s have made the UK worse off in 1981 than it would have been in their absence.

All these calculations overestimate the annual value of North Sea output because they do not recognise that North Sea oil and gas is a wasting asset.[1] At the production rate of 1980, proven reserves may be sufficient for fifteen years of production, and if production rates are accelerated, the day when the reserves are exhausted will be brought nearer. The North Sea represents a finite capital asset, and some allowance for the need to maintain its value should be made in considering how much of production in any given year should be reflected in living standards.

(1) Estimates of net national product do, of course, take account of the ageing of items such as production platforms and pipelines.

II Some economic implications

This section discusses a number of economic questions, such as the effects of changes in the real price of oil on the world economy in general and the UK in particular, and then raises some policy issues. The relevant conclusions of Part I can perhaps be summarised as follows:

- The UK is somewhat less than self-sufficient in oil, in the sense that the ratio of reserves to consumption is a little lower than the ratio for the world as a whole may be.
- This is reinforced by the relatively high cost of exploiting UK energy reserves.
- The present value of the economic rents accruing from the oil and gas fields (other than the Southern Basin) presently in production or under development is approximately 45% of one year's GNP. The inclusion of other gas at world prices and oil in fields not yet under development would raise this figure—to perhaps 60%–120% of current annual GNP.

If a real rate of return of 5% could be earned on the 60%–120% of GNP suggested for the present value of rents, a substantial increase in private and public consumption on this account of some 3%–6% of current GNP would be sustainable.[1] This increase should be treated as additional to whatever the level of consumption would have been if the UK had had to import oil, not as an addition to current levels of consumption. At a production level equal to oil self-sufficiency—about 80 million tonnes annually—and at the 1980 oil price, production would be worth some £10 billion, or over 5% of GNP at factor cost in 1980. If production were to reach 120 million tonnes in 1985, and the real oil price were unchanged, sales revenue might then approach 8% of GNP. This would probably substantially exceed its contribution to permanent income. In other words, to maintain the real value of capital represented by the North Sea asset, any excess of sales revenue during the next decade or so over and above this contribution to permanent income would have to be invested. If the revenues were in fact devoted to consumption, the element of capital consumption would not be recognised in the conventional national accounts, for (as explained above) the conventional accounts include as income not the contribution to permanent income from North Sea assets but the value of current North Sea output. It is difficult to draw straightforward conclusions for policy; the policy implications are discussed further in the conclusions to this article.

Oil price rises and the world economy

As noted, the profile of the real oil price is important in assessing the addition to consumption made possible by North Sea reserves. In considering the relationship between real oil prices and economic welfare in the world as a whole and in this country, it is instructive to take first the case of a country which is representative of the world as a whole in having expected oil production and consumption profiles which are identical. This means that it is self-sufficient both in that at expected oil prices the present value of its production and consumption are equal, and in that its current trade in oil is also in balance. Suppose then that estimated reserves in the rest of the world were downgraded: a higher current, and expected future real price, of oil would result. The country in question could choose to isolate its consumers from the income loss suffered by the rest of the world—which is now not as well off as it thought—by taxing production of oil and subsidising domestic prices so as to leave the domestic price unchanged. Domestic oil consumption and production would be unchanged, if the tax and subsidy rules were thought to be permanent, and the country would still be self-sufficient in a present value sense.

Although able to insulate itself in this way from the direct effects of the oil price rise, the country's potential welfare would not be unaffected. First, the set of taxes and subsidies would distort trade; their removal would open up opportunities for profitable trade involving increased exports of oil. (The size of this welfare improvement—arising from the exchange of oil exports for imports, resulting from higher production and lower domestic consumption at the new higher price—would depend on the price elasticities of supply and demand. Such evidence as is available suggests that these are small, so that the welfare gain might be fairly minor.)

Second, there would be important indirect consequences for this representative self-sufficient country. The general price level and the level of activity in the world as a whole would be altered, as oil importers and exporters adjusted their expenditure in response to the income transfers generated by the changes in the price of oil. OECD studies indicate that these effects can be substantial: on plausible assumptions, a 10% rise in the nominal price of oil and other internationally traded fuels might increase the domestic price level in OECD countries by 1% after two years, and reduce their output by about 0.4%. The country in question would suffer, at an unchanged exchange rate, from somewhat higher imported inflation and from somewhat lower world demand for its products. A further, and potentially important, indirect effect on the self-sufficient country of the oil price rise in world markets might be transmitted by the exchange rate. It is possible that, for a number of reasons discussed in some detail below, the real exchange rate would rise, offsetting the effects of faster world inflation and improving domestic living standards through a terms of trade gain, but depressing real output in the sectors producing goods for export or competing with imports, by worsening competitiveness. The country might then either lose or gain from a change in the world oil price. Economic activity would be temporarily depressed (and inflation might be higher), but the real income of those in work would improve; real national disposable income might rise or fall.

(1) The required real rate of return on public sector investment programmes is 5%.

A change in the price of oil also leads to transfers of income between oil producers and oil consumers within the country, just as it does in the international community. The price increase would initially transfer income from consumers to producers, but most of the producers' gains would probably be passed on to the government in taxes of one sort or another. The government might choose eventually to return much of the revenue to its citizens by cutting other taxes, thus in effect compensating for the higher price they have to pay for fuels, rather than by raising public expenditure. These distributional and fiscal adjustments, and any associated uncertainty, are a further source of possible welfare effects.

A country with no oil of its own would be much worse off in this changed world. It would face a fall in its real income, and a major deterioration in its trade balance, with no other *direct* implications for its economic structure. The response to this would be a fall in consumption of all categories of output, and in order to restore balance in the external account there would have to be substantial falls in imports, and rises in exports, of tradable goods—in particular, manufactures. Where manufactures are an important part of exports, and exports of manufactures are a large share of manufacturing output, the result would be a rise in manufacturing output at full employment, while output in construction and in public administration would probably fall. Such an economy would be obliged to industrialise, relative to the trend, in order to pay for imports of dearer oil.

This analysis of structural changes in the typical OECD economy is highly simplified. It abstracts from the lengthy adjustment period during which oil importers typically ran current account deficits, while slowly adjusting to the effects of the shock. This breathing space was facilitated by the ability of international capital markets to recycle the surplus funds built up by the oil exporters (who on their side took time to adjust their expenditures to match their increased oil income) in order to finance the deficits of the oil importers. And it takes no account of the influence of the higher real oil price on the structure of demand, an influence now seen to be of considerable and growing importance in the long run in restraining consumption by oil importing countries. But the simple approach describes well the main features of the reaction of industrialised countries to the 1973–74 oil price rise, and is proving equally applicable in the period following the 1979 rises.

The UK is rather more than self-sufficient in oil in current terms, and may export substantial quantities over the next few years. But it is probably somewhat short of being self-sufficient in present value terms. In the longer run, it will probably have to revert to importing oil at a higher real price than today, or—if the real price has risen to make them economic—to making oil substitutes out of domestic coal. In either case, the real resource cost that the UK will have to pay for fuel in future is likely to be greater than the real resource cost of producing North Sea oil. The UK lies somewhere between the representative self-sufficient country and the typical industrialised oil importer. Higher real oil prices are not only a source of short-run disruptions, but represent a long-run deterioration, relative to prior expectations, in its prospective living standards. This deterioration is, however, likely to be much less severe than that experienced by most of its neighbours and competitors, and the ultimate need to industrialise is correspondingly less marked.

Trade balance and the exchange rate

A rise in the price of oil constitutes a direct deterioration in the overall terms of trade for an industrialised oil importing country: it has to supply more goods—usually manufactures—for each barrel of oil it imports. To that extent, the real exchange rate of the oil importer has deteriorated against that of the exporter, and there is a transfer of income from the oil importer to the oil exporter. The importer has to devote more resources to the production of manufacturing for export when, as is usual, the demand for oil is rather price-inelastic. This is the process described earlier, and referred to as industrialisation.

This process need have no major effect on real exchange rates between oil importing countries when measured in terms of the typical exports of this group. Any changes that do take place will reflect the different extent to which oil importers are dependent on oil, with countries which import a substantial quantity of oil relative to their manufacturing exports needing to gain some competitive advantage against those less affected, in order that trade balance be eventually re-established everywhere. An industrialised country self-sufficient in oil, then, will tend to lose competitiveness relative to other industrialised countries: its real exchange rate in terms of manufactures will probably rise. Depending on what happens to total world demand for 'industrial' products, however, exports of manufactures by the self-sufficient country will, in general, be little different in the new balance of trade equilibrium. The worsening of price competitiveness should only be sufficient to ensure that the *extra* imports of manufactures by oil exporters come from oil importing countries, so that the self-sufficient country remains in trade balance at an almost unchanged level of exports[1], but with a smaller *share* of an enlarged total of world trade in manufactures.

It is difficult to judge how large the movements in competitiveness need be to restore a worldwide balance of trade in manufactures. In the long run, the necessary adjustments may be rather minor, with only small second-round consequences, through the terms of trade, for the level of real income in the country which is self-sufficient in oil. Further small, second-round, effects may arise to the extent that oil importers and oil exporters differ in their marginal propensities to import a particular

(1) To the extent that the terms of trade of the self-sufficient country have improved, some minor fall in export volumes will be needed to maintain trade balance.

country's goods in response to a change in income. These are difficult to assess, but may on balance tend to favour the UK in the circumstances of an oil price rise.

An analysis of this type may, however, be misleading in its concentration on the price movements required to produce a long-run equilibrium. How are the necessary exchange rate movements brought about, and what happens in the intervening period? In practice, oil producers have accumulated financial assets following oil price increases. For some producers, this arises because there are unavoidable delays in adjusting their imports in line with their newly increased export earnings, while others lack sufficient development opportunities at home to do other than invest their revenues abroad, even in the fairly long run. The result is that oil importers have run large current account deficits following each round of oil price rises, which have been financed largely by private and official borrowing from (ultimately) the oil exporting countries as a group, through the intermediation of international banks and agencies.

This would, in itself, not cause movements in exchange rates between oil importing countries if oil exporters as a whole were happy to accept claims on oil importers which corresponded to their extra oil bills. The *ex ante* currency composition of claims that oil importers wish to create as a counterpart of the extra value of oil imports will not, in general, coincide with the composition of the desired asset portfolios of oil exporters at existing exchange rates. As a result, nominal exchange rates between oil importers are likely to alter until portfolio equilibrium is reached, changing the currency composition of the asset demands of the oil exporters and the assets supplied by oil importers. A country which faces an extra oil deficit that is larger in relation to the total addition to oil exporters' revenues than is the share of its currency in oil exporters' desired asset portfolios, is likely to see its nominal exchange rate fall; and a country like the UK, self-sufficient in oil, which thus releases no extra assets in its own currency on to world markets in response to an oil price rise, may see its exchange rate rise in consequence unless deficit countries meet the asset demands of oil exporters by running down their sterling assets, or issuing sterling claims.

The movements in real exchange rates and in competitiveness which these discrepancies between asset demands and asset supplies engender in the short run are not necessarily those needed in the longer run to re-establish trade equilibrium. A country with a large oil deficit, and thus with a major need to industrialise after an oil price rise, may see little movement in its real exchange rate because its currency is favoured by oil exporting countries. In the somewhat longer run, however, asset preferences are likely to alter so that adjustment is indeed promoted by movements in exchange rates: and if the initial change in competitiveness was inadequate, or perverse, the subsequent adjustment may be more substantial and more rapid than would have been desired.

How can the movements of the UK's real exchange rate over the period be assessed in this framework? Even after the subsequent weakening of sterling, the deterioration in price competitiveness in manufactures in 1979–80 was, and remains, much more than sufficient to divert the *extra* export demand of enriched oil producers away from UK output towards that of oil importers, whatever date is used to assess the equilibrium level of competitiveness before the oil price rise. Large shifts in shares of world trade have taken place in the past with small, or even unobservable, movements in competitiveness, and there is no reason to suppose that a major change was required to reduce the UK's share by the small amount needed to re-establish long-run trade equilibrium following the second oil shock. To some extent, the overvaluation of sterling may be a short-run phenomenon, resulting from sterling assets constituting a greater share of oil producers' desired portfolios at the equilibrium set of exchange rates than would have been supplied as a consequence of oil importing countries' trade deficits.

But the size of any such asset effect on the real exchange rate of sterling is impossible to assess with any confidence; and there are other plausible reasons for sterling's rise between 1978 and 1980. One of these was the high level of domestic interest rates for much of this period, compared with those in other financial centres.

The structure of the UK economy

The argument in the previous section pointed to the pressure on industrialised countries without oil of their own to move resources into the production of traded goods in response to higher real oil prices, so as to be in a position to pay for imported oil. The UK, in contrast, is spared this pressure in the short run, by virtue of being at least self-sufficient in oil for the next several years. It is not, of course, spared the pressure to re-allocate resources within the industrial sector, in response to the changed relative price of oil. And in the longer run the UK too will be under pressure to industrialise, to adapt to a higher real cost of energy. It matters little whether this energy comes from abroad, or from higher-cost domestic sources such as coal, or oil in still deeper water. In the former case, tradable goods for export will have to be produced, whereas in the latter the UK will either have to provide industrial resources for energy extraction directly, or by purchase from abroad. The composition of industrial output may differ between these cases, but in both a higher share of national resources will have to be devoted to industrial production, relative to the underlying trends, than if the oil price rises of the last decade had not happened.

In the short run, however, this process of industrialisation relative to trend may be interrupted by, among other things, temporary losses of competitiveness arising from other countries' surpluses and asset preferences, or as a result of particular depletion policy and revenue allocation decisions. Such cycles of contraction and expansion in particular sectors of the economy would be of little consequence if resources—in particular labour—could be easily moved from one form of productive activity to another, with negligible social costs and losses to national

output. Indeed, some would see a period of contraction such as that which industry has recently been experiencing as a useful way of weeding out unhealthy firms and activities, so as to free resources for the expansion of those more likely to succeed. But this process carries substantial economic and human costs in terms of unemployment, and could at some point prove difficult to reverse. A skilled industrial labour force takes time to create; and firms cannot quickly re-establish themselves in markets at home or abroad which they have once been obliged to leave. Research into, and development of, improved products is likely to require a substantial industrial base, and certain types of domestic activity, particularly susceptible to damage from worsened price competitiveness, may carry benefits to the rest of manufacturing industry which are greater than the value of their output would directly indicate. These considerations would argue for minimising the adverse consequences, for the structure of the onshore economy, of the UK's temporary status as an oil exporter whose currency is in international demand.

These propositions have been disputed by some[1] who have reached opposite conclusions, although the structure of their argument is similar. The differences lie in two areas, of which the more important is the choice of reference period. If North Sea oil had not been discovered until 1976, it would have been appropriate to respond to the 1973–74 price rises by embarking on industrialisation and then to have put that process partially into reverse when North Sea oil was discovered. As Chart 2 makes clear, however, the size of North Sea reserves was already fairly well understood in 1973. The second issue is the size of the North Sea; de-industrialisation would be called for if, contrary to the discussion above, the UK were likely to be a permanent net exporter of oil. Given that the UK is probably only a temporary net oil exporter, temporary de-industrialisation might be appropriate if the UK could not resort to the international capital market and if trade had to be balanced year by year. But if this were the case, the UK would hardly choose to be a significant net exporter of oil.

Depletion policy

It was argued earlier that it is important to see oil and gas in the North Sea as a capital asset—as a store of current and future consumption in part made possible by substantial investment of resources in its discovery and exploitation. The determination of the optimum rate at which to produce oil and gas would in principle be relatively straightforward, if it could be treated in isolation from its macroeconomic consequences for the UK, and if the future evolution of real prices and real costs were known. The rule would then be to choose, within any technical production constraints, a profile for production that maximised the present value of the differences between sales revenue and costs of extraction, using an appropriate discount rate. Other things being equal, the faster the real oil price was expected to rise, the more production would be postponed; and the higher the discount rate, the more it would be advanced.

There are, of course, a number of severe practical difficulties in any simple application of this theoretical principle. The likely evolution of real oil prices over the relevant decades cannot be forecast with certainty, and domestic costs are difficult—though perhaps less so—to predict. In addition to technical constraints on the pattern of production, the size of North Sea reserves is uncertain. It is not easy to decide within a wide range what discount factor best reflects the rate at which the UK as a whole is prepared to exchange present consumption for consumption in the future. Moreover, the oil companies that have invested heavily in the North Sea may face financial constraints and investment possibilities that make their optimal depletion rates different from those that would otherwise be desirable; some recognition of the need to protect their interest has already been given in government guarantees.

Severe though these technical difficulties are, they might prove less important than a failure to assess properly the economic consequences of a given depletion policy. One of these relates to the security of supply: it is likely to be of considerable economic and political value to the UK to be in a position to save itself, and its main economic partners, from the worst disruptive consequences of any future interruption to world oil supplies. Another consequence is, as noted above, the risk that if the UK were to become a major oil exporter and did not spend its export earnings on imports or services additional to what it might otherwise have imported, a contraction would be forced on the industrial base, which would later need to be reversed, probably at high cost. In themselves, these arguments urge more in the direction of cautious depletion than would be suggested by the application (so far as that is possible) of the simple maximisation procedure outlined above. It should be noted that the use made of revenues from faster depletion would depend in part on how government revenues from North Sea oil were treated. Under the present financial strategy, and with any given level of public expenditure, faster depletion and consequent higher revenue from oil would permit other taxes to be reduced—increasing purchasing power and eliminating much of the risk just indicated that faster depletion would lead to industrial contraction.

Conclusions

North Sea oil and gas make the UK better off than if it had been obliged, like most industrial countries, to import its oil. The resources needed to produce a typical barrel of oil from the North Sea are, however, large, and exceed those which were needed to buy it from abroad before the oil price rise of 1973.

In other words, the combination of discovering the North Sea reserves and suffering from the price rises of the 1970s leaves the UK worse off than if neither event had occurred—though it is also true that the price rises promoted a fuller and faster development of the North Sea. The degree to which the UK is worse off is, however, small,

(1) Notably P J Forsyth and J A Kay, in 'The economic implications of North Sea oil revenues' (*The Journal of the Institute of Fiscal Studies*, vol 1 no 3).

both in relation to a hypothetical situation in which the UK had no oil, and in comparison with other countries who now need to import high-priced oil. Indirectly the UK's position has clearly also been worsened, along with that of other countries, by world inflation and recession, themselves in part the consequence of developments in the international oil market.

The fact that oil-related developments over the last decade at home and abroad have, taken together, had little effect on the UK's welfare has certain important implications. In the first place, it means that no spending bonanza is justified because of North Sea oil. In the second place, it means that no large degree of structural change (towards de-industrialisation) is desirable or inevitable because of the direct effects of the UK's oil endowment. It is *other* countries who need to expand their industrial sectors to export more to pay for high-priced oil. The UK may, however, later have to face the need for structural change, as oil fields dry up, or as the resource costs rise in the future. This relatively favourable position does not exempt the UK from the need, which confronts all countries, to adapt consumption and production patterns to the high energy prices of the 1980s.

It has been suggested that North Sea oil and gas should be seen as capital assets. One implication is that the extent to which the UK is better off than if it had no oil reserves is measured by the addition to consumption which could be sustained indefinitely as a result of exploiting North Sea oil. In the course of the next decade, net revenues from oil and gas sales will probably exceed this amount. The illustrative calculations presented earlier suggest that even by 1985 sales revenue net of current costs may amount to 5%–7% of GNP, whereas the permanent increment to consumption made possible by North Sea oil might be of the order of 3%–6% of GNP. It might be argued that any excess of net revenues over permanent income in the years to come should be used to acquire assets which would provide income in the following decades, when the UK will revert to being a net importer of oil.

This argument is, however, difficult to apply, for two main reasons. First, the size of total capital formation at home is not entirely governed by policy decisions, though it can be influenced by them; and the same is true of the net accumulation of foreign assets (ie the current balance of payments). Higher capital formation has sometimes been thought desirable in the past for reasons quite apart from North Sea oil considerations; but this has not been easy to bring about.

Second, the level of investment at home or abroad is likely to be affected by such macroeconomic variables as the rate of growth in the economy, the degree of under-utilisation of resources, and the exchange rate; and these may be more directly subject to the influence of policy than the level of investment itself. But policy affecting the general balance of the economy cannot be decided by reference only to considerations related to the North Sea. The UK is now in recession, which means that the non-North Sea capital stock is less fully utilised than usual, and investment is lower than its pre-recession level. But the possibility of faster growth of output, which would absorb resources now unutilised and also stimulate higher investment, cannot be considered in isolation from the problem of inflation. Thus the profile of North Sea production cannot be given exclusive weight in assessing the need for any stimulus to domestic investment. Similar difficulties would arise in seeking to transform North Sea output in excess of the permanent increment to consumption into external assets, financial or real. This would require an improvement in the current balance of payments—which would stand to be affected, for instance, by the exchange rate. But the exchange rate has a widespread influence on the economy. The rate is (indirectly) influenced by policy; but policy has to be decided on a wide range of considerations, of which those related to North Sea oil could only form a part.

To some considerable degree, however, market forces are themselves likely to produce a higher level of investment. Less production would mean that more oil reserves would be preserved for posterity—it would be the equivalent, in value terms, of more rapid depletion combined with greater investment in other assets. If, on the other hand, oil production were higher, this would mean more oil exports (or fewer imports). The current balance of payments (and thus net investment abroad) would then be likely to be stronger (though not necessarily to the same extent) as compared with what would have happened with a policy of slower depletion.

The question whether the UK is taking full advantage of the wealth represented by the North Sea is difficult to discuss outside the context of general economic policy, which has to be decided with reference to the position of the economy as a whole. But although it does not appear possible to draw any more precise lessons for policy, it could certainly be argued that the probable development of North Sea output over the next decade is an additional powerful general reason for favouring investment, to the extent that such a bias can be made effective.

Appendix
North Sea oil and gas in the national accounts

The CSO estimate[1] of net output in the oil and gas extraction industries (MLH 104) is shown as line 1 in Table H. This index grew by a factor of about 320 from 1975–80, and the weight of MLH 104 in total output grew from 0.11 to 40 parts per thousand, an only slightly greater factor of about 350. This suggests that the deflator for value added in MLH 104 rose by only a small amount relative to the general price level; under such conditions, the choice of base year makes little difference to the measured growth of output. Line 3 demonstrates this point: line 3.1 is output growth at 1975 prices, as published, and line 3.2 is an estimate of output growth at 1980 prices on the assumption that relative price changes elsewhere in the economy are unimportant. At 1980 prices, output growth from 1975–80 is estimated to be 0.7 percentage points higher than at 1975 prices.

Table H
Oil and gas in domestic output[a]

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1975–80
1 Output of MLH (1975=100)	..	..	..	..	..	100	5,123	15,023	21,796	31,333	32,110	
2 GDP(O) *excluding* MLH 104 (1975=100)	..	..	..	..	..	100	101.3	102.9	105.6	106.9	103.7	
3 Growth of GDP(O)												
1 at 1975 prices	..	+1.5	+3.0	+5.8	−1.7	− 2.0	+1.9	+2.6	+3.3	+2.2	−2.8	+7.2
2 at 1980 prices(b)	..	—	—	—	—	—	+2.0	+2.8	+3.4	+2.3	−2.8	+7.9
4 Factor incomes in oil and gas (£ millions)	28	−11	45	43	5	− 30	521	1,845	2,488	5,144	7,649	
5 Royalties and licence fees (£ millions)	4	36	24	15	18	23	76	234	286	531	1,156	
6 Oil and gas incomes as a percentage share of GDP(Y)	0.1	—	0.1	0.1	—	—	0.5	1.5	1.7	3.1	3.9	
7 Oil and gas incomes plus royalties and licence fees as a percentage share of GDP(Y) plus royalties and licence fees	0.1	—	0.1	0.1	—	—	0.5	1.7	1.9	3.4	4.5	

.. not available.

(a) GDP(O) refers to the output measure, at factor cost. GDP(Y) refers to the income measure, at factor cost and at current prices.

(b) The 1980 price estimate uses 1980 shares in value added (line 6) to aggregate the output series in lines 3 and 4. This amounts to assuming that there is no significant relative change in the price of value added in the component industries of either output series.

During this period, however, the price of North Sea oil rose by almost 80% in real terms, and the real producer price of gas nearly doubled: the CSO estimates thus suggest that there has been a considerable rise in one or both of:

- the volume of input required to produce a unit of oil or gas;
- the real price of inputs to the industry.

The estimation of the volume of net output in MLH 104 is, however, far from straightforward. The industry is defined to include a number of specific oil and gas-related services, as well as exploration, development and production activities. The CSO prepares output indicators for thirteen separate activities within MLH 104, using various confidential data collected each quarter from the oil and gas industry: the weights used to aggregate these series are based on estimated shares of factor incomes within MLH 104 in 1975 and 1976. In summary, these are:

	Parts per 1,000 in GDP
Extraction of oil and gas	2.01
Exploration on UK Continental Shelf	−2.58
Other activities	0.68
Total	0.11

Each separate output indicator (for, say, net output of oil from a fixed platform) suffers from the usual difficulty of collecting adequate information for a proper double-deflation[2] calculation of net output. The very large weights for individual activities, necessitated by the pattern of factor incomes in 1975, may have the effect of magnifying any consequential errors many times in the final estimate of net output in MLH 104 as a whole. Furthermore, the use of these fixed weights may become increasingly inappropriate as the balance of activity in MLH 104 shifts away from exploration towards development and production: such structural change may well have been more marked in the oil and gas industry than in the economy more generally. For example, the share of operating expenditures in all North Sea costs has risen from less than 5% in 1975 to nearly 20% in 1980. But the consequences for the estimate of output economy-wide would, of course, be very minor.

A further complication arises from the treatment in the national accounts of taxes levied on domestic oil. Royalties and licence fees in the North Sea are treated as indirect taxes, whereas all other North Sea taxes are treated as direct taxes. However, royalties on oil differ from most expenditure taxes in that they are more likely to be borne by the seller. Expenditure taxes such as VAT are generally charged both on domestic production and imports, but remitted on exports: they can thus insert a wedge between the price of a good on the home market, and its price on world markets. By contrast, North Sea oil fetches the

(1) Details of the calculations are given in the CSO publication 'Output measures: occasional paper no 10; MLH 104—petroleum and natural gas'. February 1979.

(2) This term refers to the best statistical practice of calculating net output from separate estimates of gross output volume and of input volume.

prevailing world price both at home and abroad, and producers receive this price, less any tax the government may levy. The incidence of royalties is thus rather clearly on factor incomes in MLH 104. In measuring the contribution of oil and gas to domestic output, it is therefore probably more appropriate to treat royalties as a direct tax rather than as part of factor cost adjustment. Line 6 of Table H shows factor incomes in MLH 104 as conventionally measured, and line 7 shows royalties and licence fees. By 1980 these are large enough to increase significantly the share of oil and gas incomes in GDP, from 3.9% to 4.5%. If royalties had been abandoned in favour of, say, petroleum revenue tax, measured incomes earned in the North Sea would have risen by about £1 billion in 1980, and GDP at current factor cost would have been about ½% higher.

The treatment of gas production poses a somewhat similar problem. Throughout the period, gas producers in the North Sea have sold their gas to the British Gas Corporation, as sole buyers, at a price substantially below that ruling on world markets. If gas were sold at a price which reflected its thermal equivalence to oil, sales revenues in the North Sea would have been about one sixth higher in 1980. Factor incomes in MLH 104 would have been correspondingly increased, and the trading surplus of nationalised industries correspondingly reduced. If gas had been sold at this price by producers, the price of gas to consumers might have been higher: in this case, the whole structure of the economy, as well as of the national accounts, would have been different. To illustrate how the arrangements affect the estimated output of MLH 104, it is helpful to consider an alternative arrangement which would still have left consumer prices at the levels they actually attained; this could have been achieved by taxing the higher incomes of gas producers so as to compensate for the worsened financial position of the British Gas Corporation. In this case, and assuming the volume of gas production unchanged by the move from a low producer price to a high producer price plus extra taxes on income, the estimate of factor incomes in gas production would have been substantially higher, and the value added in other industries would not have changed. Thus, as in the case of royalties, the effect of the particular route chosen by government to meet its broader objectives is likely to have led to a comparatively low estimate of net output in MLH 104.

In the absence of sufficient detailed information on component industries within MLH 104, a possible approach is to:

- include royalties and licence fees in factor incomes in MLH 104;
- revalue gas production as though producers had received its opportunity cost to domestic users.(1)

Table J
Factor incomes in oil and gas

	1975	1976	1977	1978	1979	1980	1975–80
1 Factor incomes in oil and gas (£ millions)	−30	521	1,845	2,488	5,144	7,649	
2 Royalties and licence fees (£ millions)	23	76	234	286	531	1,156	
3 Additional sales revenue through valuing gas at opportunity cost (£ millions)	820	1,010	1,290	1,010	1,330	1,680	
4 Estimate of notional factor incomes in oil and gas (£ millions)	813	1,607	3,369	3,784	7,005	10,485	
5 Deflator for notional factor incomes (1975 = 100) (*see below*)	100	130	163	150	210	309	
6 Volume of notional net output in oil and gas (1975 = 100)	100	152	254	310	410	417	
7 CSO measure of net output volume in oil and gas (1975 = 100)	100	5,123	15,023	21,796	31,333	32,110	
8 Output growth at 1975 prices based on notional factor incomes (per cent)		1.7	2.4	3.0	2.0	−2.8	+6.4
9 Output growth at 1980 prices based on notional factor incomes (per cent)		2.0	2.9	3.2	2.5	−2.8	+8.0
Estimation of deflator							
Sales value of oil and gas at opportunity cost of gas (£ millions)	1,070	1,910	3,840	4,240	7,560	11,150	
Output volume (mtoe)(a)	33.4	45.8	73.5	87.9	112.1	112.6	
Average price per tonne (£)	32.0	41.7	52.2	48.2	67.4	99.0	

(a) Million tonnes oil equivalent.

The resulting estimate of 'notional' factor incomes in MLH 104 is shown in line 4 of Table J. Valuing gas at opportunity cost adds about 1% to GDP at current factor cost in both 1975 and 1980, and royalties add another ½% in 1980.

The derivation of a constant price equivalent to 'notional' factor income presents problems, in the absence of data on component series in MLH 104. One simple possibility is to construct a deflator for the chief categories of *gross* output—sales of oil and gas—and apply it to the estimate of net 'notional' output described above. (The deflator, shown in line 5, is also calculated as though gas were sold at opportunity cost.) An index for net output in MLH 104 is thus derived (line 6), and grows by about a factor of 4, compared with a factor of more than 300 for the CSO measure, reflecting different contributions to GDP in the base year.

The procedure outlined above is clearly deficient in assuming that the deflator for gross output can be applied to a measure of net output in current prices. This would be valid only if the deflator for inputs in MLH 104 had grown at a similar rate to that for gross output. In fact, prices generally in the economy approximately doubled from 1975–80, and it is unlikely that the price of inputs to the North Sea grew by as much as the 210% suggested by line 5. But even though the measure of net 'notional' output volume in line 6 underestimates its growth, its use in conjunction with the CSO measure may help to delimit the uncertainties.

An estimate of total output in the prices of any year may be made by weighting together the index of 'notional' output in MLH 104 and the CSO measure of non-oil output (shown as line 2 in Table H) using shares(2) of GDP plus royalties, and with gas valued at opportunity cost in that year. Estimates on this basis of real output growth economy-wide in the prices of 1975, and of 1980, are shown in lines 8 and 9. By 1980, the output index stands about 1.6 percentage points higher in the prices of 1980 than in the prices of 1975, where the CSO measure would indicate a difference of 0.7 percentage points. The difference between the two sets of figures indicates the range of measures which can be derived from alternative conceptual frameworks.

In the revised output calculation, all the government's tax take has been treated as a factor income, and in fact the bulk of the surplus in the North Sea does accrue to government in this way. This is indeed the appropriate treatment if it is wished to measure the benefit of oil, compared with not having any domestic production: oil is being valued in the accounts at the price that would have had to be paid if it were imported. This treatment is not necessarily appropriate, however, in assessing how well off the UK is on account of North Sea output. It is important, then, to look at measures of economic welfare, as well as of output.

(1) Data on the price of gas in international trade is scanty. As a working assumption, it is taken to be the average value of a thermal equivalent of heavy fuel oil.

(2) 'Notional' output in MLH 104 has a weight of 8.5 points per 1,000 in 1975, and 53.4 points in 1980.

The national accounts measure economic welfare by a construct known as real national disposable income[1] (RNDI), which attempts to measure the volume of final goods and services which national output could buy. This adds, to changes in domestic output measures of the sort discussed above, changes in final resource utilisation made possible by:

- changes in the terms of trade;
- net flows of interest, profits, dividends and current transfers from abroad.

The terms of trade improve when the average value of UK exports rises relative to the average value of UK imports. The UK is then in a position to import a greater volume of foreign goods for use at home for a given volume of exports, while maintaining trade balance, or to export less while importing the same. Such an improvement in the measured terms of trade could have three possible causes:

- A change in the relative price of different goods. Since the UK exports a lot of manufactures, and imports a lot of basic materials, any weakening in commodity prices relative to those of manufactures will produce a terms of trade gain.
- A higher real exchange rate. If the UK's real exchange rate rises, so that price competitiveness worsens in each category of traded output, then the UK will gain in income, at a given level of trade and activity.
- A change in the composition of trade. If the composition of UK exports shifts more than the composition of imports towards the goods whose prices have grown the most since the base year, the UK gains in income.

Table K
Changes in domestic output and national disposable income

£ millions at 1975 prices

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1975–80
1 Net output at constant market prices with an addition for gas at opportunity cost (Bank estimate)		+1,790	+3,440	+7,220	−1,650	−1,160	+2,860	+1,830	+3,850	+1,810	−2,680	
2 *Of which: net output in MLH 104 (notional measure)*		*+ 10*	*+ 260*	*− 10*	*+ 280*	—	*+ 430*	*+ 830*	*+ 440*	*+ 830*	*+ 50*	
3 Terms of trade effect on RNDI		+ 470	+ 90	−2,790	−3,730	+1,900	− 560	+ 560	+1,520	+1,450	+1,810	
4 Effect on RNDI of net property income from abroad and net current transfers		− 200	− 60	+ 820	− 230	− 950	+ 230	−1,380	− 150	− 70	− 430	
5 **Total: Bank proxy for RNDI**		**+2,060**	**+3,470**	**+5,250**	**−5,610**	**− 210**	**+2,530**	**+1,010**	**+5,220**	**+3,190**	**−1,300**	
Memorandum items Bank proxy for RNDI:												
6 Level	100,450	102,510	105,980	111,230	105,620	105,410	107,940	108,950	114,170	117,360	116,060	
7 Growth (per cent)		+2.1	+3.4	+5.0	−5.5	−0.2	+2.4	+0.9	+4.8	+ 2.8	−1.1	+10.1
8 Growth of RNDI (CSO estimate) per cent		+2.0	+3.2	+5.0	−5.4	−0.2	+2.5	+1.2	+5.1	+3.0	−0.8	+11.5
9 Growth of GNP (per cent)(a)		+1.8	+3.3	+7.2	−1.8	−1.1	+2.9	+2.0	+3.8	+1.8	−2.0	+ 8.6

(a) Average estimate at market prices, as published.

Table K shows CSO estimates of the effects of changes in terms of trade, and of net flows of interest, profits, dividends and current transfers, on changes in RNDI (lines 3 and 4). These are combined with an estimate of output excluding MLH 104, and with an estimate of 'notional' output in MLH 104, both at the prices of 1975, to give a measure of total changes in RNDI. This measure is deficient in that no attempt is made to carry through to lines 3 and 4 the new approach embodied in the estimates of line 2: but the errors from this effect are likely to be minor. The table also shows (line 8) the CSO's estimate of the growth of RNDI, using a conventional estimate of net output in MLH 104.

It is necessary to note that movements in the real exchange rate (and thus in the terms of trade) may partly result from developments in the real oil price, and in UK oil production. Even if the UK had no net trade in oil, change in the world oil price might well alter its terms of trade. In addition, there are now substantial outflows of interest, profits, and dividends as a result of foreign companies' participation in the North Sea, which will tend to lessen RNDI for a given GDP.

Nevertheless, it is possible to discern two phases. From 1973–76, the UK lost real income through worsened terms of trade, offset to some extent by growing gas output in the North Sea and by lessened oil imports. In following years, the growing output of oil added substantially to domestic output, and produced further terms of trade gains as the composition of exports and imports shifted towards balance in the trading of oil. By 1979–80, the UK was in rough balance in trade in oil, and so, unlike most other industrialised countries, did not lose income through the terms of trade as a result of the most recent substantial rise of oil prices.

(1) See J Hibbert "Measuring changes in the nation's real income" in the CSO's *Economic Trends*, January 1975.