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Petroleum Tax Competition Subject of Capital Rationing

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Petroleum Tax Competition Subject to Capital Rationing

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Petroleum Tax Competition Subject to Capital Rationing

Abstract

The recent dramatic fall in oil prices has led to extensive capital rationing in international oil companies, and subsequent fierce competition between resource extraction countries to attract scarce investment. This situation is not adequately addressed by the large literature on international taxation and multinational companies, since it fails to take account of capital rationing in its assumption that companies sanction all projects with a positive net present value. The paper examines the effect of tax design on international capital allocation when companies ration capital. We analyse capital allocation and government take for four equal oil projects in three different fiscal regimes: the US GoM, UK upstream and Norway offshore. Implications for optimal tax design are discussed.

JEL-Codes: H210, H250, F230, Q400, G120, G310.

Keywords: taxation, international companies, project metrics, project valuation, oil projects.

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1. Introduction

The tax competition literature assumes that the aim of company investment decisions at all points in time is simply to realise every project with a positive net present value (NPV). See, eg, Olsen and Osmundsen (2011), Kind, Midelfart and Schjelderup (2005), and Haufler and Wooton (1999). However, tax competition is often exacerbated by capital rationing. Countries must now struggle to attract investment from limited company investment budgets. The assumption made in the current literature precludes a vital element in tax competition. Capital rationing amplifies the intensity of tax competition. In addition, the capital rationing metrics applied by multinational companies alter the nature of the localisation game.

The challenge of optimal tax design when companies ration capital is of relevance in many industries. We apply a case from the petroleum sector, where a volatile oil price imposes dramatic capital rationing at times. According to Wood Mackenzie Ltd,¹ because of the slump in prices, the oil and gas industry will cut USD 1 trillion from planned spending on exploration and development. Worldwide investment in the development of oil and gas resources will be cut by 22 per cent, or USD 740 billion, from 2015 to 2020. This is lower than was anticipated before prices plunged in 2014, with the deepest cuts in the USA. A further USD 300 billion will be eliminated from exploration spending. Oil companies ration capital even when the oil price is rising, since they know from experience that overly rapid growth leads to lower quality, inadequate project management and cost overruns (Osmundsen et al (2006)).

Several reasons may prompt companies to delay or refrain from investing in projects with a positive NPV. In the current situation, oil companies have cut investment budgets in response to a dramatic reduction in cash flow owing to an oil price reduction which reached 70 per cent at the most. Since companies prefer to fund a considerable part of new investment from their cash flow, they therefore cut capital spending. They are reluctant to cut back on dividends promised to shareholders, and are careful not to increase debt levels due to credit rating concerns and fear

¹

<http://www.bloomberg.com/news/articles/2016-06-15/oil-industry-to-cut-1-trillion-in-spending-after-price-slump>

of financial stress. Another main reason for refusing to sanction projects with positive NPVs, which does not relate to the market or to any financial position the company might occupy, is the organisational aspect of using resources other than financial ones in an optimal way. In other words, the decision may be linked to capacity constraints with regard to experienced project personnel and managers. Given continued low prices and great uncertainty about the future level of oil prices, this tightening of investment requirements may be the only way to avoid large losses. It is also a signal to the organisation that it needs to find new technical solutions which may reduce costs and make projects more robust at lower price levels. Large nonlinearity from possible losses probably exists, and is perceived much greater than losses from not sanctioning projects with positive NPVs based on very uncertain expected prices. This may make it appropriate for companies to delay or refrain from sanctioning projects with positive NPVs.

At a general business level, a literature demonstrates that internal funds are an important determinant for company investment. See, eg, Hubbard et al (1995). Several studies compare different upstream petroleum fiscal systems, but without accounting for capital rationing – eg, Blake and Roberts (2006). Not much can be found in the academic literature on capital rationing. Instead, it largely addresses the evaluation of investment projects involving both uncertainty and flexibility (see, eg, Bjerksund and Ekern, 1990). The focus here is on an investment opportunity where the deferrable investment decision may be made contingent on future information emerging about the risky output price. Decision criteria take the form of adjusted breakeven prices (BEPs). The real option approach is relevant in the current situation, where an increase in oil price volatility may call for investment deferral, but does not come close to explaining the level of capital rationing we experience in the petroleum industry. The Norwegian-based oil company AkerBP recently announced that new projects must satisfy a BEP of USD 35 per barrel, while most analysts estimate a real oil price of USD 60 per barrel. A large difference in project value exists between an expected price scenario of USD 60 per barrel and the AkerBP sanction criterion of a BEP below USD 35/bbl. Where projects with a positive NPV at the expected price of USD 60/bbl are concerned, the option value of waiting (based on any reasonable oil price model) can only justify a minor part of this project value difference. The remainder represents capital rationing. The current dramatic fall in oil prices has prompted the oil companies to impose strict capital constraints, with cancellations and delayed project decisions as the result. In Norway, for example, Statoil as operator for the Snorre Extension and

Johan Castberg oil projects has again postponed a green light on the grounds that it needs to undertake additional optimisation and evaluation.

For a discussion of current issues pertaining to petroleum investment projects in the absence of capital constraints, see Osmundsen et al (2015). The investment decision when some constraint exists becomes rather more complicated than accepting all projects with an NPV greater than zero (Ingersoll and Ross, 1992). Myers (1974) showed that the weighted average cost of capital is not appropriate when capital constraints apply, and that a solution must be found at the corporate portfolio level.

In this paper, we describe the actual investment policy of multinational oil companies and the effect of tax design on investment location decisions. Oil companies apply capital rationing – ie, a positive NPV is not sufficient to get a project sanctioned. We describe the profitability hurdles (metrics) which projects must surpass and, by applying them to model petroleum fields, analyse how tax design affects capital allocation between countries in a context where capital is being rationed. According to Wood Mackenzie, the international petroleum companies have a high level of requirements for the internal rate of return (IRR) in new projects, “with 15 per cent considered the standard industry benchmark for a robust project”.² This is way above the cost of capital for oil and gas projects, which is about nine per cent.³ Capital rationing is typically implemented not only by the IRR, but also by imposing BEPs below the expected oil price or a hurdle for NPV in the form of an NPV index (NPVI). We describe these decision criteria and analyse their effect on capital allocation across countries with different tax systems.

According to economic theory, the correct solution when an investment regime with constraints has been introduced is to apply a portfolio model for choosing the combination of projects in the opportunity set with the highest overall NPV. We look at solutions with two levels of capital constraint for four different projects in three different fiscal regimes. These projects are categorised as large, large marginal, medium and small. The UK offshore, the US Gulf of Mexico (GoM) and Norway offshore are the fiscal regimes chosen. The optimising solution, which may only be applied at the highest corporate level, is often simplified by looking at key metrics such as the IRR, the NPVI and the BEP of the projects (Emhjellen et al, 2006). This is done to achieve decentralised evaluation in organisations which make investment decisions on

² <https://www.woodmac.com/analysis/12134873>

³ Osmundsen et al (2015).

a daily basis and in different countries with varying fiscal regimes. The reasoning is that formal optimisation of the project portfolio can only be undertaken at the highest corporate level, and that the organisation therefore needs simplified metrics for decentralised testing of project profitability. These also function as financial targets for the organisation and create discipline, with a reduced number of projects being presented to management for decisions.

When comparing fiscal regimes for the petroleum sector, the concept of government take is often applied. This is defined as the percentage of net cash flow accruing to the government over the life cycle of a project, including income taxes, royalties, profit petroleum share, bonus payments, value-added taxes, excise duties, excess profit taxes, remittance taxes, state oil company carried interests, import duties, etc. These payments differ in their timing, so a discounted government take needs to be calculated.

We examine the extent to which NPVI, IRR and BEP will yield different project selections than those obtained by optimising portfolio NPV, given the capital constraint of USD 70 billion in investment.

Project robustness in terms of resilience to a fall in oil price is currently the focus of attention in the oil companies. A low BEP gives an indication, but we also examine the changes in the after-tax return for the projects in the three fiscal regimes with high and low oil prices. We find that the tax systems in the UK and Norwegian fiscal regimes help to alleviate the effects of the price drop on the projects.

The paper is organised as follows: Section 2 presents the data and calculates the NPV before and after tax in order to illustrate the difference in government take between Norway, the UK and the US Gulf of Mexico. We also find the solution for the portfolio which maximises NPV given two natural limits on capital budgets, USD 40 billion and USD 70 billion in investment, when total possible investments are 117 billion USD. In section 3, we describe the three different metrics we use to evaluate the projects in terms of ranking. Section 4 examines the portfolio ranking of model oil and gas projects on the basis of the metrics, and juxtaposes these against those obtained by maximising total portfolio NPV, given the constraints. Section 5 presents the analysis of project returns with changes in prices and discusses company behaviour in terms of project robustness and project selection. We conclude in section 6.

2. The data, government take and project selection

The data consist of four oil projects which we have named "large", large marginal", "medium" and "small", reflecting the barrels of oil equivalent they can produce. These are representative of the industry. The large and medium fields are typical in that they are stand-alone developments, while the small field is typical in that it is tied back to an existing development for fluid processing. The large marginal field has less volume compared with total cost. This is often related to greater water depth, higher temperature, more difficult geology or a combination of such factors. Table 2.1 summarises the total Capex cost and total volume.

Table 2.1: The oil projects

| | CAPEX(Mill USD) | Oil(Mill Bbl) |
|----------------|-----------------|---------------|
| Large | 15000 | 1200 |
| Large Marginal | 15000 | 840 |
| Medium | 8000 | 500 |
| Small | 1000 | 35 |

As can be seen from table 2.1, the projects have not only very different capital investment requirements but also varying volumes to produce. Investment ranges from USD 1 to 15 billion, while production volumes vary from 35 to 1200 million barrels. The complete data for the projects, including the calculations, are provided in appendix I. Although some could argue that the effect of debt financing through interest deductions will differ for the three fiscal regimes, we have chosen to use the same weighted average cost of capital (WACC) at a nominal 10 per cent. This is because financing is undertaken at the corporate level. Debt level is evaluated and decided, and the most reasonable financing independent of country is evaluated. The WACC chosen is reasonable for the industry, although some analysts might consider it to lie at the lower end of what is applied in the upstream sector.

The fiscal regimes of the three countries differ. The US offshore tax regime has a royalty of 12.5 per cent on gross production income and a corporate tax rate of 35 per cent. Depreciation depends on the type of investment but is typically front-end loaded within eight years, but no earlier than production start. In our analysis, we have chosen depreciation rules for the "facilities" category with the following annual percentages from the first year of production to

year eight: 14.3, 24.5, 17.5, 12.5, 8.9, 8.9, 8.9 and 4.5. Operating cost is expensed. No deduction is made for interest, since this is assumed to be included in the cost of capital.⁴

The UK tax system has an ordinary tax rate of 30 per cent and an offshore tax rate of 32 per cent. All operating and investment costs are expensed in the year they occur. In addition comes an additional depreciation allowance against the offshore tax of 62.5 per cent for investments in the year they are made. There is no deduction for interest.

In Norway, the ordinary tax rate is 25 per cent while the additional offshore tax rate is 53 per cent. Operating costs may be deducted from these taxes, while investment is depreciated on a straight-line basis over six years from the year of investment. In addition comes an extra depreciation allowance of 22 per cent of investment against the offshore tax (5.5 per cent annually for four years). Interest on upstream investment is deductible from both corporate tax and offshore tax, restricted to the maximum interest payable on a loan equal to 50 per cent of the remaining tax value of the capital expenditure. Interest payments can be deducted from the total tax of 78 per cent. In our analysis, only the interest against offshore tax is included in the valuation. The interest deduction from ordinary tax is assumed to be included in the cost of capital.

A tax analysis for the three regimes is performed on four model fields. See appendix I. We apply a real oil price of USD 60 (2015) per barrel and a two per cent inflation rate. Table 2.2 below presents NPV and the government take for the consolidated case and a ringfenced case. A consolidated case is one where a company in a taxpaying position can let the cost of the project be offset against its other income for tax purposes. A ringfenced case is one where the company is not in a tax position and the costs must be carried forward for offsetting against future project income. The latter position is relevant for new entrants as well as some of the existing companies in the current circumstances, given the large drop in product prices.

⁴ It is normal in the GoM fiscal regime with signature bonuses applicable to large prospective areas. We do not account for these, since the data is privileged and the proportion of an area bonus applicable to a particular project is difficult to assess.

Table 2.2: NPV and government take

| | | NPV | NPV after tax | NPV after tax | NPV tax | NPV tax | Gov. take | Gov. take |
|---------|----------------|------------|---------------|---------------|--------------|-------------|-----------|-----------|
| | | Before tax | Consolidated | Ring fenced | Consolidated | Ring fenced | % Cons. | % Ringf. |
| USA GoM | Large marginal | 4863 | 456 | 381 | 4407 | 4482 | 90,6 % | 92,2 % |
| Norway | Large marginal | 4863 | 1002 | 337 | 3861 | 4526 | 79,4 % | 93,1 % |
| Norway | Small | 483 | 107 | 74 | 376 | 409 | 77,8 % | 84,7 % |
| Norway | Medium | 5978 | 1392 | 1211 | 4586 | 4767 | 76,7 % | 79,7 % |
| Norway | Large | 12600 | 2982 | 2530 | 9618 | 10070 | 76,3 % | 79,9 % |
| USA GoM | Small | 483 | 133 | 106 | 350 | 377 | 72,5 % | 78,1 % |
| USA GoM | Medium | 5978 | 2140 | 2132 | 3838 | 3846 | 64,2 % | 64,3 % |
| USA GoM | Large | 12600 | 4812 | 4786 | 7788 | 7814 | 61,8 % | 62,0 % |
| UK Up. | Large | 12600 | 6529 | 6049 | 6071 | 6551 | 48,2 % | 52,0 % |
| UK Up. | Medium | 5978 | 3227 | 2997 | 2751 | 2981 | 46,0 % | 49,9 % |
| UK Up. | Small | 483 | 332 | 307 | 151 | 176 | 31,3 % | 36,4 % |
| UK Up. | Large marginal | 4863 | 3393 | 2671 | 1470 | 2192 | 30,2 % | 45,1 % |

Project calculations are displayed in Table 2.2. The first observation is that the government take for the large field is very high in Norway, at more than 76 per cent of the project's NPV, and considerably lower in the UK at 48.2 per cent consolidated. The US GoM lies in between at 62 per cent. The second observation is that the US tax for the large marginal field is very high, with a government take of more than 90 per cent. The Norwegian tax for the large marginal field is 79.4 per cent given a consolidated tax position and considerably higher when ringfenced (93.1 per cent). The UK has by far the lowest tax burden for this project, at 30.2 per cent consolidated and 45.1 per cent ringfenced. Where the medium-sized field is concerned, Norway again has by far the highest government take – about 10 per cent above the USA and roughly 30 per cent higher than the UK. With the small field, Norway's government take is about five per cent higher than the USA, and the UK again shows very low percentages of 31.3 and 36.4 per cent (ringfenced).

We now analyse the optimal portfolio with the goal of maximising portfolio NPV. The total portfolio consists of these nine projects, and we allow for the oil companies holding only a partial equity interest in the projects, since this is often the real position given the presence of other partners and the ability to alter the equity interest through purchase or sale. We also focus on consolidated NPV, since this predominantly is the situation – at least for mature oil companies. Total investment and NPVs are presented in table 2.3.

Table 2.3: Project NPV and investments

| | | Capex Mill USD | NPV Consolidated |
|---------|----------------|-------------------|---------------------|
| Norway | Large | 15000 | 2982 |
| Norway | Large Marignal | 15000 | 1002 |
| Norway | Medium | 8000 | 1392 |
| Norway | Small | 1000 | 107 |
| USA GoM | Large | 15000 | 4812 |
| USA GoM | Large Marignal | 15000 | 456 |
| USA GoM | Medium | 8000 | 2140 |
| USA GoM | Small | 1000 | 133 |
| UK Up. | Large | 15000 | 6529 |
| UK Up. | Large Marignal | 15000 | 3393 |
| UK Up. | Medium | 8000 | 3277 |
| UK Up. | Small | 1000 | 332 |
| Sum | Total | 117000 | 26555 |

We first analyse this on a wholly owned basis. Since all the projects have a positive NPV after tax, they would all be sanctioned and developed in a world with no constraints. The total investment would be USD 117 billion and generate an NPV of USD 26.6 billion. Capital budgets permit all the projects analysed – ie, tax competition in this instance is instigated by capital constraints.

The value of the portfolio of projects may be written as:

$$NPV_p = \sum_{i=1}^N V_i X_i$$

In equation 2.1, V_i denotes the NPV of project i , and X_i the relative percentage invested in project i , ($i=1,..N$).

We introduce partial ownership and a budget constraint. By allowing for a reduced equity share in the projects, the mathematical optimising solution will indicate the attractiveness of the projects for a company in the different fiscal regimes given the capital budgeting constraint. We examine first a limit of USD 40 billion on the capital budget. With this investment constraint, equation 2.1 is maximised subject to:

$$X_i \geq 0$$

$$X_i \leq 1$$

and

$$\sum_{i=1}^N I_i X_i \leq 40.000 ,$$

where I_i is the undiscounted investment (capital expenditure – Capex) in project I , and X_i is the percentage invested in i .

Table 2.4 presents the portfolio optimisation result with a capital constraint of USD 40 billion.

Table 2.4 NPV optimisation given constraint of USD 40 billion

| | | Capex Mill USD | NPV Consolidated | Percentage Included | NPV given constraint | Capex given constraint |
|---------|----------------|-------------------|---------------------|------------------------|-------------------------|---------------------------|
| UK Up. | Large | 15000 | 6529 | 100 % | 6529 | 15000 |
| USA GoM | Large | 15000 | 4812 | 100 % | 4812 | 15000 |
| UK Up. | Medium | 8000 | 3277 | 100 % | 3277 | 8000 |
| UK Up. | Small | 1000 | 332 | 100 % | 332 | 1000 |
| USA GoM | Medium | 8000 | 2140 | 13 % | 268 | 1000 |
| Norway | Large | 15000 | 2982 | 0 % | 0 | 0 |
| Norway | Large marginal | 15000 | 1002 | 0 % | 0 | 0 |
| Norway | Medium | 8000 | 1392 | 0 % | 0 | 0 |
| Norway | Small | 1000 | 107 | 0 % | 0 | 0 |
| USA GoM | Large marginal | 15000 | 456 | 0 % | 0 | 0 |
| USA GoM | Small | 1000 | 133 | 0 % | 0 | 0 |
| UK Up. | Large marginal | 15000 | 3393 | 0 % | 0 | 0 |
| Sum | Total | 117000 | 26555 | | 15218 | 40000 |

The first observation is that no Norwegian project is included. These projects do not have a sufficiently high NPV after tax compared with the investment needed. All projects in the UK are included except the large marginal field. The US large project is included 100 per cent and the US medium project absorbs the rest of the investment and is included with 13 per cent of the project. The total NPV is USD 15.2 billion.

If the capital limit is raised to a higher level, 70 USD billion, the result changes to the one presented in table 2.5.

Table 2.5 NPV optimisation given constraint of USD 70 billion.

| | | Capex Mill USD | NPV Consolidated | Percentage Included | NPV given constraint | Capex given constraint |
|---------|----------------|-------------------|---------------------|------------------------|-------------------------|---------------------------|
| UK Up. | Large | 15000 | 6529 | 100 % | 6529 | 15000 |
| USA GoM | Large | 15000 | 4812 | 100 % | 4812 | 15000 |
| UK Up. | Large marginal | 15000 | 3393 | 100 % | 3393 | 15000 |
| UK Up. | Medium | 8000 | 3277 | 100 % | 3277 | 8000 |
| USA GoM | Medium | 8000 | 2140 | 100 % | 2140 | 8000 |
| Norway | Large | 15000 | 2982 | 53 % | 1590 | 8000 |
| UK Up. | Small | 1000 | 332 | 100 % | 332 | 1000 |
| Norway | Large marginal | 15000 | 1002 | 0 % | 0 | 0 |
| Norway | Medium | 8000 | 1392 | 0 % | 0 | 0 |
| Norway | Small | 1000 | 107 | 0 % | 0 | 0 |
| USA GoM | Large marginal | 15000 | 456 | 0 % | 0 | 0 |
| USA GoM | Small | 1000 | 133 | 0 % | 0 | 0 |
| Sum | Total | 117000 | 26555 | | 22073 | 70000 |

The optimisation selects all the projects in the UK, the large and medium US projects and the large Norwegian project (but with only 53 per cent). The Norwegian fiscal regime is not favourable when companies operate with a before-tax capital constraint. However, the US tax on a large marginal field is the highest and almost no NPV is left in the project after tax. That makes it very unattractive for capital allocation with a constraint.

Simple metrics like the NPVI, the IRR and the BEP per barrel are used as project sanction criteria in the industry. We now analyse how project choice based on these metrics, with the same capital constraint, might differ from project optimisation solutions obtained by mathematical programming. First, we present the three metrics.

3. The three metrics

International oil companies do not use formalised portfolio models for decision making. This is too bureaucratic. Instead, simplified project metrics are calculated by individual divisions and communicated to central management. Projects must reach certain metric thresholds to be sanctioned.

The first metric we present is the IRR, which is described in many finance textbooks (see Brealey and Myers, 2011, and Copeland and Weston, 2005). It is defined as the rate of return which gives an NPV of zero:

$$NPV = \sum_{t=0}^T \frac{X_t}{(1 + IRR)^t} = 0, \quad (3.1)$$

where X_t is the expected net cash flow after tax in period t .

The second metric is the NPVI, defined as the after-tax NPV of the project⁵ divided by the before-tax NPV of investment (Kind, Tveteras and Osmundsen, 2005):⁶

$$NPVI = \sum_{t=0}^T \frac{X_t}{(1 + r)^t} / \sum_{t=0}^T \frac{I_t}{(1 + r)^t}, \quad (3.2)$$

where I_t is expected investment in period t and r is the WACC. It is our understanding that this metric is used by the dominant international oil companies in periods when oil prices are fairly stable.

The third metric is the BEP of the project (Jovanovic, 1999). It is often used by the oil industry in times like the present, when oil prices are volatile.⁷ This is a variant of (3.1) in that the variable to be estimated, BEP, is in the numerator:

$$NPV = \sum_{t=0}^T \frac{(x_t P)(1 - s) - C_t}{(1 + r)^t} = 0, \quad (3.3)$$

Where x_t is production in period t and s is the marginal tax rate, C_t is total cost – ie, the sum of investment and operating cost – and r is the WACC. P is the constant price which gives an NPV equal to zero after tax – ie, the BEP. The solution is obtained by iteration.

An example of applying BEP as an investment decision criterion is provided by Statoil. The oil company presented a BEP requirement of USD 50 per barrel for all projects at its Capital Market Day in June 2015. This was clearly a capital rationing mechanism, since it operated at the same time with an expected oil price of USD 80 per barrel in its expected NPV estimate.⁸

⁵ For simplicity, we have assumed 100 per cent equity financing.

⁶ Companies apply traditional NPV values – ie, all cash flow components are discounted by the same discount rate. For a discussion of differentiated discount rates applied to partial cash flows, see Osmundsen et al (2015).

⁷ The financial press frequently reports on BEPs in different extraction regions, and much attention is currently being paid to the BEP of US tight oil. See, eg,

<http://uk.businessinsider.com/cash-cost-breakeven-oil-prices-2015-12?r=US&IR=T>.

⁸ *Dagens Næringsliv* (Norwegian Business Daily), 24 August 2015.

4. Maximising portfolio NPV with capital constraints juxtaposed against metric selections

To illuminate the capital allocation problem facing the international oil companies, the marginal tax rates for the projects in the various tax regimes have been estimated. These tax rates differ from the total government-take tax rate estimated in table 2.2, which can be regarded as an average tax rate. The marginal tax rate is estimated by calculating the effect on tax of investing 10 per cent more in each of the projects. With a capital constraint, this is the capital budgeting decision which faces the companies, since they can choose to invest or divest in each of the fiscal regimes. The result is presented in table 4.1

Table 4.1 Marginal tax rate in the fiscal regimes for each project

| | Base NPV <u>before tax</u> | New NPV <u>before tax</u> | Base NPV <u>after tax</u> | New NPV <u>after tax</u> | Change NPV <u>after tax</u> | Change PVM <u>Capex</u> | Marginal tax <u>rate</u> |
|------------------------|-------------------------------|------------------------------|------------------------------|-----------------------------|--------------------------------|----------------------------|-----------------------------|
| Uk, Small | 483 | 406 | 332 | 314 | -18 | 77 | 76,62 % |
| Uk, Medium | 5978 | 5419 | 3277 | 3135 | -142 | 559 | 74,60 % |
| Uk, Large marginal | 4863 | 3875 | 3393 | 3133 | -260 | 988 | 73,68 % |
| Uk, Large | 12600 | 11613 | 6529 | 6269 | -260 | 987 | 73,66 % |
| Norway Large marginal | 4863 | 3875 | 1002 | 725 | -277 | 988 | 71,96 % |
| Norway, Large | 12600 | 11613 | 2982 | 2705 | -277 | 987 | 71,94 % |
| Norway, Medium | 5978 | 5419 | 1392 | 1235 | -157 | 559 | 71,91 % |
| Norway, Small | 483 | 406 | 107 | 85 | -22 | 77 | 71,43 % |
| US Gom, small | 483 | 406 | 134 | 77 | -57 | 77 | 25,97 % |
| US Gom, Medium | 5978 | 5419 | 2140 | 1717 | -423 | 559 | 24,33 % |
| US Gom, Large marginal | 4863 | 3875 | 456 | -299 | -755 | 988 | 23,58 % |
| US Gom, Large | 12600 | 11613 | 4812 | 4056 | -756 | 987 | 23,40 % |

The results show quite similar marginal tax rates for the three projects in each fiscal regime, but substantial differences between these regimes. While Norwegian and UK marginal tax rates are above 71 per cent, the figure in the USA ranges from 23 to 26 per cent. The results of the metric calculation and juxtaposition with the mathematical optimisation solution are presented in table 4.2. Where the metrics are concerned, it is reasonable to assume that everything will be invested in the project with the best score until the budget limit is reached.

Table 4.2 Maximising the NPV solution with capital constraint
juxtaposed against metric solutions

| | | <u>NL</u> | <u>NLm</u> | <u>NM</u> | <u>NS</u> | <u>US L</u> | <u>USLm</u> | <u>US M</u> | <u>US S</u> | <u>UK L</u> | <u>UKLm</u> | <u>UK M</u> | <u>UK S</u> | <u>Sum</u> |
|-----------|---------------|-------------|------------|-----------|-----------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------|
| Capex | MUSD | 15000 | 15000 | 8000 | 1000 | 15000 | 15000 | 8000 | 1000 | 15000 | 15000 | 8000 | 1000 | 117000 |
| NPV a.tax | consol. | 2982 | 1002 | 1392 | 107 | 4812 | 456 | 2140 | 133 | 6529 | 3393 | 3277 | 332 | 26555 |
| NPV | optimsolution | 1590 | | | | 4812 | | 2140 | | 6529 | 3393 | 3277 | 332 | 22073 |
| Metric 1 | IRR | 16,0 % | 11,0 % | 15,9 % | 16,3 % | 15,1 % | 8,8 % | 15,1 % | 16,6 % | 28,2 % | 20,1 % | 31,4 % | 64,4 % | |
| Capex | | 15000 | | 8000 | 1000 | 6000 | | | 1000 | 15000 | 15000 | 8000 | 1000 | 70000 |
| NPV a.tax | | 2982 | | 1392 | 107 | 1925 | | | 133 | 6529 | 3393 | 3277 | 332 | 20070 |
| Metric 2 | NPVI | 0,30 | 0,10 | 0,25 | 0,14 | 0,49 | 0,05 | 0,38 | 0,17 | 0,66 | 0,34 | 0,58 | 0,43 | |
| Capex | | 8000 | | | | 15000 | | 8000 | | 15000 | 15000 | 8000 | 1000 | 70000 |
| NPV a.tax | | 1590 | | | | 4812 | | 2140 | | 6529 | 3393 | 3277 | 332 | 22073 |
| Metric 4 | BE | 35,4 | 48,9 | 37,7 | 44,1 | 42,4 | 58,7 | 44,9 | 51,6 | 25,6 | 34,9 | 26,5 | 27,8 | |
| Capex | | 15000 | | 8000 | | 8000 | | | | 15000 | 15000 | 8000 | 1000 | 70000 |
| NPV a.tax | | 2982 | | 1392 | | 2566 | | | | 6529 | 3393 | 3277 | 332 | 20471 |

Reading from left to right, the columns provide the information on the projects (project titles abbreviated) with respect to the headings on the left-hand side of the table. On the right-hand side, the sum of the Capex and the total NPV solution (in bold) are given for each of the solutions.

The NPVI metric gives the same investment allocation as the mathematical programming solution (as expected with an undiscounted before-Capex constraint) – ie, it includes the same projects 100 per cent and, at the margin, reduced the investment in the Norwegian large project to 53 per cent. This solution generates a total portfolio NPV of USD 22 073 million. The BEP solution gives a lower total NPV (USD 20 471 million). The IRR metric yields the lowest total NPV solution of USD 20 070 million. It includes two of the smaller projects with a sufficiently high IRR (the US small project and the Norwegian small projects with IRRs of 16.6 and 16.3 per cent respectively). The IRR solution at the margin reduces investment in the US large project to 40 per cent. The BEP allocation also implies a reduction of this project, but only to 53 per cent. All the solutions include the UK projects, even the large marginal project not included for the two other fiscal regimes in any of the metrics.

The capital requirement and investment financing for a company will always be linked to its after-tax cash flow. If a company has real capital constraints and desires to maximise the value of its investment opportunities in different fiscal regimes, it will need to examine after-tax metrics or use after-tax constraints. Before-tax constraints and before-tax metrics like the NPVI do not account for the tax effects of investment. This metric, however, that implicitly presumes a before-tax capital constraint, can be justified if critical personnel is the scarce factor, as the need for personnel is typically linked to the level of before tax investment.

Returning to the present situation, with scarce capital, appendix II displays the optimal portfolio choice – ie, maximum NPV with an after-tax investment constraint corresponding to a before-tax budget limit of USD 70 billion (with marginal tax rates as specified in table 4.1). The optimising solution is given the minimum of the sum of the present value of after tax cost allowed where the corresponding sum of the before tax is 70 billion. This sum of the after tax cost is 22.7 billion USD. The portfolio NPV is now reduced from USD 22 073 million to USD 20 472 million. The reason is that the goal of minimising the sum of the present value of the after tax costs cuts back on investments that have positive NPVs even more than the before tax constraint. The solution is equal to the portfolio investment choice obtained using the BEP metrics in table 4.2. The BEP metric, which is the before-tax price necessary to make the present value of the after-tax cash flow equal to zero, is therefore a reasonable simplifying metric for choosing a portfolio based on after-tax constraint.

Note that the design of the tax systems has a large impact on the cash flow profiles of the companies. The portfolio cash flow resulting from the NPV optimisation with a before-tax constraint and the solution with after-tax constraint in appendix II and the difference in cashflow between these portfolios are given in appendix III. The before-tax constraint gives a much higher financing need in the early years, since the oil company does not account for the fact that the resource extraction countries are carrying part of the investment via the tax system (tax credits). Companies operating in several tax regimes will probably consider the after-tax effect when seeking finance for their activities. In such a situation, fiscal regimes providing early deductions – as in Norway and the UK – will be much more competitive with fiscal regimes like the US GoM which have late deductions. For the first five years, from 2018 to 2022, the accumulated "investments" needed after tax is USD 4 441 million greater for the portfolio with the before-tax constraint on investments than the after tax constraint on investments. However, the return on the difference in the portfolios based on the cash-flow difference for all the years from 2018 to 2047 is 13.7 per cent. With the after-tax constraint, this return is deemed to be insufficiently high. The after tax constraint selection using the IRR metric gives an even lower financing need than the portfolio selection based on the breakeven price metric. The accumulated cashflow need is 7.525 billion USD less in just four years (until 2021) with the IRR metric. However, the return That illustrates how companies with capital constraints may require very high returns for projects to be sanctioned.

All the metrics in table 4.2 are used at times by oil and gas companies when evaluating projects, but companies are now using the BEP metric as the project selection criterion. The BEP seems to attract particular attention when the long-term price pattern represents the major concern. That is descriptive of the current position, with a volatile oil market. The companies seem to follow their expressed strategy of electing to delay projects which do not satisfy their breakeven targets. Attention is concentrated on cost reduction and project optimisation to meet the BEP. On its Capital Market Day in June 2015, Statoil made particular mention of the need for projects to have a positive NPV at USD 50 per barrel. As has been shown above, the BEP gave the same solution as portfolio maximisation with an after-tax constraint. The metric is therefore a good approximation for portfolio maximisation with an after-tax budget constraint.

5. Project return robustness

Since attention at oil companies is focused on the breakeven oil price and project robustness to price risk, it is interesting to examine the robustness of the after-tax return of the projects to a change in the oil price. This may indicate how far the tax system alleviates price risk relative to the before-tax return – to what degree does the tax system change the impact of the after-tax return compared with the before-tax return? The BEPs estimated for the projects give an indication. Based on the IRR before tax, the tax cash flow and the after-tax cash flow, however, a clear indication can be obtained of where the fiscal regime has the biggest or smallest impact on the systematic price risk (given the fact that most of the systematic risk is related to oil price). Given that negative cash flows from the project may be offset against other income (consolidated), a tax regime based on a cash-flow tax would give the same changes in before- and after-tax return. This is not the case for the three fiscal regimes we analyse. In table 5.1 below, we show the IRR for the projects at base price (USD 60/bbl) and at the lower level of USD 40/bbl and the higher of USD 80 /bbl.

Table 5.1 Project returns in fiscal regimes given realised oil prices

| | <u>60 Usd</u> | <u>60 Usd</u> | <u>40 Usd</u> | <u>40 Usd</u> | <u>80 Usd</u> | <u>80 Usd</u> | <u>% change</u> | <u>% change</u> | <u>% change</u> | <u>% change</u> |
|------------------------|---------------|---------------|---------------|---------------|---------------|---------------|-----------------|-----------------|-----------------|-----------------|
| | <u>B.t.</u> | <u>A.t.c.</u> | <u>B.t.</u> | <u>A.t.c.</u> | <u>B.t.</u> | <u>A.t.c.</u> | <u>40 B.t.</u> | <u>40 A.t.</u> | <u>80 B.t.</u> | <u>80 A.t.</u> |
| Norway, Large | 22,8 % | 16,0 % | 12,8 % | 9,9 % | 30,7 % | 21,0 % | -43,9 % | -38,1 % | 34,6 % | 31,3 % |
| Norway Large marginal | 14,6 % | 11,0 % | 5,4 % | 5,8 % | 21,6 % | 15,2 % | -63,0 % | -47,3 % | 47,9 % | 38,2 % |
| Norway, Medium | 24,1 % | 15,9 % | 12,0 % | 9,1 % | 33,9 % | 21,7 % | -50,2 % | -42,8 % | 40,7 % | 36,5 % |
| Norway, Small | 39,8 % | 16,3 % | 6,9 % | 6,6 % | 70,4 % | 27,9 % | -82,7 % | -59,5 % | 76,9 % | 71,2 % |
| US Gom, Large | 22,8 % | 15,1 % | 12,8 % | 7,3 % | 30,7 % | 21,1 % | -43,9 % | -51,7 % | 34,6 % | 39,7 % |
| US Gom, Large marginal | 14,6 % | 8,8 % | 5,4 % | 1,3 % | 21,6 % | 14,2 % | -63,0 % | -85,2 % | 47,9 % | 61,4 % |
| US Gom, Medium | 24,1 % | 15,1 % | 12,0 % | 5,9 % | 33,9 % | 22,3 % | -50,2 % | -60,9 % | 40,7 % | 47,7 % |
| US Gom, small | 39,8 % | 16,6 % | 6,9 % | -2,1 % | 70,4 % | 34,6 % | -82,7 % | -112,7 % | 76,9 % | 108,4 % |
| Uk, Large | 22,8 % | 28,2 % | 12,8 % | 18,4 % | 30,7 % | 35,7 % | -43,9 % | -34,8 % | 34,6 % | 26,6 % |
| Uk, Large marginal | 14,6 % | 20,1 % | 5,4 % | 11,3 % | 21,6 % | 26,9 % | -63,0 % | -43,8 % | 47,9 % | 33,8 % |
| Uk, Medium | 24,1 % | 31,4 % | 12,0 % | 19,3 % | 33,9 % | 40,9 % | -50,2 % | -38,5 % | 40,7 % | 30,3 % |
| Uk, Small | 39,8 % | 64,4 % | 6,9 % | 30,5 % | 70,4 % | 98,2 % | -82,7 % | -52,6 % | 76,9 % | 52,5 % |

Results for the return change are displayed in table 5.1. This shows that, while the tax system is dampening the effect of a price change in Norway and the UK, it is actually increasing the risk of oil projects in the USA in terms of a higher change in after-tax returns than before-tax returns. The risk reduction on the after-tax return is somewhat greater in the UK than in Norway, but the return gain with higher prices is also the lowest. For all the fiscal regimes, the return change is highest for the small project.

6. Conclusion

Taxation theory presumes that companies sanction all projects with a positive NPV. This is at odds with reality, where companies ration capital. We examine capital allocation in multinational oil companies by applying model fields in the USA, the UK and Norway, and analyse how capital allocation by international oil companies is affected by the various tax systems.

Starting off with a mathematical portfolio optimisation model, we find that no Norwegian projects are developed with the tightest capital constraint (USD 40 billion), while three in the UK and two in the USA will be. With a less stringent capital constraint of USD 70 billion, the same two projects in the USA are developed, all four in the UK, and only the large project in Norway. One might therefore question the competitiveness of the Norwegian fiscal regime in current market conditions. The US authorities should worry about cream-skimming, since projects perceived to be marginal by capital-rationing oil companies – and which therefore fail to be sanctioned – may be profitable for society.

Capital rationing is often implemented by simple decentralised profitability metrics. We have analysed capital allocation under different metrics and tax systems. Juxtaposing the metric results against the results from portfolio NPV maximisation with capital constraints, we find that the NPVI metric provides the same choice as portfolio optimisation with a before-tax constraint. The IRR metric has its own solution with the lowest portfolio NPV. The BEP metric gives an intermediate solution and the same solution as that obtained with a minimising present value of after-tax cost constraint. The solutions obtained by the NPVI (before tax) and the BEP (after-tax) metrics indicate large differences in the company's financing needs.

Subjecting project profitability to a robustness test in terms of resilience to a fall in oil prices demonstrates that the British and Norwegian fiscal regimes alleviate some price risk by reducing the change in after-tax return compared with the before-tax return. The opposite is true of the fiscal regime in the US GoM, which increases company risk.

A topic for future research is to expand the strategic tax competition literature to take account of investment metrics in the description of company investment allocation. The current literature so far simply assumes that all projects with a positive NPV are sanctioned. Changing company behaviour in the models is likely to alter investment allocation and optimal tax design.

The international tax literature also implicitly assumes that government and companies have the same requirement for the rate of return. Since capital rationing implies a requirement greater than the opportunity cost of capital, the tax analysis must account for the fact that society may require much lower rates of return than the oil companies. An intertemporal model framework is called for. Norway has a real rate of return requirement of seven per cent, for instance, whereas a current stipulation of international oil company requirements is 15 per cent.⁹ Thus, it may prove beneficial for government to carry a large fraction of the initial investment, as is the case in the British and Norwegian petroleum tax systems, and secure higher tax revenue later in the project life cycle. The risk premium demanded by the companies for their capital investment may thereby be reduced and expected government revenue maximised. This conclusion is reversed for developing countries with a limited ability to carry risk and an immediate need for revenue. That is also what we observe in the latter countries, with royalty

⁹ <https://www.woodmac.com/analysis/12134873>

payments, for example, and international oil companies carrying investment on behalf of the state oil company.

In Norway and to some extent the UK, petroleum revenue comprises a significant fraction of government income. Tailoring a special tax system for this industry thus makes sense. In the USA, the petroleum industry is one sector among many, and attention has often focused on production rather than revenue. Tailoring of the petroleum taxation has therefore not been on the agenda to the same extent. In spite of a large capital exposure for the oil companies, the USA attracts big investment and secures substantial revenues. This mainly reflects geological prospectivity, which has been excluded from the present paper, as well as less stringent regulation. Differences in prospectivity are also an important factor when comparing the British and Norwegian tax systems. The UK sector is more mature and less prospective by nature, and must offer more generous fiscal terms to attract investment. Norway's continental shelf has a more diversified maturity, but certain areas seem to fail to attract sufficient new investment and may need improved fiscal terms.

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APPENDIX I: Large field

| | Norway Upstream | | | | | | | | | | US Gulf of Mexico | | | | | | | | | | UK Upstream | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| | Oil | | | | | Income Opex Capex | | | | | Btax | | | | | Tax | | | | | A.tax | | | | | Tax | | | | | A. tax | | | | | Btax | | | | | Sp. Tax | | | | | Co. tax | | | | | A. tax | | | | | Sp. Tax | | | | | Co. tax | | | | | A. tax | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | M.bbl | M.usd | M.usd | M.usd | M.usd | ring f. | ring f. | ring f. | cons. | cons. | M.usd | ring f. | ring f. | ring f. | cons. | cons. | M.usd | ring f. | ring f. | ring f. | cons. | cons. | M.usd | ring f. | ring f. | ring f. | cons. | cons. | M.usd | ring f. | ring f. | ring f. | cons. | cons. | M.usd | ring f. | ring f. | ring f. | cons. | cons. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Sum | 1200 | 97329 | 21000 | 15000 | 61329 | 44480 | 16849 | 45544 | 15785 | | 61329 | 12190 | 17198 | 31940 | 12190 | 17198 | 31940 | 61329 | 14626 | 16524 | 30180 | 16625 | 18398 | 26305 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

APPENDIX I: Large marginal oil field

| Norway Upstream | | | | | | | | | | US Gulf of Mexico | | | | | | | | | | UK Upstream | | | | | | | | | |
|---|------|-------|-------|-------|-------|-----|-------|-------|-------|---|------|------|-------|------|------|-------|-------|--|--|--|-------|-------|-------|-------|-------|-------|--|--|--|
| Oil Income Opex Capex Blatx Tax Atlatx Tax Atlatx | | | | | | | | | | Blatx Royatx Co.Tax Atlatx Royatx Co.Tax Atlatx | | | | | | | | | | Blatx Sp.TaxCo.Tax Atlatx Sp.TaxCo.Tax Atlatx | | | | | | | | | |
| M.bbl Musd Musd Musd Musd ring f. ring f. cons. cons. | | | | | | | | | | Musd ring f. ring f. ring f. cons. cons. cons. | | | | | | | | | | Musd ring f. ring f. ring f. cons. cons. cons. | | | | | | | | | |
| Sum | 840 | 68130 | 19200 | 15000 | 33930 | | 11479 | | | 33930 | 8533 | 8889 | 16508 | 8533 | 8889 | 16508 | | | | 33930 | 5097 | 7591 | 21242 | 7857 | 10179 | 15894 | | | |
| 2019 | | | | 1500 | -1500 | | -1500 | -127 | -1373 | -1500 | | | -2250 | | | -1500 | -1500 | | | -1500 | | | | -480 | -300 | -720 | | | |
| 2020 | | | | 2250 | -2250 | | -2250 | -446 | -1804 | -2250 | | | -2250 | | | -2250 | -2250 | | | -2250 | | | | -720 | -600 | -930 | | | |
| 2021 | | | | 3750 | -3750 | | -3750 | -955 | -2795 | -3750 | | | -3750 | | | -3750 | -3750 | | | -3750 | | | | -1200 | -975 | -1575 | | | |
| 2022 | | | | 3750 | -3750 | | -3750 | -1584 | -2166 | -3750 | | | -3750 | | | -3750 | -3750 | | | -3750 | | | | -1200 | -1125 | -1425 | | | |
| 2023 | 16,8 | 1158 | 684 | 3750 | -3276 | | -3276 | -1997 | -1279 | -3276 | 145 | | -3421 | 145 | -635 | -2786 | -3276 | | | -3276 | -1419 | -1030 | -827 | | | | | | |
| 2024 | 74,8 | 5256 | 974 | | 4282 | | 4282 | -562 | 4843 | 4282 | 658 | | 3624 | 658 | -17 | 3641 | 4282 | | | 4282 | -312 | 529 | 4065 | | | | | | |
| 2025 | 74,8 | 5361 | 974 | | 4387 | | 4387 | 1184 | 3203 | 4387 | 671 | 286 | 3430 | 671 | 382 | 3333 | 4387 | | | 4387 | 456 | 1306 | 2625 | | | | | | |
| 2026 | 68,9 | 5038 | 944 | | 4093 | | 4093 | 1494 | 2600 | 4093 | 631 | 685 | 2777 | 631 | 556 | 2906 | 4093 | | | 4093 | 1310 | 1257 | 1526 | | | | | | |
| 2027 | 64,7 | 4825 | 923 | | 3902 | 186 | 3716 | 1827 | 2075 | 3902 | 604 | 625 | 2673 | 604 | 685 | 2612 | 3902 | | | 3902 | 1249 | 1190 | 1464 | | | | | | |
| 2028 | 60,5 | 4602 | 902 | | 3700 | 570 | 3130 | 2229 | 1471 | 3700 | 576 | 560 | 2563 | 576 | 625 | 2498 | 3700 | | | 3700 | 1184 | 1130 | 1386 | | | | | | |
| 2029 | 56,3 | 4368 | 881 | | 3487 | | 1444 | 2043 | 2559 | 3487 | 547 | 727 | 2213 | 547 | 560 | 2380 | 3487 | | | | 140 | 3347 | 1116 | 1067 | 1304 | | | | |
| 2030 | 52,1 | 4123 | 860 | | 3263 | | 2332 | 931 | 2632 | 3263 | 516 | 890 | 1856 | 516 | 890 | 1653 | 3263 | | | | 722 | 2540 | 1044 | 1001 | 1217 | | | | |
| 2031 | 47,9 | 3866 | 839 | | 3027 | | 2453 | 574 | 2453 | 3027 | 484 | 815 | 1728 | 484 | 890 | 1514 | 3027 | | | | 932 | 2095 | 969 | 932 | 1127 | | | | |
| 2032 | 43,7 | 3598 | 818 | | 2779 | | 2264 | 515 | 2264 | 2779 | 451 | 736 | 1592 | 451 | 815 | 1514 | 2779 | | | | 126 | 859 | 1795 | 889 | 859 | 1031 | | | |
| 2033 | 39,5 | 3317 | 797 | | 2519 | | 2067 | 453 | 2067 | 2519 | 415 | 654 | 1450 | 415 | 736 | 1368 | 2519 | | | | 806 | 782 | 931 | 806 | 782 | 931 | | | |
| 2034 | 35,3 | 3023 | 776 | | 2247 | | 1859 | 388 | 1859 | 2247 | 379 | 567 | 1301 | 379 | 654 | 1214 | 2247 | | | | 719 | 701 | 827 | 719 | 701 | 827 | | | |
| 2035 | 31,1 | 2717 | 755 | | 1961 | | 1641 | 320 | 1641 | 1961 | 340 | 477 | 1144 | 340 | 567 | 1054 | 1961 | | | | 628 | 617 | 717 | 628 | 617 | 717 | | | |
| 2036 | 26,9 | 2397 | 734 | | 1662 | | 1413 | 249 | 1413 | 1662 | 300 | 382 | 980 | 300 | 477 | 885 | 1662 | | | | 532 | 529 | 602 | 532 | 529 | 602 | | | |
| 2037 | 22,7 | 2063 | 713 | | 1349 | | 1174 | 175 | 1174 | 1349 | 258 | 327 | 764 | 258 | 382 | 709 | 1349 | | | | 432 | 436 | 481 | 432 | 436 | 481 | | | |
| 2038 | 20,2 | 1870 | 701 | | 1169 | | 982 | 187 | 982 | 1169 | 234 | 270 | 665 | 234 | 327 | 608 | 1169 | | | | 374 | 369 | 426 | 374 | 369 | 426 | | | |
| 2039 | 17,6 | 1669 | 688 | | 981 | | 839 | 142 | 839 | 981 | 209 | 210 | 561 | 209 | 270 | 502 | 981 | | | | 314 | 313 | 354 | 314 | 313 | 354 | | | |
| 2040 | 15,1 | 1459 | 676 | | 784 | | 688 | 95 | 688 | 784 | 183 | 148 | 453 | 183 | 210 | 391 | 784 | | | | 251 | 255 | 278 | 251 | 255 | 278 | | | |
| 2041 | 12,6 | 1240 | 663 | | 577 | | 531 | 47 | 531 | 577 | 155 | 131 | 291 | 155 | 148 | 274 | 577 | | | | 185 | 194 | 199 | 185 | 194 | 199 | | | |
| 2042 | 11,8 | 1181 | 659 | | 522 | | 429 | 93 | 429 | 522 | 148 | 113 | 261 | 148 | 131 | 243 | 522 | | | | 167 | 162 | 193 | 167 | 162 | 193 | | | |
| 2043 | 10,9 | 1118 | 655 | | 464 | | 384 | 79 | 384 | 464 | 140 | 95 | 229 | 140 | 113 | 210 | 464 | | | | 148 | 145 | 170 | 148 | 145 | 170 | | | |
| 2044 | 10,1 | 1053 | 650 | | 403 | | 338 | 65 | 338 | 403 | 132 | 75 | 195 | 132 | 95 | 176 | 403 | | | | 129 | 127 | 147 | 129 | 127 | 147 | | | |
| 2045 | 9,2 | 985 | 646 | | 338 | | 289 | 49 | 289 | 338 | 123 | 55 | 160 | 123 | 75 | 140 | 338 | | | | 108 | 108 | 122 | 108 | 108 | 122 | | | |
| 2046 | 8,4 | 913 | 642 | | 271 | | 238 | 33 | 238 | 271 | 114 | 60 | 96 | 114 | 55 | 102 | 271 | | | | 87 | 88 | 96 | 87 | 88 | 96 | | | |
| 2047 | 8,4 | 931 | 642 | | 289 | | 218 | 71 | 218 | 289 | 117 | 0 | 173 | 117 | 60 | 112 | 289 | | | | 93 | 85 | 112 | 93 | 85 | 112 | | | |
| 2048 | | | | | | | -113 | | -113 | | | | | | | | | | | | | 29 | -29 | | 29 | -29 | | | |

APPENDIX I: Small field

| Norway Upstream | | | | | | | | | | | |
|-------------------|------------|-------------|------------|-----------------|-----------------|-------------|------------------|-------------|------------|-----------------------|-------------|
| Oil Income M.bbl | Opex M.usd | Capex M.usd | Btax M.usd | Sp. Tax ring f. | Co. Tax ring f. | A.tax cons. | Sp. TaxCo. cons. | A.tax cons. | Btax M.usd | Roya. Co. Tax ring f. | A.tax cons. |
| | | | | | | | | | | | |
| Sum | 35 | 2352 | 375 | 1000 | 977 | 403 | 263 | 310 | 367 | 244 | 366 |
| 2018 | | | 400 | -400 | | | -400 | -25 | -8 | -366 | -400 |
| 2019 | 5.3 | 341 | 66 | 600 | -325 | | -330 | -17 | 5 | -313 | -325 |
| 2020 | 12.3 | 812 | 101 | | 710 | 106 | 532 | 134 | 81 | 495 | 710 |
| 2021 | 8.8 | 591 | 84 | | 507 | 178 | 219 | 198 | 111 | 199 | 507 |
| 2022 | 5.3 | 362 | 66 | | 296 | 96 | 141 | 96 | 59 | 141 | 296 |
| 2023 | 3.5 | 246 | 58 | | 189 | 23 | 16 | 3 | 6 | 179 | 189 |
| 2024 | | | | | | | | -21 | -10 | 30 | |
| US Gulf of Mexico | | | | | | | | | | | |
| Oil Income M.bbl | Opex M.usd | Capex M.usd | Btax M.usd | Sp. Tax ring f. | Co. Tax ring f. | A.tax cons. | Sp. TaxCo. cons. | A.tax cons. | Btax M.usd | Roya. Co. Tax ring f. | A.tax cons. |
| | | | | | | | | | | | |
| Sum | 35 | 2352 | 375 | 1000 | 977 | 403 | 263 | 310 | 367 | 244 | 366 |
| 2018 | | | 400 | -400 | | | -400 | -25 | -8 | -366 | -400 |
| 2019 | 5.3 | 341 | 66 | 600 | -325 | | -330 | -17 | 5 | -313 | -325 |
| 2020 | 12.3 | 812 | 101 | | 710 | 106 | 532 | 134 | 81 | 495 | 710 |
| 2021 | 8.8 | 591 | 84 | | 507 | 178 | 219 | 198 | 111 | 199 | 507 |
| 2022 | 5.3 | 362 | 66 | | 296 | 96 | 141 | 96 | 59 | 141 | 296 |
| 2023 | 3.5 | 246 | 58 | | 189 | 23 | 16 | 3 | 6 | 179 | 189 |
| 2024 | | | | | | | | -21 | -10 | 30 | |
| UK Upstream | | | | | | | | | | | |
| Oil Income M.bbl | Opex M.usd | Capex M.usd | Btax M.usd | Sp. Tax ring f. | Co. Tax ring f. | A.tax cons. | Sp. TaxCo. cons. | A.tax cons. | Btax M.usd | Roya. Co. Tax ring f. | A.tax cons. |
| | | | | | | | | | | | |
| Sum | 35 | 2352 | 375 | 1000 | 977 | 403 | 263 | 310 | 367 | 244 | 366 |
| 2018 | | | 400 | -400 | | | -400 | -25 | -8 | -366 | -400 |
| 2019 | 5.3 | 341 | 66 | 600 | -325 | | -330 | -17 | 5 | -313 | -325 |
| 2020 | 12.3 | 812 | 101 | | 710 | 106 | 532 | 134 | 81 | 495 | 710 |
| 2021 | 8.8 | 591 | 84 | | 507 | 178 | 219 | 198 | 111 | 199 | 507 |
| 2022 | 5.3 | 362 | 66 | | 296 | 96 | 141 | 96 | 59 | 141 | 296 |
| 2023 | 3.5 | 246 | 58 | | 189 | 23 | 16 | 3 | 6 | 179 | 189 |
| 2024 | | | | | | | | -21 | -10 | 30 | |

APPENDIX II: Portfolio optimisation with minimum of sum of present value of cost as constraint

| | | Capex | PV after tax cost | NPV Cons. | Percent Incl. | NPV w. constr. | PV a.t. cost w. constraint | Capex w. constr. |
|---------|----------------|----------|----------------------|--------------|------------------|-------------------|-------------------------------|---------------------|
| | | Mill USD | | | | | | |
| Norway | Large | 15000 | 4206 | 2982 | 100 % | 2982 | 4206 | 15000 |
| Norway | Large Marginal | 15000 | 4051 | 1002 | 0 % | 0 | 0 | 0 |
| Norway | Medium | 8000 | 2301 | 1392 | 100 % | 1391 | 2299 | 7994 |
| Norway | Small | 1000 | 290 | 107 | 0 % | 0 | 0 | 0 |
| USA GoM | Large | 15000 | 11479 | 4812 | 53 % | 2568 | 6127 | 8006 |
| USA GoM | Large Marginal | 15000 | 11041 | 456 | 0 % | 0 | 0 | 0 |
| USA GoM | Medium | 8000 | 6200 | 2140 | 0 % | 0 | 0 | 0 |
| USA GoM | Small | 1000 | 751 | 133 | 0 % | 0 | 0 | 0 |
| UK Up. | Large | 15000 | 3948 | 6529 | 100 % | 6529 | 3948 | 15000 |
| UK Up. | Large Marginal | 15000 | 3802 | 3393 | 100 % | 3393 | 3802 | 15000 |
| UK Up. | Medium | 8000 | 2081 | 3277 | 100 % | 3277 | 2081 | 8000 |
| UK Up. | Small | 1000 | 237 | 332 | 100 % | 332 | 237 | 1000 |
| Sum | Total | 117000 | 50386 | 26555 | | 20472 | 22700 | 70000 |

*PV after-tax cost using the marginal tax rates in table 4.1

APPENDIX III: Portfolio Cash flows

| Years | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 | 2040 | 2041 | 2042 | 2043 | 2044 | 2045 | 2046 | 2047 |
|---------------------------------|-------|-------|--------|-------|-------|-------|-------|-------|-------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| CF a.tax Table 4.2 | -5893 | -7720 | -10647 | -8293 | 1012 | 19603 | 13823 | 10693 | 9379 | 8422 | 7400 | 6309 | 5507 | 4868 | 4310 | 3735 | 3159 | 2663 | 1585 | 1514 | 1249 | 983 | 716 | 712 | 630 | 549 | 467 | 384 | 433 | -183 |
| CF a.tax Table 4.3 | -5740 | -7173 | -9547 | -6883 | 2044 | 19802 | 13194 | 9801 | 8236 | 6948 | 5863 | 5012 | 4441 | 3923 | 3489 | 3011 | 2532 | 2137 | 1092 | 1295 | 1061 | 826 | 590 | 619 | 547 | 475 | 402 | 329 | 390 | -249 |
| CF Difference Table 4.2-4.3 | -153 | -547 | -1099 | -1410 | -1032 | -198 | 629 | 892 | 1143 | 1473 | 1537 | 1297 | 1066 | 946 | 821 | 724 | 627 | 526 | 494 | 219 | 188 | 157 | 126 | 92 | 83 | 74 | 64 | 55 | 44 | 66 |
| Accumulated diff. Table 4.2-4.3 | -153 | -701 | -1800 | -3210 | -4242 | -4441 | -3812 | -2920 | -1777 | -304 | 1233 | 2530 | 3596 | 4542 | 5363 | 6087 | 6714 | 7240 | 7734 | 7952 | 8140 | 8297 | 8424 | 8516 | 8599 | 8672 | 8736 | 8791 | 8834 | 8900 |

APPENDIX IV: Portfolio Cashflow comparisons with IRR

| Years | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 | 2040 | 2041 | 2042 | 2043 | 2044 | 2045 | 2046 | 2047 |
|------------------------------------|-------|-------|-------|--------|--------|-------|-------|------|------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| CF atax IRR metric port. | -4793 | -6008 | -5965 | -5052 | 484 | 14375 | 9981 | 7512 | 6393 | 5241 | 4298 | 3651 | 3289 | 2971 | 2698 | 2373 | 2032 | 1740 | 1671 | 1844 | 1542 | 1226 | 896 | 953 | 860 | 762 | 638 | 550 | 660 | -429 |
| CF Difference with NPV port. | -1100 | -1712 | -4681 | -3241 | 528 | 5228 | 3842 | 3180 | 2986 | 3180 | 3102 | 2658 | 2217 | 1897 | 1612 | 1362 | 1126 | 923 | -85 | -330 | -293 | -243 | -180 | -242 | -229 | -213 | -192 | -166 | -227 | 246 |
| CF Difference with Breakeven port. | -947 | -1165 | -3582 | -1831 | 1560 | 5427 | 3213 | 2289 | 1843 | 1707 | 1565 | 1361 | 1151 | 951 | 790 | 638 | 499 | 397 | -579 | -548 | -481 | -400 | -306 | -334 | -312 | -286 | -256 | -221 | -271 | 180 |
| Accum. Diff. With NPV port. | -1100 | -2813 | -7494 | -10735 | -10207 | -4978 | -1136 | 2044 | 5030 | 8210 | 11312 | 13970 | 16187 | 18084 | 19696 | 21058 | 22184 | 23107 | 23022 | 22692 | 22399 | 22156 | 21976 | 21735 | 21505 | 21292 | 21100 | 20934 | 20707 | 20953 |
| Accum. Diff. With Breakeven port. | -947 | -2112 | -5694 | -7525 | -5965 | -538 | 2676 | 4964 | 6807 | 8514 | 10079 | 11440 | 12591 | 13542 | 14333 | 14971 | 15470 | 15867 | 15288 | 14740 | 14259 | 13859 | 13553 | 13219 | 12907 | 12620 | 12364 | 12143 | 11873 | 12053 |