Discount rate and tax in petroleum activity[1]

By Diderik Lund, professor, Department of Economics, University of Oslo

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Some quotations are in Norwegian in the original, but here only the author's translations are given

An article in *Samfunnsøkonomen* no. 5/2013 directs criticism in strong words against proposals from the Ministry of Finance of changes in the petroleum tax. Among other things, the Ministry is accused of errors of calculation, and of using theory unknown to the oil companies. The purpose of my article is to show that rather, the errors of calculation are with those who criticize, and that the theory is well known and recommended by many scholars in valuation, at least outside of the oil companies. As time passes, the oil companies will also learn new and more precise methods of valuation. If the process is slow, some projects may be abandoned for erroneous reasons in the meantime. To some extent projects may be taken over by companies with other valuation methods.

1. INTRODUCTION

In connection with the Revised National Budget 2013, the Cabinet put forward proposals for changes in the petroleum tax (Prop. 150 LS (2012–2013)), which were sanctioned by Stortinget [the parliament] 17 June 2013. The proposal is to reduce the uplift in calculation of the special [petroleum] tax. The main features of the system are presented in Box 5.1 p. 11 in Prop. 150 LS (2012–2013). There is no disagreement between the critics and the Ministry over the actual description of the proposed amendment, so it will not be repeated here.

In an article in *Samfunnsøkonomen* Osmundsen and Johnsen (2013) criticize the proposal and the motivation given for it. Osmundsen and Johnsen have also written several newspaper articles on the topic.[2] They have to some extent used strong words, that the Ministry of Finance makes errors in calculations and uses theory unknown to the oil companies. The most important difference in method between the critics and the Ministry regards valuation of future cash flows. The Ministry divides these into different cash flow parts with different risks. They claim that future tax deductions can be seen as certain, and calculate present values of these with a risk free interest rate. Osmundsen and Johnsen (2013) instead find present value with a discount rate applicable to expected yearly net cash flows, based on a type of average risk. I will call this a uniform discount rate. It exceeds the risk free interest rate, and the deductions appear as less valuable. Below I will show that the two valuation methods are consistent if one adjusts the uniform discount rate to reflect the relevant average risk.

The proposal continues the main ideas from the report of the Petroleum Tax Commission, NOU (2000:18). I was a member of this commission, and of a similar Danish public commission (Skatteministeriet 2001), which followed the same main ideas. I have not been involved in the authorities' preparation of this year's proposal. In this article I will explain parts of the theory behind the proposal, and discuss the criticism, with which I mostly disagree. If someone makes errors of calculation, it is rather the critics. It is completely

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[2] In *Aftenposten* I find articles by Osmundsen and Johnsen or Osmundsen alone 10 May, 16 May, 29 May, 11 June, and 19 June, the last entitled «Klippe, klippe, klippe om oljeskatt». In *Dagens Næringsliv* there are articles 13 May and 21 May. To save space not all of these are included in the reference list.

unjustified to use such strong language about methods that are theoretically well justified, but perhaps controversial. When Osmundsen and Johnsen claim to base themselves on standard theory, this is misleading.

It is not possible to treat all issues concerning the petroleum tax in this article. Some of the controversial issues have previously been discussed by Lund (2001) and Osmundsen (2002). I review the literature in the field in Lund (2009). Parts of what follows, repeat things I have written previously, but are nevertheless necessary to show the logic. I will not go in detail on the numerical examples of the Ministry or the critics. The Ministry of Finance (2013) points out in its reply that table 2 in Osmundsen and Johnsen (2013) shows that the tax system gives incentives for overinvestment at the margin, also when a uniform discount rate of nine percent nominally after tax is used.

Section 2 in the following discusses what is a neutral tax system. Section 3 discusses how one may find a discount rate to be used for net cash flows under a given tax system. Section 4 discusses the claims about errors of calculation. Section 5 tries to show that the methods used by the Ministry are known in the literature. Section 6 shows that it is also known that a uniform discount rate is decreasing in the tax rate (except under a pure cash flow tax). Section 7 considers some other arguments. Section 8 discusses whether one should tax based on what companies themselves report about decision criteria, and section 9 discusses what more should be done about the tax system. Section 10 concludes.

2. NEUTRALITY

A basic property of valuation models in financial economics is *value additivity*. This means that today's valuation of having a claim to a sum of future, uncertain cash flows equals the sum of the valuations of each cash flow. If $V_0(X_t)$ denotes the valuation today (time 0) of a claim to a cash flow X_t to be received at time t, value additivity can be expressed as

$$V_0(aY_t + bZ_t) = aV_0(Y_t) + bV_0(Z_t), \tag{1}$$

where Y_t and Z_t are cash flow elements, and a and b are constants. This should be uncontroversial, and is, e.g., characterized as one of the universally accepted results in financial economics by Brealey et al. (2011, p. 901). If value additivity does not hold, one could, e.g., create values by combining securities in financial markets.

Value additivity is the basis for results on neutral taxation of firms, i.e., taxation which does not affect firms' decisions relative to a hypothetical situation in which they pay no taxes. By a *pure cash flow tax*, I mean a proportional tax on non-financial cash flows, X_t, with a constant rate τ (between 0 and 1) and immediate refund when the cash flow is negative. This system is neutral because the present value after tax is positive if and only if the present value before tax is positive:

$$\sum_{t=0}^{T} V_0(X_t) > 0 \Leftrightarrow \sum_{t=0}^{T} V_0((1-\tau)X_t) = (1-\tau)\sum_{t=0}^{T} V_0(X_t) > 0. \tag{2}$$

The firms accept projects for which the value after tax, on the right-hand side of the equivalence relation, is positive. This occurs if and only if the value on the left-hand side, before tax, is positive. It is outside the topic of this article to consider possible reasons why the authorities might want something other than neutral taxation.

In a pure cash flow tax an investment will allow an immediate deduction in the same year. The government pays out in case the net cash flow is negative. When typical tax systems instead allow deductions (depreciation and uplift) that are proportional to investment, but postponed in time, one may achieve neutrality if firms perceive deductions as equivalent with those that would have been allowed under pure cash flow taxation. How this can be achieved is a core issue in the disagreement between Osmundsen and Johnsen (2013) and the Ministry of Finance.

The theory in Fane (1987) and Bond and Devereux (1995) is that if firms can be certain to receive the deductions, they will calculate their present value with a risk free interest rate as discount rate. This is the approach of the ministry. Osmundsen and Johnsen (2013) have several objections. Partly they claim that this is not the way the firms calculate, and partly they claim that the deductions are not risk free. They argue that the firms use the same discount rate for all net cash flows (and thus for all elements of those), not partial cash flow discounting with distinction between different degrees of risk for different parts.

Here it is worth observing that Norwegian petroleum taxation has come very far, probably farther than any other tax system, in making the deductions risk free for the firms. This was the most important action suggested by the petroleum tax commission (Petroleumsskatte-utvalget, NOU 2000:18) to attract new firms to the Norwegian sector in spite of a high tax rate. With high uncertainty and long lead time between exploration start and revenues, it is imperative for new firms to get to enjoy tax deductions soon and with certainty. First, each firm is taxed consolidated for its whole activity on the shelf, in contrast with the type of tax "ring fence" around each field that exists in many other countries. Second, losses can be carried forward with interest,[3] and at termination of activity, the tax value of any remaining losses is refunded. Third, from 2005 onwards it is unnecessary to carry forward losses from exploration costs. The tax value of these deductions is refunded directly if firms do not have income in which to subtract the deductions.

This should accommodate the achievement of neutrality by designing the tax system as if deduction values can be perceived as certain. But it is true, as pointed out by Emhjellen and Osmundsen (2011), that future Storting cannot be committed by today's Storting. From the firms' point of view, future tax deductions will never be completely risk free.

3. A UNIFORM DISCOUNT RATE, BUT WHICH ONE?

The main point of objection from Osmundsen and Johnsen (2013) is that firms actually use the same discount rate for cash flows after tax in all countries, adjusted for country risk, if any.[4] This uniform discount rate will likely include a type of average risk adjustment, and will exceed the risk free interest rate. Thus firms will perceive future tax deductions as less valuable than what is calculated by authorities. They claim that the method with a uniform discount rate is "theoretically and empirically well established" (p. 17, my transl.).

I will first consider how such a uniform discount rate possibly must be determined in order to take the tax system into account. It is interesting to clarify this even if partial cash flow discounting exists as alternative method. Then I return to what has been known about the two different methods, for the oil companies and through textbooks.

[3] The interest rate is a government rate after tax and is set by regulation in January of the subsequent year.

[4] The magnitude of country risk has not been made into a topic of disagreement, but instead whether it is wise to use the same discount rate for the net cash flow irrespective of the tax system.

The following relies on Lund (2000 sect. 9, 2002, 2013), who discusses many more details, i.a., loan financing. I limit the discussion to a model with only equity and only one future period, where subscript for period is omitted.[5] As opposed to the aforementioned previous work, below I will allow for the possibility that future tax deductions are subject to political risk.

There seems to be agreement that firms use the Capital Asset Pricing Model (CAPM) (Sharpe 1964, Lintner 1965, Mossin 1966) to risk adjust discount rates.[6] The model says that

$$E(r_i) = r + \beta_i[E(r_m) - r], \tag{3}$$

where r_i is the rate of return on shares in firm i, r is the risk free interest rate, r_m is the rate of return on the market portfolio, and $\beta_i \equiv \text{cov}(r_i, r_m)/\text{var}(r_m)$, where $E(\cdot)$ denotes expectation, cov denotes covariance, and var denotes variance.

It is supposedly uncontroversial that «The company cost of capital is *not* the correct discount rate if the new projects are more or less risky than the firm's existing business» (Brealey et al., 2011, sect. 9.1). To discount the expected value of a future cash flow X in a particular project, a risk adjustment is used, based on its beta value,

$$\beta_X = \frac{\text{cov}(X/V(X), r_m)}{\text{var}(r_m)}, \tag{4}$$

i.e., a beta value as if a firm had X as the only cash flow next period. The firms should be well acquainted with having to choose risk adjustment based on characteristics of each project. But the following seems to be controversial: A discount rate for the net cash flow of a project will be a decreasing function of the tax rate. One should notice that this does not hold for the type of cash flow tax that was discussed above, but for systems in which investments give deductions over many subsequent periods, such as depreciation and uplift. The model below shows the relationship.

I consider a simple model in which next period's cash flow before tax is $X = PQ$, the product of an uncertain oil price and a quantity known with certainty. Assume that this cash flow follows an investment I at time 0, and that the investment gives rise to a deduction cI in the tax base next period.[7] This deduction can be risky for several reasons. We can distinguish between normal business risk under given tax rules, for instance low realized oil price leading to a negative tax base, and the risk perceived by firms that rules may be changed. I refer to Lund (2013) for the first case, but will now consider c as subject to political risk. Next period's cash flow after tax is

$$X_E = PQ - \tau(PQ - cI) = PQ(1 - \tau) + \tau cI. \tag{5}$$

[5] Lund (2002) extends to many periods with certainty about future tax position. Lu (2012) extends to many periods with uncertainty about future tax position. Vegara (2010) introduces inflation.

[6] The beta measure of risk is mentioned by Osmundsen and Johnsen (2013, p. 17), the CAPM underlies Emhjellen and Osmundsen (2011) and Summers (1987), and the dissemination of the CAPM is documented by Graham and Harvey (2001). The presentation here is not explicit on how taxes affect the equilibrium in the model. r can be interpreted as the interest rate after tax. This is made more precise in Lund (2013).

[7] In the simple model there is only one deduction. In reality this corresponds to depreciation and uplift, i.e., deductions that are proportional to investments, but postponed to later periods. In the simple model there are no operating costs or interest costs, since these are unnecessary for showing the main point.

As seen from period 0 this is valued at

$$V(X_E) = Q(1-\tau)V(P) + \tau IV(c), \tag{6}$$

based on equation (1), value additivity. The investment project that consists of the cash flow $-I$ in period 0 and the cash flow (5) in period 1, is exactly marginal after tax, i.e., has a net value equal to zero, if the value in (6) is equal to I. This implies

$$Q(1-\tau)V(P) = I(1-\tau V(c)). \tag{7}$$

It is shown in Lund (2013) that it is the beta value for such a marginal project that must be used to find the discount rate for investment decisions.[8] This beta value is a value weighted average of the beta values of the two elements of the cash flow, i.e.,

$$\beta_E = \frac{Q(1-\tau)V(P)}{Q(1-\tau)V(P) + \tau IV(c)}\beta_P + \frac{\tau IV(c)}{Q(1-\tau)V(P) + \tau IV(c)}\beta_c$$

$$= \big(1-\tau V(c)\big)\beta_P + \tau V(c)\beta_c, \tag{8}$$

where the final, simplified expression is found by substituting in from (7).

It is not obvious that future tax deductions have a positive beta value, i.e., that they are positively correlated with r_m. For the argument's sake, I shall first assume that it is positive, but small. It seems obvious that deductions in the Norwegian system have a beta value substantially lower than 0.9, which is the business beta that Osmundsen and Johnsen (2013 p. 16) mention for oil companies. This value will be used as an example of β_P in what follows.[9]

As long as $\beta_c < \beta_P$, the beta value after tax, β_E, will be decreasing in the tax rate. With a tax rate of 78 percent, the effect is strong. If, e.g., $\beta_P = 0.9$, while $\beta_c = 0.2$, and simultaneously $V(c) = 0.75$, then $\beta_E \approx 0.49$. If the tax rate is instead 28 percent, then $\beta_E \approx 0.75$, i.e., much closer to β_P.

If the model should be extended to hold for many periods, $V(c)$ should represent the present value of all deductions following the investment of one money unit. This is set as low as 0.75 per NOK invested in the example above. A low value may reflect high systematic risk, high risk free interest rate, and/or deductions being distributed over a long time period. Political risk about c is only relevant if it is correlated with the market portfolio, at least as long as the firms rely on the CAPM, which seems to be uncontroversial.

In the theory of Fane (1987) and Bond and Devereux (1995), one has $V(c) = 1$ because deductions are received with certainty and include interest accumulation which compensates for delay. This is also the situation the Ministry of Finance tries to achieve, based on the

[8] See also p. 83 in Korsvold (1984).

[9] It will lead to far here to give a precise discussion of what kind of average the above-mentioned business beta represents. Leverage, operating costs and tax affect this. It is conceivable that 0.9 is an average of after-tax beta values across many tax systems, which, in case, should indicate that the correct β_P for our purpose should be even higher.

political risk being negligible. Then one will also have $\beta_c = 0$. With 78 percent tax one gets $\beta_E = 0.198$. The high tax rate can reduce the relevant beta value dramatically.

It is not obvious that the firms can use this method of calculation in practice to find useful discount rates for the net cash flow after tax. The purpose of the analysis in Lund (2013) is primarily to show the magnitude of the effects, which illustrates the mistake in using a constant discount rate. The analysis shows that the correct discount rate will depend on several factors, among which is the uncertainty about the future tax position, which will depend on the profitability of the project.

If we consider typical tax systems internationally, also for other types of economic activity, most systems will only give depreciation allowances that add up to the nominal, historical value of investment. Also, when a firm has a loss (negative tax base) in one year, it will at best be able to carry this forward without any interest accumulation. To find the value of tax deductions in such cases, and possibly a correct discount rate for net cash flows, it is not possible to use formulae like in Lund (2013). Jacoby and Laughton (1992), Lund (1992), and Bradley (1998) show that this can be done with Monte Carlo simulation, where one, inter alia, may introduce uncertainty in more variables and different assumptions about price processes.

With focus on the American system for corporation tax, Summers (1987, p. 298) was skeptical of the possibility of using correct discount rates for total, net cash flow, which in case would have to reflect «average degree of riskiness». Instead he recommends partial cash flow discounting.

4. WHO MAKES ERRORS OF CALCULATION?

The results above clearly show that oil companies cannot possibly find correct values of their projects if they use the same discount rate for net cash flow under the Norwegian petroleum tax system as under other systems with far lower tax rates. At the same time the method raises doubts about claims from Osmundsen and Johnsen (2013) that the Ministry of Finance makes errors of calculation. Their claims are based on their own calculation in which β_E is kept constant. That is, it is taken for granted that a firm's discount rate should be kept unaltered when they arrive in a new country with a new tax system. Osmundsen and Johnsen (2013, p. 17, my transl.) are aware that "the value of the tax deductions make up the [larger] share of the present value for normal projects" under the Norwegian system.[10] But they think that it will then be correct to adjust upwards the discount rate for the other part of the cash flow (p. 17, first paragraph in second column), so that the average is unchanged. They justify this by the other part of the cash flow (i.e., $PQ(1-\tau)$ in the simple model above) becoming more risky when one "removes such a substantial, presumably risk free cash flow" (p. 17, bottom, my transl.). But this is in conflict with value additivity.

The conclusion is that there is no good justification for maintaining the same discount rate when arriving in a country with substantially higher tax rate and high deduction values.

5. IS THE METHOD KNOWN FROM THE ACADEMIC LITERATURE?

An important point for Osmundsen and Johnsen (2013) is that the Ministry of Finance relies on a "selectively chosen theory" (p. 15) that is "unknown and incomprehensible for the companies" (p. 19), and this "is not even mentioned in central textbooks in the field" (p. 20,

[10] This is true for marginal projects, cf. equations (7) and (8). But the more resource rent there is in a project, the lower is the fraction of value made up of tax deductions, cf. Lund (2013).

my translations). Osmundsen (2013, my transl.) claims that one must "rely on the investment model that is used by the oil companies, and that is found in textbooks in universities and colleges," while he complains that the ministry relies on a 13 year old report.

Who has the authorities on their side is of course less interesting than who is right. But I will present some opposing views about the status in the academic literature, partly because this is so strongly emphasized by the two, and partly because the dissemination of new ideas in itself can be an argument for how generous deductions should be allowed by the tax system. Even if there are many nuances in the literature I refer to below, it will in any case be clear that Osmundsen and Johnsen (2013) are far from giving an adequate picture.

The academic literature in both public and financial economics has applied partial cash flow discounting to increasing degree, both before and after the year 2000. Concerning tax on corporations in particular, the *Mirrlees Review* is presumably the main authority during recent years. In its chapter 10, Griffith et al. (2010, p. 976) write about systems that allow deductions with interest accumulation over a number of years: «In principle it is not necessary to include a risk premium in the imputed rate of return, provided the tax reduction stemming from the ACE allowance is a 'safe' cash flow from the viewpoint of the firm». Then there is a longer discussion, in which they maintain that a risk premium is unnecessary as long as the tax system allows full loss offset. They do not mention the political risk for future changes, and it is natural to conclude that they do not see this as an important factor.

Tax on natural resource extraction in particular is discussed in a report from the International Monetary Fund (IMF), IMF (2012). It is mentioned (p. 20) that the influential contribution from Garnaut and Clunies Ross (1975) assumed that a similar interest accumulation, to maintain the risk adjusted present value of the deductions, had to be based on «the minimum required rate of return for the investor; this choice is now widely questioned». This means that the IMF today suggests that such generous deductions would give incentives for overinvestment, because the statement from 1975 has been interpreted in direction of a uniform discount rate which is not adjusted for the tax system. Appendix IV in IMF (2012) discusses this in particular, under the heading «What 'Uplift' Rate should be used in Rent Taxes.» Here it is stated,

> «The benchmark result on this issue is that if deferred tax benefits are certain to be ultimately received by the taxpayer (including, if necessary, as payments from the government), then carry forward of unrealized benefits at a risk-free rate is in principle appropriate (Fane, 1987; Bond and Devereux, 1995 and 2003). Where there is doubt as to the government's commitment to provide these benefits, risk-adjustment for that possibility—which, importantly, does not mean adjusting for the riskiness of companies' own cash flows—is appropriate» (p. 48).

The latter refers to the difference between β_c and β_P above. It will be a mistake to use the latter to risk adjust the present value of future tax deductions. IMF (2012) concludes that the former is lower, and that «... staff generally advise developing countries to use low rates of uplift and to consider time-limiting them» (p. 48).

There are also numerous academic articles in public economics dealing with the same issue. For instance, Zodrow (2006) writes that «... negative cash flows should in principle be carried forward at the nominal risk-free interest rate. The determinations of this rate would inevitably be controversial» (p. 283). More interesting in Norway is presumably Sørensen (2005), who

gives the theoretical basis for the Norwegian tax reform of 2006. He writes that «a shareholder income tax with an RRA equal to the risk-free interest rate will ensure investment neutrality» (p. 793).[11] I cannot support the view in Emhjellen and Osmundsen (2011) that «Present tax theory usually presumes average discount rates» (p. 45).

It is nevertheless relevant to find out what is mentioned about partial cash flow discounting, and in particular about tax deductions for investments, within financial economics and the more specialized literature on petroleum investment. The topic is far from unknown. Before real options are considered, it is usual in textbooks to present three methods for investment decisions. In Bøhren and Michalsen (2012) these are called "Justert nåverdi," "Totalkapitalmetoden," and "Egenkapitalmetoden" (ch. 9). In Ross et al. (2010) they are called Adjusted present value (APV), Weighted average cost of capital (WACC) and Flow to equity (ch. 18). Partial cash flow discounting belongs in the first of these, APV. The method was first suggested by Myers (1974).

In the presentation of the methods these textbooks consider taxed firms that invest under uncertainty, partly financed by debt. The value of future tax deductions for depreciation and similar has not been much in focus, and someone will perhaps perceive that the APV method is not about this. On the other hand, the value of future tax deductions for interest on debt has been strongly in focus in the discussion about the usefulness of APV. The topical Norwegian debate concerns both, and the principles for valuation of both types of tax deductions will be the same. At the time of investment there is certainty about the magnitude of investment and debt and the corresponding deductions (at least as long as politicians do not change the systems). What creates a bigger challenge is that future debt and investment are not known with certainty. This is discussed in section 7 below.

Even if it has not been strongly in focus, the valuation of future depreciation deductions is mentioned, also in textbooks in financial economics. Brealey et al. (2011) has the same view as Osmundsen and Johnsen (2013) on what is the most common method, but also make it clear that partial cash flow discounting gives the right result:

> «Capital projects are normally valued by discounting the total after-tax cash flow they are expected to generate. Depreciation tax shields contribute to project cash flow, but they are not valued separately; they are just folded into project cash flows along with dozens, or hundreds, of other specific inflows and outflows. The project's opportunity cost of capital reflects the average risk of the resulting aggregate.
>
> However, suppose we ask what depreciation tax shields are worth *by themselves.* For a firm that's sure to pay taxes, depreciation tax shields are a safe, nominal flow. Therefore, they should be discounted at the firm's after-tax borrowing rate» (p. 528).

It will be natural that deductions for depreciation and uplift are valued by themselves when firms gradually to a larger extent rely on the APV method. Hillier et al. (2008, p. 496) write in a concluding paragraph: «Some analysts prefer the WACC method to the APV approach since it is the more commonly used approach. However, the WACC method is appropriate only in limited circumstances. For example, if the debt capacity of a project changes over time, the WACC method is difficult to apply. In addition, in contrast to the APV framework, the WACC method cannot easily be adapted to evaluate investments with real options. For

[11] RRA is the Rate of Return Allowance (kapitalavkastningsfradrag in Norwegian), cf. NOU (2000:18), sect. 9.5.1.

this reason, the APV method should be implemented for all major investments, although corporations may want to be aware of their WACC and use that method to evaluate smaller projects.» This raises doubt over the claims that the ministry is selective and uses a method that is unknown and incomprehensible, and that is not mentioned in central textbooks. It also raises doubt over an absolute statement about partial cash flow discounting in Osmundsen (2002, p. 12, my transl.): "The method has been evaluated and rejected."

Effects of different tax systems do not catch so much attention in the U.S.A., where most textbooks in financial economics are written. But some write in particular on international investments. Lessard (1979) recommends the APV method, and writes: «... it is useful to separate depreciation tax shields (and other accounting allocations over time) from operating cash flows» (p. 583). Furthermore,

> «Technically, the depreciation tax shields are subject only to the risk that the firm cannot make use of them. This may be serious in certain cases, but in general if the firm cannot take the deductions directly, it can carry them forward or backward in time or, in the ultimate case, transfer them to another firm through merger. Roughly speaking, then, [the discount rate for expected depreciation tax shields] will involve only a small risk premium and can be approximated by the interest rate on the firm's debt in the currency in question» (p. 590).

It is peculiar that Osmundsen and Johnsen (2013) claim that the ministry's method, which relies on the same idea as Lessard (1979), "totally fails to satisfy desired characteristics of a good method of analysis" (p. 15, my transl.).

In the literature on petroleum investment the topic appears in several articles. Back in 1986 the development was just started. Ekern and Bøhren (1986, p. 32, my transl.) write "Practitioners will likely want easy standard methods for which it is simple to find estimates on magnitudes to plug into the models. Those who would have such exaggerated hopes will be sadly disappointed. Profitability analysis is both an art and a science, where one cannot mechanically and unproblematically follow recipes. (See Bøhren, Ekern, Johnsen and Korsvold (1984) and Johnsen (1985).)"

Later the methods have been improved and put into use. Emhjellen and Osmundsen (2011) refer to Jacoby and Laugthon (1992) using partial cash flow discounting. Since the 1992 article is published in *Energy Journal*, one of the leading academic journals covering petroleum economics, the method should be known to the oil companies. Further developments of the method are in a special issue of the journal in 1998, edited by Laughton (1998). He uses the concept Modern Asset Pricing (MAP) for methods that include partial cash flow discounting and real option valuation. He writes, inter alia,

> «The use of MAP methods in the financial analysis of 'real assets' in the upstream petroleum industry, and elsewhere, is still in its infancy.
>
> This may be beginning to change. Over the next decade, given the proper stimuli, project evaluation methods based on MAP ideas may have a significant positive impact on the way leading-edge non-financial organisations think about the project alternatives available to them» (p. 5).

He refers to studies using MAP to analyze «real world applications of significance» (footnote 5). Again it is somewhat surprising that it is claimed that the methods are not known among oil companies and cannot be found in textbooks. My own summary is that the methods are known and advancing.

6. ARE THE RESULTS KNOWN IN THE ACADEMIC LITERATURE?

It is shown above that the methods with and without partial cash flow discounting are known in the academic literature. But it is also interesting that the result that β_E is decreasing in the tax rate, is known from before; also before Lund (2000). Emhjellen and Osmundsen (2011) refer to Jacoby and Laughton (1992). They include a more detailed model of effects of a petroleum tax system under uncertainty. They do not consider political risk. When tax rules are taken as exogenous, there is still uncertainty about future tax deductions because the firm may be out of tax position in some years if oil prices are low. They model a tax system in which there is, as opposed to the Norwegian petroleum tax system, no complete loss offset with interest accumulation and refund if activities close down.

In a multi-period model it is very limited what can be derived of analytical results about this type of asymmetric tax. Like Lund (1992), Jacoby and Laughton (1992) thus use Monte Carlo simulation to find adjusted present values. But after these present values have been found, they ask what discount rate for expected *net* cash flow will result in these values. They call such a discount rate an Equivalent Constant Discount Rate (ECDR). From this it is possible to calculate a related beta value, that corresponds to β_E above. In complicated models one thus needs first to calculate adjusted present value, before one may find the correct beta value and discount rate for net cash flow.

They do the calculations before and after tax, and write: «The effect of the tax system on the ECDR is striking. The current real ECDRs are lower after-tax than pre-tax, indicating that the tax payments are more risky than the pre-tax cash flow» (p. 42).[12] This concerns exactly the issue discussed above: What will be the correct discount rate for expected net cash flow when one takes into account tax deductions having other risk characteristics than the pre-tax cash flow. The direction of the effect of taxation is the same, and the results are referred to as striking.

In Lund (2013) I attempt to analyze the issue as far as possible with analytic models. I also refer to others who have found that the risk after tax is lower than before tax when there are depreciation deductions, inter alia, Galai (1998) and Rao and Stevens (2006). I also show that the latter and Jacoby and Laughton (1992) find a discount rate for the average risk in the net cash flow. But in order to make the right decisions based on net cash flow, one needs to know the risk at the margin, which in general will be even lower. Thus the result will be even more striking.

7. SOME OTHER ARGUMENTS.

Osmundsen and Johnsen (2013) write: «... the Ministry of Finance chooses to rely on partial cash flow discounting. Not as a general principle, which would be to split into different partial cash flows of different risk classes. Only the tax effects of depreciation, uplift and debt should be separated out according to the ministry" (p. 13, my transl.) This criticism is

[12] The last part of the statement, that tax payments are more risky, is consistent with what I have done in equations (5) – (8), but was not explained above. The tax payments correspond to $\tau(PQ - cI)$. The beta value for these exceed β_P, something that is good for the taxpayer (see, e.g., Emhjellen and Osmundsen (2011), p. 46, bottom).

mistaken. Value additivity implies exactly that the ministry can restrict itself to consider the valuation of these deductions, cf., e.g., the quotes from Lessard (1979) and Brealey et al. (2011). It is not necessary for the authorities to worry about what is the correct discount rate for other parts of the cash flow.

Osmundsen and Johnsen (2013) write, as an additional argument that tax deductions are risky: «In addition one has a significant cost risk resulting from a very long investment period, and the tax depreciation and uplift are in any case not certain before the investment cost is known" (p. 13, my transl.). This is correct, but the uncertainty is not different from under a pure cash flow tax. In that system one also does not know the deductions before investments are known.

In my view it is uncontroversial that a pure cash flow tax is neutral also when costs are uncertain. This holds in particular also when the firm can choose future investments after they get to know realizations of a future oil price (Lund 2011). This is covered by the theory of real options. Bond and Devereux (1995, sect. 3) finds that also a tax with postponed deductions (which have the same present value as deductions in a cash flow tax) is neutral towards a real option decision when deductions, as seen from the time of the investment decision, are certain.

A very simple example in Figure 1 illustrates how this will work.[13] The upper tree in the diagram shows the development of the oil price for $t = 0,1,2$. I assume that if the oil price exceeds 1.1, an investment project will be started. It gives production and tax deductions in the subsequent periods. Investment and tax deductions are shown in the lower tree in the diagram. It is true that future tax deductions are uncertain as seen from the node at the far left ($t = 0$). But as seen from the node at which the investment decision happens ($t = 1$), they are certain. Possible decisions at previous nodes will be made under the assumption that optimal decisions are made later. To make the preceding decisions it is sufficient to know net valuation at each future node. In other words, it is sufficient that the tax system is neutral within each future sub-tree, conditional on realization of this sub-tree.

8. THE FIRMS REPORT THE USE OF OTHER CRITERIA

The argument that remains, is that the firms report that they actually use a uniform discount rate that is not adjusted for the tax level and the deductions. It is, in case, a new and questionable principle if one will ask taxpayers about their methods of calculation and base the tax system on the answers. The firms obviously have incentives to report a use of methods that leads to more lenient taxation.

[13] The space does not allow a more thorough introduction to real option theory. This type of diagram is much used, see Ekern (1988). If the model in the diagram continues in more periods, investments could of course happen also at $t = 2$, but this is not shown in the diagram.

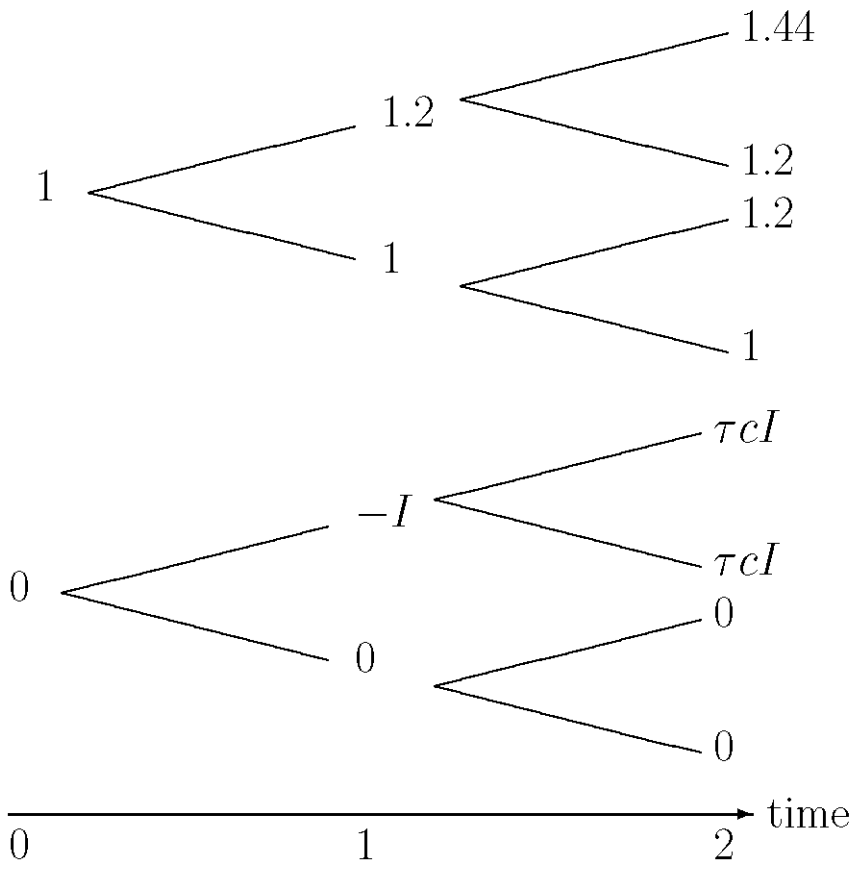

Figure 1: Example of uncertain oil price and neutral tax

My own evaluation of the situation is that more modern methods for investment decisions are being introduced rapidly, also in oil companies. It is difficult to understand that they should stick to "simple decisions models," as argued by Osmundsen and Johnsen (2013, p. 15, my transl.). Since the companies operate at a large scale, in an economic sense, they will have more to gain from improving their methods than many other industries. True enough, they could gain something to keep old methods if this actually leads to lower taxes.

The reports that the companies mostly use a uniform discount rate, cannot easily be dismissed as deliberately misleading. Since the companies are relatively open and have a degree of rotation of employees, it will be difficult to give a picture to the outside that is inconsistent with what happens on the inside. It may, however, well be the case, as mentioned by Sørlie and Reinskou (2012, p. 32), that the management of the companies have an interest in maintaining a higher return requirement vis-a-vis the different divisions than what is actually the minimum requirement when the management makes decisions. Among other things, this will counteract the tendency for divisions to exaggerate the profitability of own projects.

Openness and requirements of consistency internally in the companies will over time have to lead to change. Some inside the companies work with newer developments within investment theory, in particular, real option theory.[14] This theory is not consistent with a uniform

[14] This is, inter alia, a recurring topic in seminars arranged each year by the Norwegian Petroleum Society.

discount rate, but with the APV method (cf. the quote from Hillier et al. (2008) in section 5 above). This will be pointed out by those who work with investment theory inside the companies. It would be a paradox if the authorities in such a situation choose to base the tax system on out-dated decision criteria without support in economic theory. This would amount to authorities rewarding companies for not updating their methods.

If authorities stick to their view, there is also a question whether other companies will enter where some withdraw. There are markets for license shares, and those who value them most highly, will bid the most.

This is reminiscent of the situation around 2003, when the main features of today's system were established. The companies cooperated through Kon-kraft (2003), and asked for lower special tax. "The report recommends that targeted tax incentives are given through a reduction in the special tax on new activity. This will ensure that economically profitable projects are realized, and contributes to promote better resource management and increased activity" (p. 2, my transl.). The objections from the industry were not accepted. New companies entered at a large scale, and the activity increased. I cannot claim that this was caused solely by tax changes. In part it was related to increased oil prices, but, in any case, it is difficult to claim that the objections by the companies at the time have been verified, rather the opposite.

Anyhow, competition and new companies cannot alone solve all problems. There can be projects or parts of projects in licenses that are already awarded, that may be difficult to transfer to other companies if they rely on particular know-how that belongs to present owners. If all problems resulting from too high discount rates are to be solved, this requires companies in such licenses to revise their methods.

9. WHAT CAN BE DONE ABOUT THE TAX SYSTEM?[15]

Summers (1987) observes that most companies do not seem to take in that depreciation deductions are less risky than many other cash flow elements. This concerns mostly U.S. corporations, and he is particularly worried in relation to tax reforms, that will not be interpreted correctly by the companies. With 78 percent tax the problem is exacerbated. Bjerkedal and Johnsen (2005) discuss the problem for reform in Norwegian petroleum taxation.

Summers (1987, p. 302) suggests increased weight on immediate deductions (investment tax credits) to reduce the problem. For Norwegian petroleum taxation it will be conceivable to go even further, to a pure cash flow tax. If a normal rate of return should still be taxed as in standard corporate taxation, one could transform the special tax into a cash flow tax, but combine this with ordinary corporation tax. An objection to cash flow taxation for ordinary industrial activity is that the tax could subsidize the start of many activities that have no clear potential for economic surplus, but that give the owners other benefits, e.g., as a hobby. In petroleum activity this is less worrying, since the companies must have licenses, and must be approved technically and financially in order to apply for these. The deduction for exploration costs is already an element of a cash flow tax, and the state's direct financial interest (SDFI) has many similarities with a cash flow tax.

[15] Here I only include a few comments that are closely related to the rest of the article. For a longer discussion I refer to NOU (2000:18) and Lund (2001).

Another objection has been that authorities of other countries perhaps will not accept that a cash flow tax is a tax. There has been particular focus on the tax treaty with the U.S.A., and it is uncertain how American authorities will judge such a tax reform. If they do not accept, U.S. companies will be taxed also in their home countries for the surplus of the activity in Norway. This will give less scope for Norwegian taxes, and is thus an important objection. This is an important reason to have a special tax and not "only" SDFI.

10. CONCLUSION

A correct risk adjusted present value for taxed petroleum projects can be calculated by two methods, adjusted present value (APV) or based on a uniform discount rate. These methods are mutually consistent if the uniform discount rate is adjusted for the actual risk of the net cash flow. Under typical tax systems, in which investment deductions are given in the form of depreciation and possibly uplift, a uniform discount rate will be a decreasing function of the tax rate. In simple models it is possible to determine this discount rate analytically, but in more realistic models one has to, in practice, do the detour via adjusted present value.

The main features of this theory have been known for a long time. The claim that the Ministry of Finance makes errors of calculation because they have not adjusted the risk of the other parts of the cash flow upwards, is, however, not based on any known theory. The oil companies can benefit much from applying newer theory for investment decisions. The tax system should rather be based on their doing so, than on their using out-dated methods without theoretical basis.

The proposals for changes in the petroleum tax system are reasonable, except that it could have been better to tie the deductions to realized interest rates. A small risk premium could also have been explicitly included. But from the assumptions given in the proposal, the tax deductions are still somewhat too generous. Three conditions may justify that these deductions are close to correct: Interest rates may increase, or there exists some political risk that is positively correlated with the market portfolio in western oil importing nations, or the relevant alternative risk free return for companies is in practice not taxed.

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