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INVESTMENT BOOMS IN AN OIL ECONOMY - THE NORWEGIAN CASE

BY

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ABSTRACT

This paper discuss medium term effects on the Norwegian economy of alternative investment profiles in the petroleum sector. Following a brief discussion of the relevance of theories of optimal extraction we present three alternative profiles that stress different views on the relation between the petroleum sector and the rest of the economy. These profiles are based on "engineering-information" on each oil and gas field with regard to the commodity composition of each investment project. The economic effects of each profile are then analyzed by means of an input-output based econometric model of the Norwegian economy. The need for considering macroeconomic consequences of different investment profiles both on company and government levels is stressed.

1. INTRODUCTION

In the autumn of 1986 the prospects were bleak for Norwegian producers of investment equipment to the petroleum sector. Following the oil price collapse during spring 86, the petroleum companies reacted immediately by announcing postponement of new projects. Unless the government intervened the Norwegian offshore sector, the producers of investment equipment would have been forced to reduce production dramatically until the development of the Troll/Sleipner-fields begins in the early 1990s. The government chose to change the tax system, making investments in the petroleum sector more profitable. In addition oil prices increased to a tolerable level. A lot of the fields at the Norwegian continental shelf again seemed to be profitable to develop. Today one year after the tax cut, one talks about restricting the investment projects by organizing a "queue". An alternative regulation system would be a taxation system more robust towards fluctuating oil prices.

When the government decides on the future level of production at the Norwegian continental shelf, several targets have to be taken into account. One of the main targets is that the extraction and revenue paths must be such as to maximize the social welfare gains from the petroleum revenues. Once this optimal extraction path is fixed, the investment profile follows by necessity. Confronted with an unrenewable natural resource, both the extraction and the investment activity sooner or later must come to an end. If the offshore industry is incapable of switching to new markets or products, then a decision on optimal extraction path implies an optimal moment to close down this industry.

2. OPTIMAL EXTRACTION

The optimal extraction path can be solved as an optimal control problem. Assuming that we have a perfect market in financial assets, the optimal path can be found by maximizing the discounted net profit from the oil reserves. The discrepancy between the optimal profile for net profit from extraction and the optimal profile of spending the revenues i.e. consumption, is met by transactions in the international

capital market. We are not going to derive the model in this paper, only giving some results that such a model would give (see Pindyck (1981)), given the following assuptions in addition to the assumptions conserning the capital market.

- The petroleum price is taken as given and follows a steady and constant growth path.
- We abstract from uncertainty.
- Technological development reduces extraction costs.
- The costs depend positively upon the number of fields under development and negatively upon the amount of reserves which remains in the ground.

Such a model would give the following results:

In the interior solution, the net marginal profit from production will equal the rate of return from other assets along the optimal exploration path. If the net marginal profit is lower than this rate of return, the whole reservoir should remain in the ground. If opposite, the production will be set at its maximum, given by technological restrictions. This result is known as Hotelling's rule (see Hotelling (1931)).

The net profit depends upon the crude oil price and the extraction costs. A shift in one of these factors will lead to shifts in the rate of extraction and alter the period of production. If the expected discounted net profit shifts upwards, the consumption profile also has to shift upwards. The following shifts will give a lower rate of extraction and investment in the short run and extend the total period of extraction.

- A positive shift in the growth rate of petroleum price. The rate of return from letting the oil remain longer in the ground, will then increase relatively to the rate of return from other assets.
- A positive shift in the reduction the technological development. We then get higher cost savings and increased petroleum rent by postponing the extraction.
- A positive shift in the marginal costs due to repercussions in factor markets.

Those three factors mentioned above are likely to occur during the

next decade, we belive.

The model above has some limitations. It is not describing the impact of the activity at the shelf on the entire economy. When deciding on the extraction path, the government must take into account the direct impact the activity has on the rest of the economy, both during the investment- and the production period. We would expect that the government would like to avoid too drastic changes in the level of activity in the offshore industry.

Spending the oil revenues will have some indirect impacts on the economy. We have assumed above that it is possible to separate the spending of the revenues from the earning in time. The political realities may seem to be somewhat different. In a period of temporary high revenues, the political pressure to spend the current revenues by tax cuts or increased public spending is high.

In long term planning, a maximal discounted net profit from extraction, is a central target. But for short- and medium-term planning we are more interested in the direct and indirect impact of the petroleum activity. These impacts must be seen in relation to the main targets in the economic politics; a low rate of unemployment and inflation and a reasonable balance in the net exports of goods and services.

We will in the rest of this paper concentrate on the direct impact of the investment activity on the economy as a whole and in particular on the offshore industry. We will assume that total public spending and tax-rates are unaffected by changes in oil-revenues generated by different investment profiles. In addition we assume constant nominal interest rates and exchange rates.

3. THREE INVESTMENT PROFILES 1987-95

Since the petroleum activity started up in 1965, it has had an increasing impact on the total Norwegian economy. The investment activity has shown fluctuation around an upward trend and reached its highest level in 1986, with 36.5 Bill.Nkr (Source: National account).

We have, on the basis of information received during winter/spring

1987 from the petroleum companies operating at the Norwegian continental shelf, constructed three possible investment profiles for the period 1987-95. Some downward adjustment have been made in the operators plans between the time we finished the data prossesing and autumn 1987.

The three investment profiles are used in three different scenarios describing the Norwegian economy for the period 1987-95. Table 1 shows the three investment profiles.

Table 1: Three profiles for investments in the petroleum sector. Bill.1986-Nkr.

	87	88	89	90	91	92	93	94	95
"Maximum"	26.2	24.9	29.9	40.9	40.6	36.2	21.4	10.0	6.2
"Reference"	26.2	20.5	20.1	24.3	26.3	27.3	26.2	24.1	22.5
"90 million toe"	26.2	20.1	14.6	15.1	15.9	16.3	15.8	18.1	14.8

In the maximum-scenario the profile of petroleum investments is based on the assumption that all of the operators' timetables for new field developments are realised.

Some of the investment prosjects are already given by earlier approvals. These projects consist mainly of the investments on Troll, Sleipner, Veslefrikk, Gyda, parts of Tommeliten and on fields already on stream. In addition, in the maximum-scenario comes satellite projects and further developments at Gullfaks, Oseberg and Statfjord and new field developments at Snorre, Heidrun, Draugen and Smørbukk. The most expensive of these are Heidrun and Snorre, which according to operators' schedules, will require large investments in the early 1990s. At the same time, the large investment activity on Troll will take place. Table 2 shows the investmentstart for the fields in the three scenarios and the investment-outlays on each of them.

Figure 1 shows the total investment in the three scenarios. In addition to the investment in new oil fields, the total investments include exploration costs and investment in pipelines. The total investments in the maximum-scenario are nearly constant through 1987-88. From then on the yearly investment costs increase and peak at more than 45 Bill. Nkr in 1991 (1985-prices), before nosediving to around 10 Bill. Nkr in 1995.

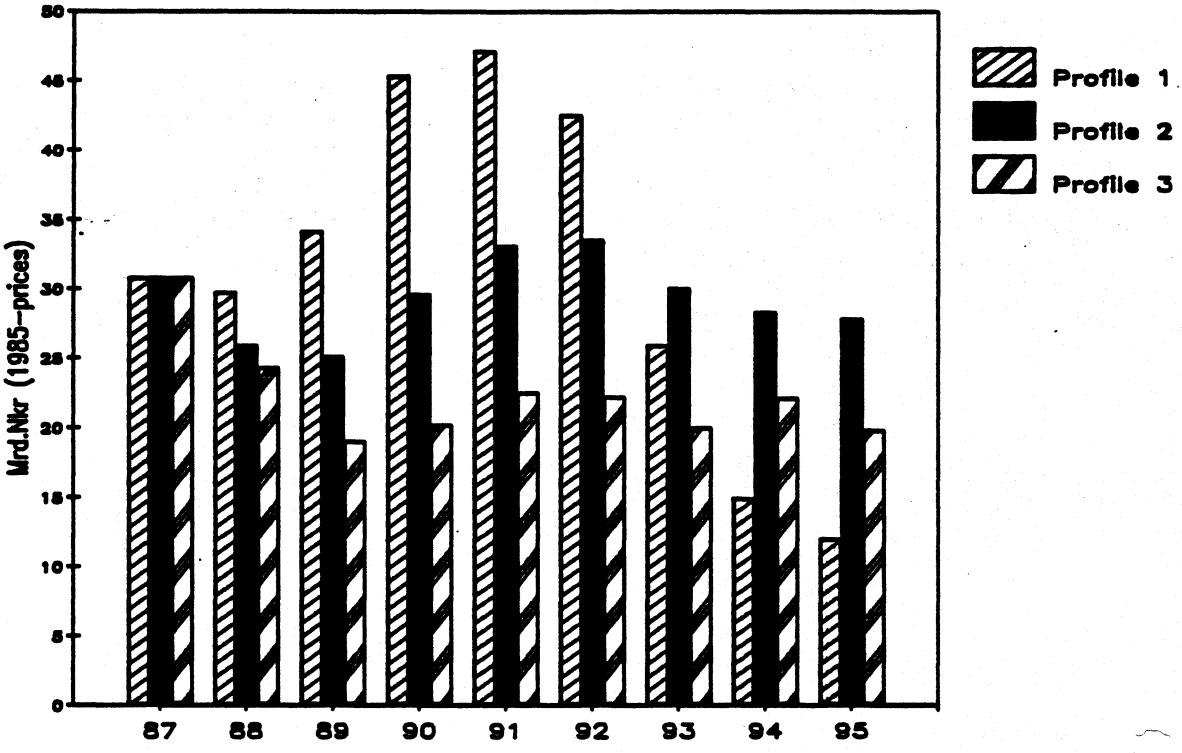
Table 2: Fields, investmentstart and -outlays. Bill Nkr (1986).

	Investmentstart			-outlays
Scenario:	Maximum	Reference	90-million toe	
Name of field				
Gyda	1987	1987	1987	7.7
Troll	89	89	89	25.9
Sleipner	88	88	88	14.0
Veslefrikk	87	87	87	5.3
Brage	88	88	91	7.5
Snorre	88	89	- [1])	25.6
Oseberg N	88	88	92	6.0
Gullfaks S	88	91	92	10.0
Tommeliten 2	88	88	88	1.0
Tommeliten 3	93	93	95	1.0
Tommeliten 4	93	-	-	1.0
Osebergsat.	92	92	95	1.5
Statfjordsat.1	90	90	95	3.5
Statfjordsat.2	91	91	95	3.5
Draugen	88	93	95	15.0
Heidrun	88	92	92	22.0
Smørbukk	90	92	-	20.0
Others [2])				66.5

[1]) Investmentstart after 1995 is marked with "-".

[2]) "Others" are projects with investmentstart before 1987.

Figure 1: Total investment in the petroleum sector. Three profiles. 1987–95.



Profile 1 is the profile of petroleum investments in the maximum-scenario, whil profile 2 corresponds to the reference scenario and profile 3 to the "90 million toe"-scenario.

In the two other scenarios we have assumed that the operators plans are not pursued because of the goverment regulating the total petroleum investment activity. The reasons for the government to regulate this activity can be as following.

First, the operators may have a different discount rate from that of the central government because of different preferences according to the profile of net profit or the extraction of an unrenewable resource.

Each operator may act as if he were price taker in the factor market. In fact, because every project is very large, he is not. When the operators take decisions about field developments whitout coordinating their schedules and without taking price repercussions in the factor market into account, the consequences can be that projects that seemed to be profitable, no longer are profitable.

The operators may neither consider the impacts of the total investment activity on the entire economy or the dependence on the petroleum sector.

In the reference scenario the investment profile is constructed with the special aim of keeping a fairly steady investment activity and activity in the offshore sector.

Since 1974, a central aspect in the petroleum policy has been to limit the total production of oil and gas to less than 90 million toe a year. The reasons for, and interpretation of this ceiling has differed according to different economic situations. In the latest report from the government to the parliament on the petroleum policy (St.meld.46, 86/87), it may seem as if this ceiling now is of less importance, but it is still mentioned.

In the scenario called "90 million toe", the investment profile is constructed on the assumption that oil and gas production never shall exeed an annual ceiling of 90 million toe. One might however interpret this "moderate" extraction alternative as being more in line with an optimal extraction path and also giving high priority to the traditionally exposed sector of the economy, in order to avoid too much dependence on oil. This is the basic idea behind this scenario.

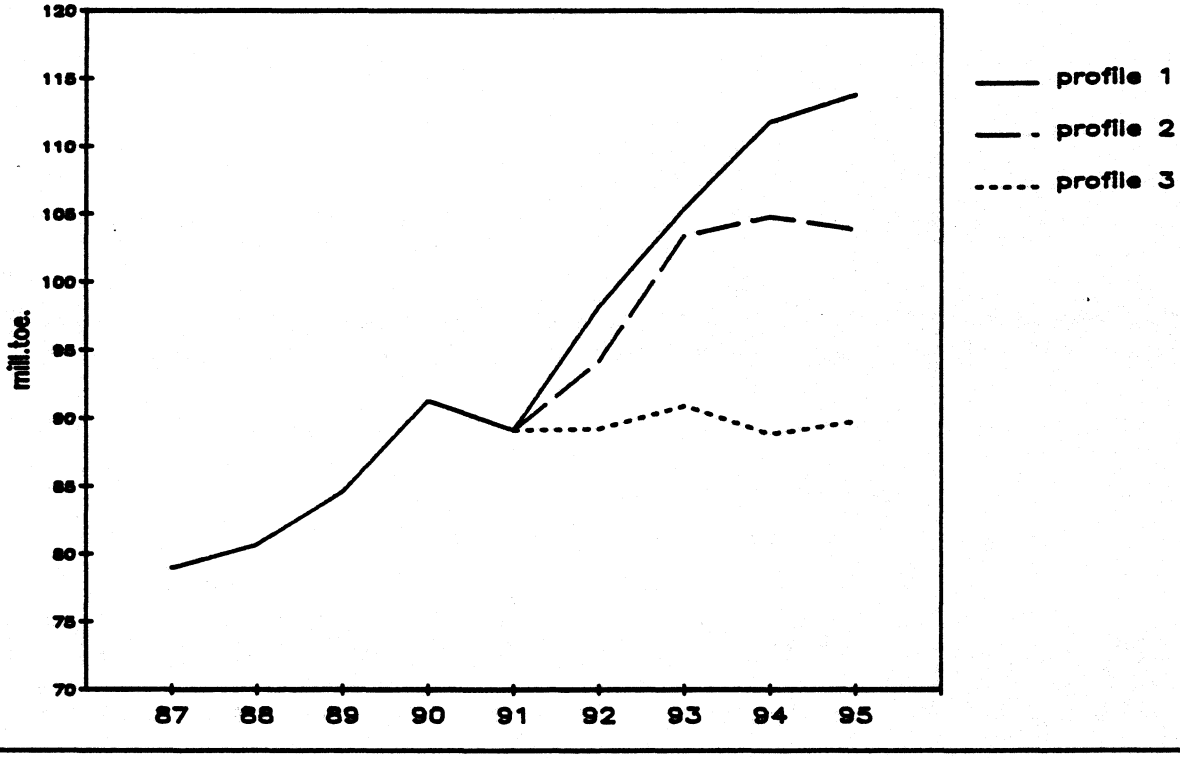
Total investment are falling from 1987 to 1988 in the reference scenario but the investment outlays are back at 1987 level in 1990. The trough in 1988-89 is due to a lot of projects coming to their end while others are just starting up. At the beginning and at the end of a field development, the yearly investment costs are low. If we had developed more fields in 1988-89, we would as shown in the maximum-scenario, got a peak when those fields reached their investment top all at the same time in 1990-92.

In the reference scenario the further development of Snorre, Gullfaks and the Haltenbanken-fields (Heidrun, Draugen and Smørbukk) have all been postponed. Investmentstart on Haltenbanken is set to 1992. The central government is under strong political pressure from both local government and industry in mid-Norway to get field developments on Haltenbanken under way.

In the scenario called "90 million toe" the annual total of investments drops to 18 Bill Nkr in 1989. Thereafter it stabilizes around 20 Bill Nkr. Fields included in this scenario are chosen so as to reach 90 million toe in the cheapest possible way. The investmentstart on Haltenbanken is set to 1992 for Heidrun and 1995 for Draugen. The start for Smørbukk and Snorre is set beyond 1995.

Figure 2 shows the petroleum production that follows from the three investment profiles. As the figure shows, the yearly production in both profile 1 and 2, exceeds 90 million toe from 1992 to 1995.

Figure 2: Oil and gas production. Mill.toe. Profiles 1, 2 and 3.



4. MODAG W

The macroeconomic impacts of the three investment profiles and the three production paths that follows, have been studied by means of MODAG W, a medium-term annual macroeconomic model of the Norwegian economy. For a more detailed presentation, see Svendsen (1988).

The theoretical framework of MODAG W is the Scandinavian theory of inflation, Keynesian macrotheory and input-output theory. The

production is determined mainly by the demand side, except for resource-based industries such as the oil industry, for which production is given exogenously while net export is endogenous. The model distinguishes between sheltered and exposed commodity markets. Competing Norwegian products are faced with separate demand curves on both foreign and domestic markets. Wage inflation is determined by the wage-corridor from the Scandinavian theory of inflation but including a Phillips-curve element. The structure and main empirical characteristics of Modag A are presented in Cappelen and Longva (1987). Only a more sophisticated wage block distinguishes MODAG W from MODAG A.

The input-output structure permits us to analyse the impact on different sectors of a shift in total demand or in the demand from a given sector. MODAG W has 41 commodities, 33 production sectors and 19 categories of private consumption. Real capital and investment are grouped into 8 categories for each of the production sectors.

The input-output coefficients are estimated from the national accounts for the base year of the model (1985). These coefficients are generally held constant over the simulation period. The demand following from investments in new oil fields are in the model spread to engineering, machinery, equipment and oil well drilling activities, by constant coefficients.

However, the commmodity composition of demand from one investment project is far from constant over time. In the beginning of the investment period the project demands mainly engineering services. In the middle of the period the demand turns towards machinery and equipment. Towards the end, the demand for oil well drilling and "set up"-services take over. Since the total investments consist of a few number of fields, aggregation will not cancel out the variation in the commodity demand. The assumption about constant input- output coefficients therefore does not fit the sector for petroleum investment. This problem is solved in our simulations by making some of the coefficients concerning these investments, exogenous. We have divided the investment outlays for each project into annual outlays on different groups of goods and services on the basis of information received about the commodity composition of demand from several projects. On the aggregate level, we have then calculated timeseries for the exogenous input-output coefficients.

5. IMPACTS ON THE NORWEGIAN ECONOMY OF DIFFERENT INVESTMENT PROFILES IN THE PETROLEUM SECTOR.

In this section we study the macroeconomic effects of three investment profiles. The impacts of the maximum-scenario and the "90 million toe" scenario are given as changes from the reference scenario.

Other exogenous variables than investment and production in the petroleum sector and export of petroleum and natural gas are given the same values in all three scenarios. This includes mainly variables relating to economic policy.

5.1 Basic features of reference scenario

Table 3 gives the average rate of growth for some main economic variables for the periods 1987-90 and 1991-95.

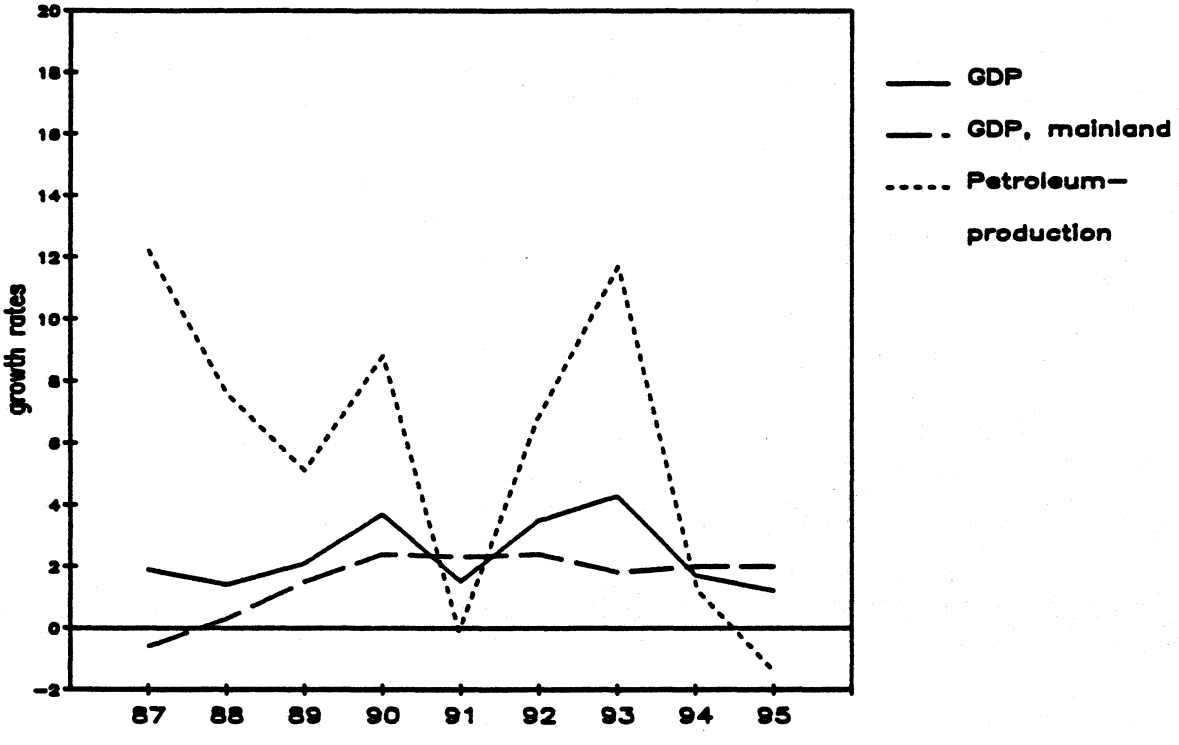
Table 3: Macroeconomic indicators. Reference scenario. Average annual growth rates. Per cent. 1987-90 and 1991-95.

	1987-90	1991-95
Gross domestic product	2.3	2.4
Gross domestic product, mainland	0.9	2.1
Exports	4.2	4.4
Imports	0.2	3.4
Private final consumption expenditure	0.7	1.9
Government final consumption expenditure	2.2	2.0
Gross capital formation	-0.5	1.2
Petroleum production	8.4	3.6
Crude oil prices (NOK), nominal	3.1	10.0
Employment	0.6	1.0
Wage-growth	6.5	4.3
Inflation	5.6	3.7
Current account,% of GDP (level)	6.0	3.3
Unemployment (level)	2.8	2.9
World market growth	2.3	2.5
World market inflation	2.6	2.9

Figure 3 shows the growth rates for GDP, GDP-mainland, and for the petroleum production. GDP, mainland, is defined as GDP excluding petroleum production and ocean transport. As it appears from figure 3, the growth rate for GDP is cyclical, and varying from 1.2 to 4.3 per cent. The trend is more stable for GDP, mainland, with a growth rate around 2 per cent from 1989 and onward. The growth in the petroleum production increases from 1989 to 1990 due to high investment activity during the mid-eighties. The investment activity during the first half

of the simulation period is the reason for the next peak in the growth rate of the petroleum production in 1993. In 1990-92 the rate of growth of GDP is higher due to the growth in the petroleum investments.

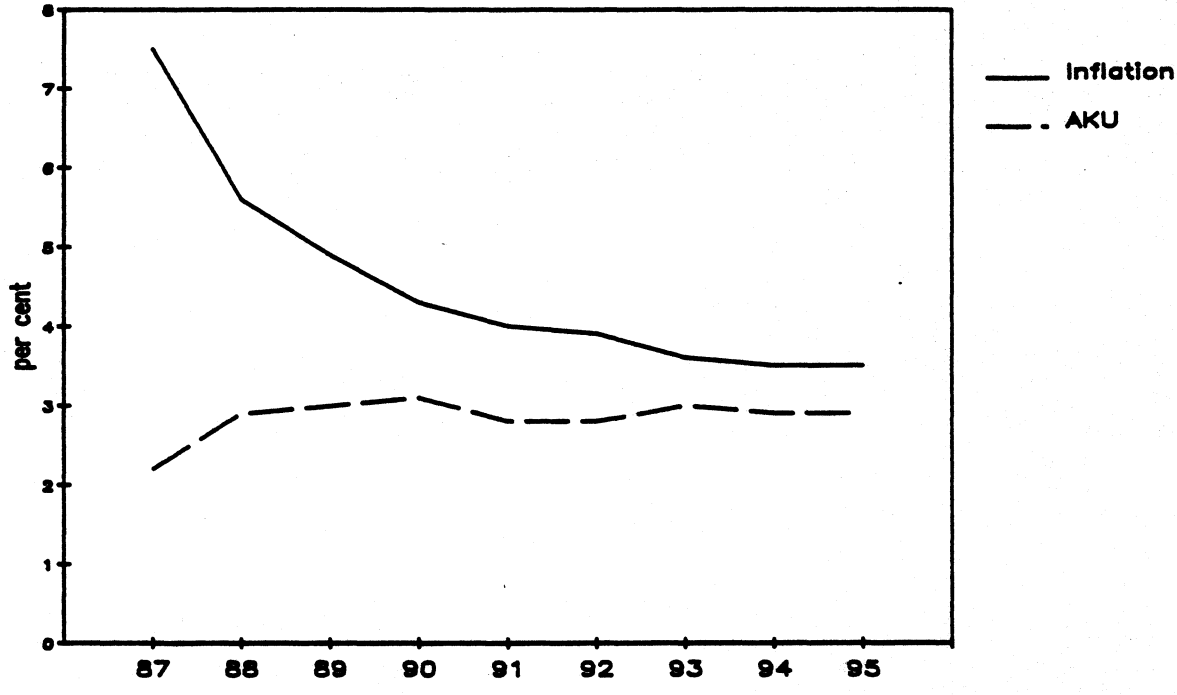
Figure 3: Average growth rates. Per cent. Reference scenario.



The high level of petroleum investment in 1990-1992, gives rise to an increasing growth rate for imports. The exports increase due to the growth in petroleum production. The current account improves during the entire period, but is negative also in 1995 according to our calculations.

The production activity in the petroleum sector, has virtually no effect on private consumption, because of the low use of labour in the production. The rate of growth in private consumption, lies steady around 2 per cent, close to the growth path for GDP, mainland. The rate of unemployment is almost constant around 3 pct., as shown in figure 4. The rate of inflation is decreasing towards 4 per cent in 1995.

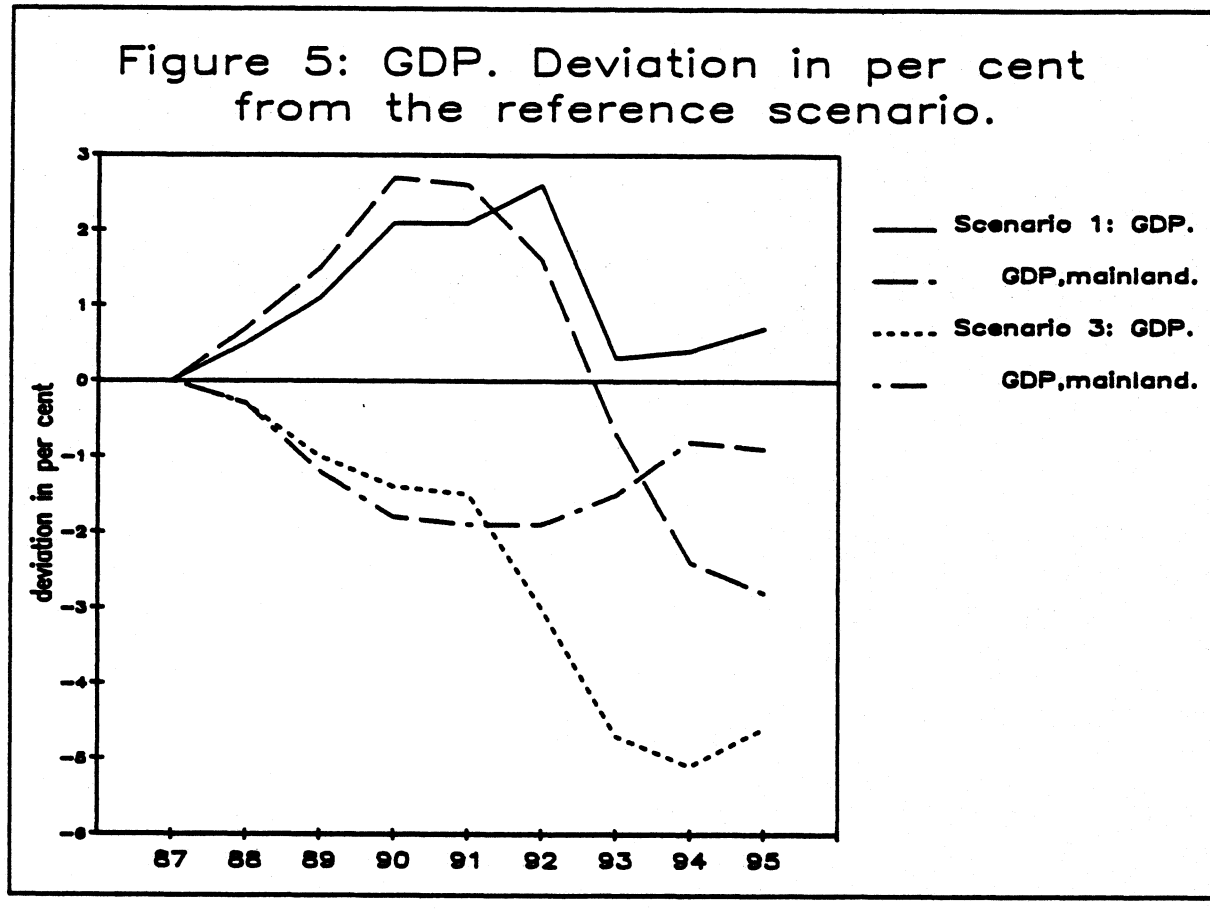
Figure 4: Reference scenario.
The unemployment rate (AKU).
The rate of inflation.



5.2 Main results on the macroeconomy of different investment profiles in the petroleum sector

The impacts of the two scenarios on the macroeconomy compared with the reference scenario, are caused by differences in the petroleum investment and -production. Investments will have a direct impact on mainland activity and, with 3-5 years lag, will influence total GDP and exports via increased capacity in the petroleum sector.

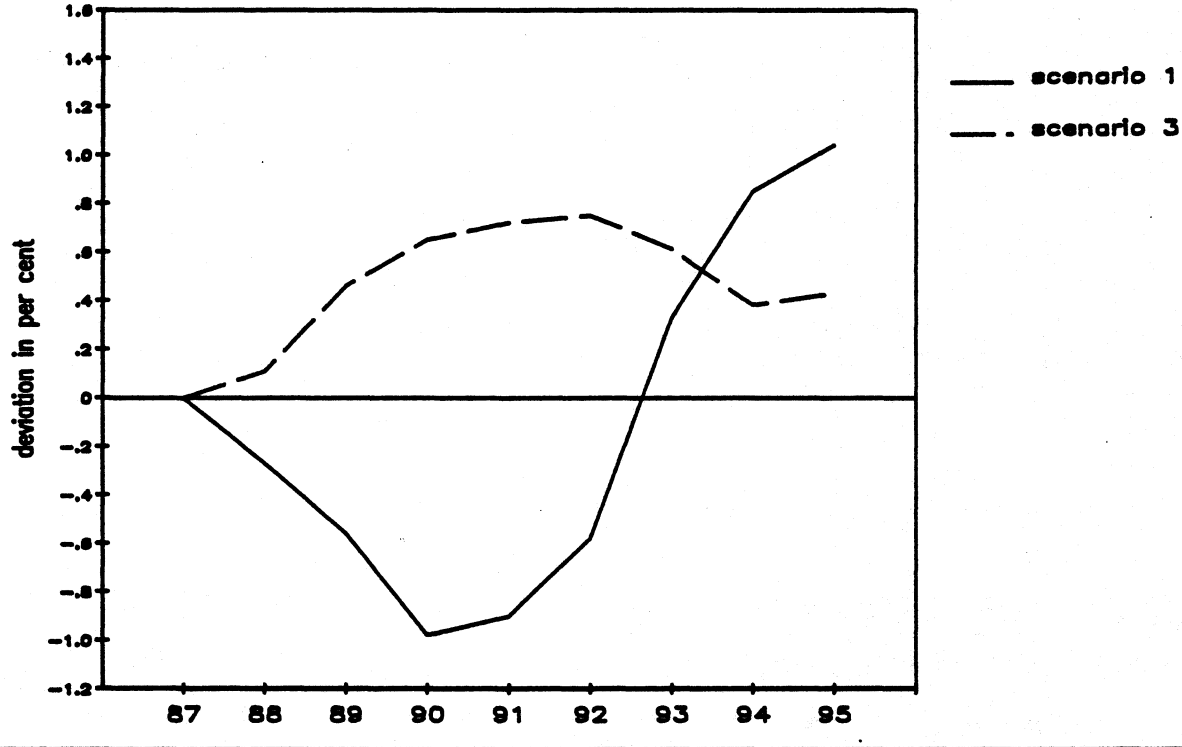
Until 1992, investments according to the maximum-scenario exceed the investments in the reference scenario and are from then on, lower. The result is, not unexpected, a higher level of GDP until 1992. This is shown in figure 5. By then the petroleum production in the maximum-scenario exceeds the production in the reference scenario, and prevents the GDP level to fall below the level in the reference scenario when the investment activity decreases. But because of the strong decrease in the investment activity, the level of GDP, mainland, is rapidly reduced relative to the reference scenario. The high investment activity in the first half of the period, has a positive effect on private consumption via employment and wages.



Scenario 1: Maximum-scenario
Scenario 3: "90 million toe"-scenario

Figure 6 shows the deviation from the reference scenario in the unemployment rate . The growth in private consumption is stronger than in the reference scenario until 1992. The rising petroleum production in the maximum-scenario has nearly no impact on the employment and wages in our model. In fact, the rate of unemployment increases from 1991 on, as shown in figure 6. So, when investments decline in 1991, the rate of growth in private consumption decreases. In 1994-95 the private consumption in this scenario is lower than in the reference scenario.

Figure 6: The unemployment rate (AKU). Deviation from the reference scenario.

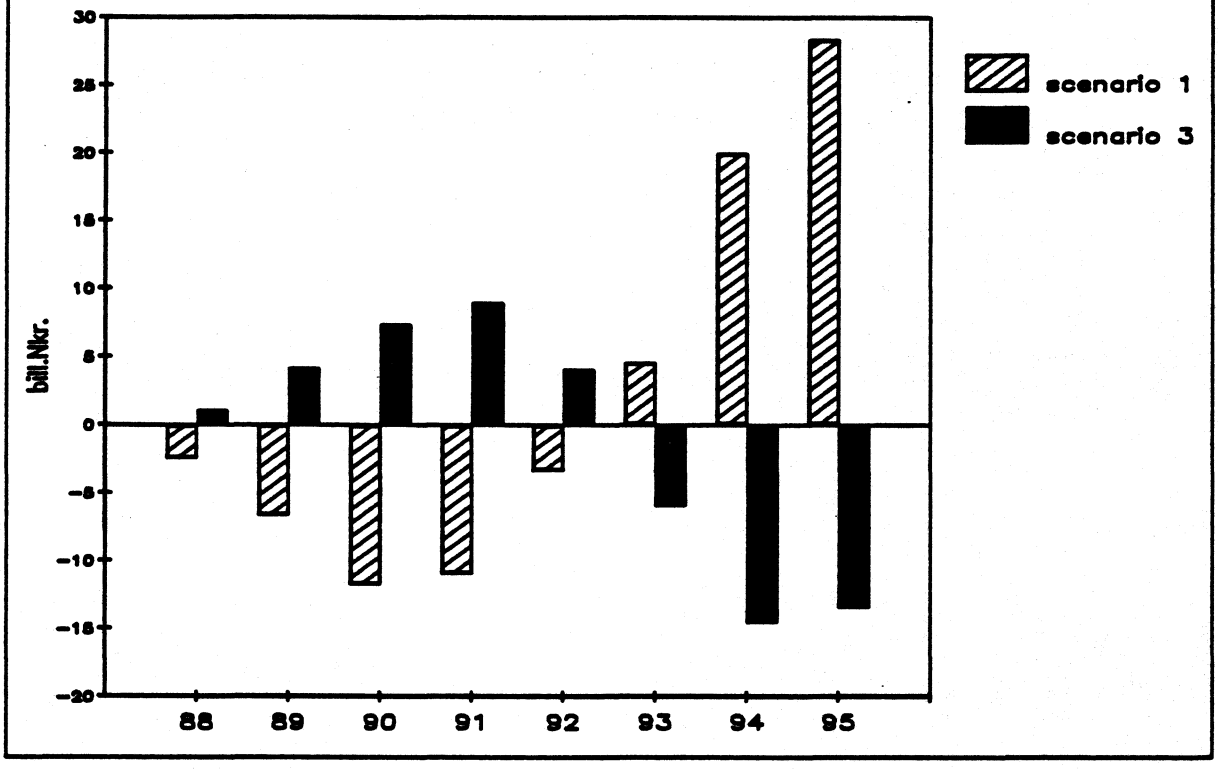


Higher activity in the economy leads to higher imports. Most of the increase consists of imports of equipment used in the petroleum sector.

Production costs increase as preassure both in product and labour markets increase. Increased export prices leads to a decline in exports of goods and services compared to the reference scenario until 1991. From then on, the increase in petroleum export gives a rapid increase in the total exports of goods and sevices. Still the export from the mainland is reduced relative to the reference scenario. The deviation in net goods and services from the reference scenario is given in figure 7.

In the "90 million toe" scenario, the petroleum investments are lower than in the reference scenario. Lower capacity in the petroleum sector results in lower production from 1992 on. As it appears from figure 5, those two circumstances lead to reduced economic activity throughout the entire period of simulation. The deviation in GDP, mainland, from the reference scenario, is reduced at the end of the period, however.

Figure 7: Net exports of goods and services. Deviation from the reference scenario.



The impact of the reduced investment activity in the petroleum sector, is amplified by lower investment activity in other sectors and lower private consumption. The rate of unemployment is increased and the rate of inflation and the real wage rate are both reduced, compared to the reference scenario.

Imports in real terms are also reduced, due to lower imports of equipment to the petroleum sector and the reduced activity in general. Because of a more favourable development in the costs of production, exports of other goods than petroleum increase compared to the reference scenario. As it appears in figure 7, until 1992 the "90 million toe" scenario shows the most favourable development with regard to the net exports of goods and services. From 1993 on, the impact of reduced petroleum production on the exports of goods and services appears and reduces the net export relative to the reference scenario. But the absolute level of the net export is still positive from 1993 on in the "90 million toe" scenario as in the two other scenarios.

5.3 The importance of the investment activity to three different production sectors

We will in this part concentrate on what happens to three production sectors, manufacturing of equipment and platforms, drilling and services as the investment activity differs. How the impulses from the investment activity are spread to these sectors one particular year, will depend on the concentration of fields in different stages of development.

Figure 8 shows how the gross production in the manufacture of machinery and equipment sector differs in the three scenarios. In all three scenarios the activity declines from 1986. The activity in the reference scenario continues to decline through 1988 but from then on we get an increase in the activity. In 1995 the activity is more than 15 per cent higher than in 1986. The growth rate is highest from 1988 to 1991, due to a number of new projects being developed. In the maximum-scenario the activity is steady from 1987 to 1988. From 1989 and onwards the higher investment activity induces increased activity in the sector which peaks in 1991. The activity is then almost 20 per cent higher than in 1986. Thereafter the activity decreases to a level in 1995 below the level in 1986. From 1993, the activity in this scenario is below that of the reference scenario. It is worth noting that the Norwegian offshore industry called for an accelerating of field developments in the autumn of 1986. The maximum-scenario is an illustration of the consequences of such an acceleration. In the "90 million toe" scenario the activity flattens through 1988-90. When the development of new fields starts up in 1991 activity increases. The level of activity never exeeds the reference scenario, but the deviation is reduced at the end of the period.

An indication of a sector's competitiveness is the deviation between the growth in domestic prices and the growth in import prices. Figure 9 shows how this deviation differs for equipment over the simulation period in the three scenarios. The deviation is highest in the maximum-scenario . The most favorable development is shown in the "90 million toe" scenario. In the maximum-scenario a larger part of goods delivered to oil investments are imported, relative to in the two other scenarios. The relative reduction in activity in the offshore

industry in the "90 million toe" scenario is less than the relative reduction in oil investment, due to an improvment of the sectors' competitiveness.

Figure 8: Manufacture of machinery and equipments. Scenario 1, 2 and 3.

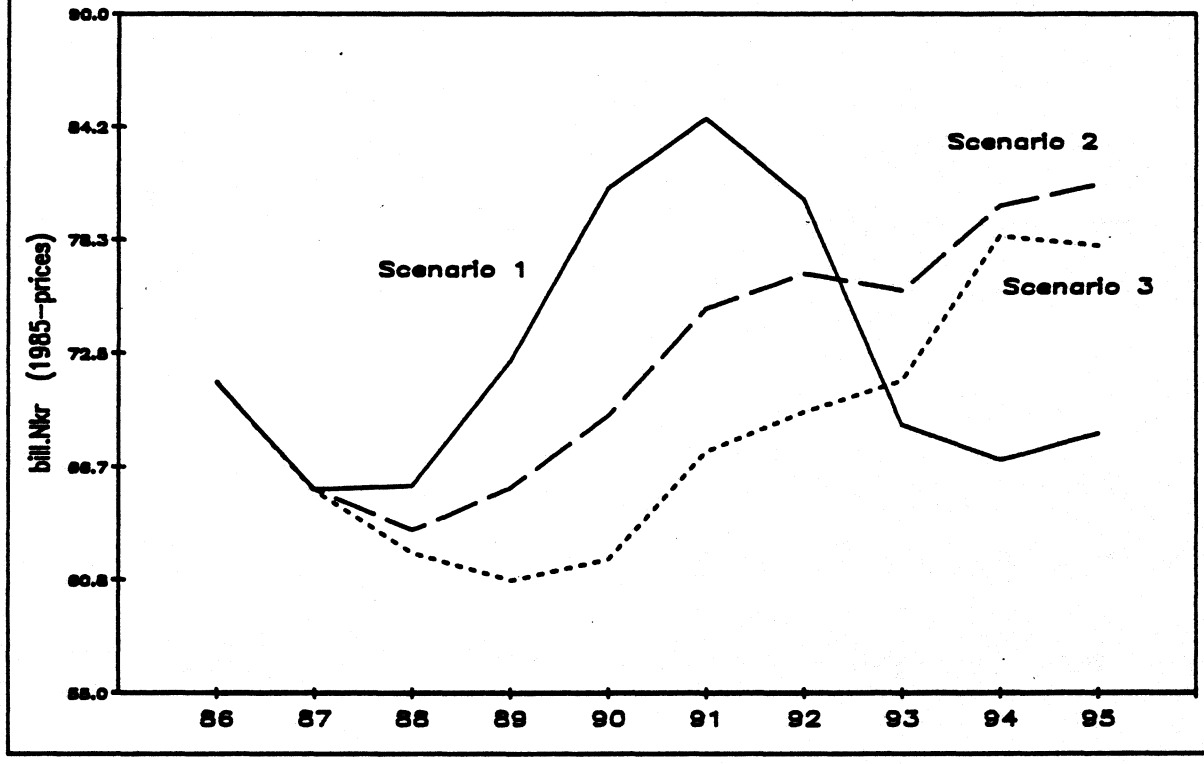
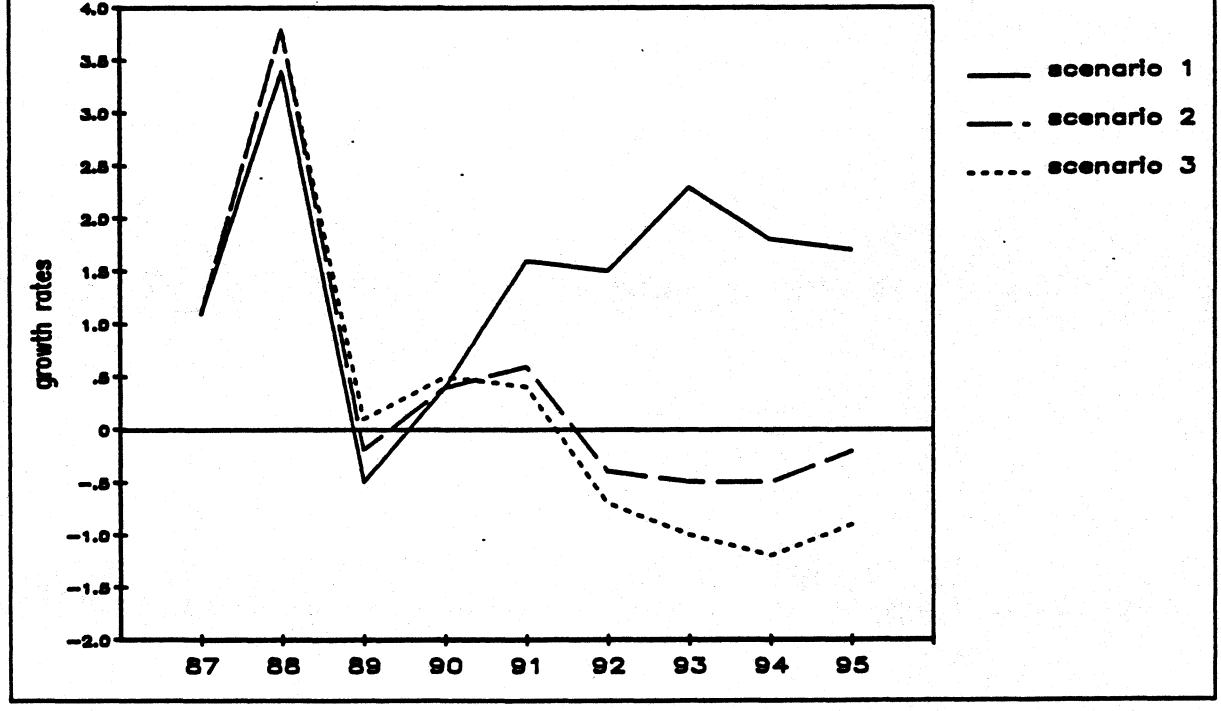


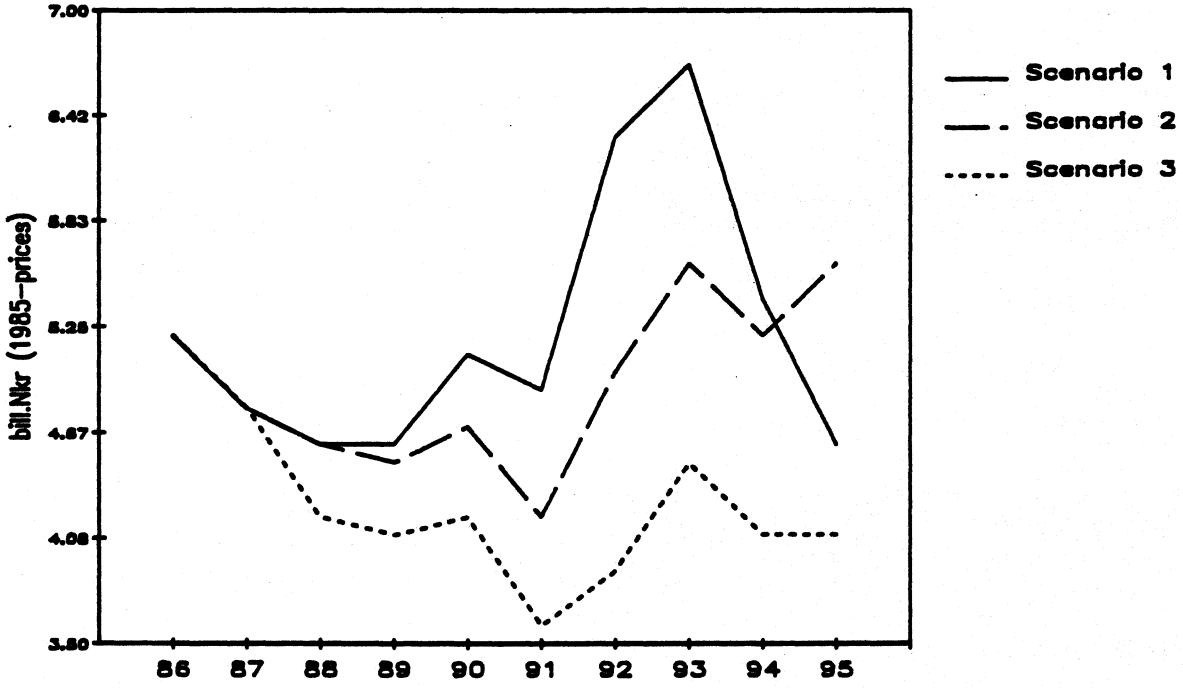
Figure 9: Growth in domestic prices — growth in import prices. Manufacture of equipment and platforms.



As it appears in figure 10 the oil well drilling activity is decreasing in all three sectors from 1986 to 1987. The deviations in the maximum and in the "90 million toe" scenario from the reference scenario, follows the same patterns as for the construction industry, but with a time lag of two years. The growth rates are more unsteady.

The same pattern is showed for services. The only difference worth mentioning, is a more favourable development in the "90 million toe" scenario towards the end of the period, due to new fields put on schedule.

Figure 10: Oil well drilling activity.
Scenario 1, 2 and 3.



6. CONCLUSION

We have seen that following the operators plans as they appeared in spring -87, implying very high level of oil-investments in the coming years, cannot prevent the activity in the offshore industry to decline somewhat from the high level in 1986. In order to prevent this drop in

activity, we may get a boom in the total economic activity later on which leads to increasing wage and price inflation. The oil investment activity absorbes a large share of the total factors of production making it difficult for other production sectors to improve their position. When the investment activity is nosediving from 1991 on, the only factor to prevent the growth rate in GDP to decrease rapidly, is the petroleum production. Because of the high activity in the offshore industry in the first half of the period, the investment costs increase.

The growth rates are more steady in the reference scenario. But the main factors behind the growth in GDP, are still the petroleum investment and production.

The growth in GDP and in the employment is reduced compared to the reference scenario in the "90 million toe" scenario. The pressure on production costs and prices is however avoided. Factors of production are reallocated to contribute to increased activity in other sectors than the petroleum sector, making the economy less dependent upon uncertain oil prices. Expecting those prices to increase after 2000, postponing the production can also contribute to an increase in discounted net profit.

An individual project evaluation cannot be undertaken in the petroleum sector without recognizing possible macroeconomic effects. The investments in the petroleum sector make up a large share of the total investments in the Norwegian economy. At the same time the petroleum investments is made up of only a few, big investment projects. Each of them has an impact on the rest of the economy. Evaluating the project should also include an evaluation of those impacts. As a part of the Norwegian petroleum policy, the operators are requested to make as much use as possible of domestic goods and services. Because of this restricion and the size of each field development, the impact on the goods and factor markets must be considered when evaluating the investment projects. The evaluation must also take into account which other projects that are going to be realised within the same range of time. If the petroleum companies are incapable of or unwilling to coordinate their investment decisions with each other or with the rest of the economy, the government can regulate the total level of investment by for example organizing a queue. Alternatively, the government can use other means in order to regulate the total economic

activity given a fluctuating and perhaps high investment activity at the shelf.

Our calculations have shown that the petroleum investments have large direct and indirect impacts on the economy in the short- and medium term. These impacts must be taken into account when deciding for the optimal extraction path derived from maximizing the dicounted net profit from extraction.

Since we finished the data processing, some adjustments have been done in the operators plans due to postponements and cost reductions. The new desired maximum investment profile lies between the investment profile in our maximum-scenario and in the reference scenario. Still, if the government want a more differentiated production in the economy and wants to prevent cycles due to fluctuations in the oil investment activity, they have to restrain the operators eagerness to invest. On account of the effects on the entire economy illustrated by our impact calculations, one may call for a level of annual investment less than 25 Bill Nkr as mentioned in the national budget for 1988.

We have in our analysis used a model which to some extent is disaggregated with regard to production sectors and commodities. The advantage with such a model, is the possibility for studying the relations between sectors in the economy and not only the impacts upon the aggregates. We also wanted to study the impact upon the supply- and engineering sectors, for whom the petroleum investments are of a great importance. However, in MODAG W the service sectors are relatively aggregated. Supply and engineering services make up only a small portion of the sector in MODAG to which they belong. The aggregation level with regard to services proved to be too high to allow for a more profound analysis of the impact of the petroleum investments on supply and engineering.

One of the basic assumptions often underlying the input-output analysis, is the assumption of constant input-output coefficients. This assumption is not valid in the sector for petroleum investments. We solved this problem by estimating timeseries for some of the coefficents, which we used in our calculations. In this way we have managed to use "engineering-based" data in our disaggregated macroeconomic model.

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