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Modeling the response to exogenous shocks: The capital uplift rate in petroleum taxation☆

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ABSTRACT

We show how a recent drop in the Norwegian capital uplift rate by two percentage points changes optimal field design and reduces field value for shareholders. Although optimal design changes considerably and value drops by 12%, the ability to reoptimize design after the shock is worth only 1.5% of field value. This evidence suggests that large behavioral effects of a shock do not necessarily imply large value effects, making it less important to always account for the taxpayers' response. The valuation error in such cases may be moderate if one instead uses the simplifying and widespread assumption of unresponsive taxpayers.

1. Introduction

Firms are exposed to exogenous shocks, such as sudden shifts in exchange rates, input and output prices, corporate law, and the tax system. Regulators, financial analysts, and researchers who want to estimate how such shocks affect the value of the firm must make a fundamental methodological choice: Can they just assume the firm's behavior does not respond to the shock (unresponsive firm), or should they instead assume that behavior changes (responsive firm)? This choice involves a tradeoff between simplicity and realism. Assuming an unresponsive firm is the simpler and easier approach, because assuming a responsive firm requires a specific model of how the firm will react. Such responsive models may be difficult to build and even harder to implement. On the other hand, responsive models may better predict what the firm will eventually do when the shock occurs (Auerbach, 2005; Boehm et al., 2014).

Studying a recent tax shock in Norway, we compare the responsive modeling approach to the unresponsive approach when estimating the effect of shocks on the taxpayer's behavior and on the value of the taxpayer's claim. We find that both effects are quite large if we assume the taxpayer responds optimally. However, the value effect is quite similar if we instead assume the taxpayer does not change behavior after the tax shock. Therefore, the improved insight gained by modeling a responsive rather than unresponsive taxpayer may not be worth the effort if the primary concern is to quantify value effects rather than behavioral effects. This is the main result of our paper.

In 2013, the Norwegian Parliament increased the level of petroleum taxation by reducing the annual capital uplift rate from 7.5% to 5.5% of capital investment (capex) per year over the first four years of the field's life. Capital uplift is extra depreciation deducted from taxable income in order to protect normal returns (taxed at 28%) from being taxed as abnormal returns (taxed at 78%). The tax change we study is large. For instance, the tax shield from capital uplift used to be 30% (i.e., 4 times

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7.5%) of capex in all planned fields on the Norwegian continental shelf and about 35% of shareholder value in the fields we consider in this paper.

We analyze how this tax shock interacts with design characteristics (e.g., capital investment, extraction rate, and production period) and with shareholder value (i.e., net present value of the owners' residual claim after taxes) in a wide range of petroleum fields. We alternatively assume shareholders respond vs. do not respond to the shock by modifying vs. not modifying the field's design after the shock. No response (i.e., exogenous design) or only limited response is by far the most common assumption (Smith, 2013). Nevertheless, Poterba (2010) advocates models that assume response (i.e., endogenous design), stating, “In any analysis of tax policy and tax reform, it is essential to recognize that taxpayers respond to taxation.”[1] Similarly, Smith (2013) says, “let tax policies for extractive resources be founded on the basis of models and methods that admit the broadest range of behavioral response.”

Our paper makes two contributions to the literature. The first is to provide new evidence about the effect of taxes on taxpayers. We use the responsive approach to estimate how the reduced capital uplift rate affects the field's optimal design and maximum shareholder value. As far as we know, this is the first study of how the capital uplift rate in petroleum taxation interacts with the behavior and the value of the firm.[2]

The second and major contribution is to clarify the importance of assuming responsive vs. unresponsive taxpayer behavior. We compare two very different approaches. What we call *the unresponsive model* assumes the firm does not change the field's design after the tax shock, meaning the design data are identical before and after the regulatory change. Using data from 2 stylized fields and 68 actual fields, we calculate the shareholder value of the field with unaltered design under the new tax regime, compare this value to the field's value under the old tax regime, and use the difference to assess the sensitivity of the value to the tax shock. This assumption of unresponsive design is often called “the scenario approach” in petroleum tax research (Smith, 2014). Examples of this widespread method are found in Bøhren and Schilbred (1980), Kemp (1987, 1992, 1994), Smith (1995, 1997), Tordo (2007), Bacon and Kojima (2008), and Hogan and Goldsworthy (2010). According to Smith (2013), the unresponsive approach is basically an accounting exercise.[3]

The alternative approach is what we call *the responsive model*, which assumes shareholders react to the tax shock by changing the field's design. Given the new tax regime, shareholders may find it optimal for tax-minimizing reasons to change design characteristics. Hence, the responsive model measures the effect of the tax shock in ways that account for the shareholders' effort to avoid taxes by developing the field differently. For instance, the reduced capital uplift rate may induce the firm to recover less of the reservoir, avoid the most capital-intensive fields, extract the petroleum less aggressively, and prolong the field's life.

We compare the unresponsive model to a rich responsive model across a variety of fields. While both models allow for optimal field design in the old tax regime, only the responsive model has this property in the new tax regime. The question is whether the two models produce significantly different shareholder values after the tax shock. If they do, the unresponsive model is seriously biased, and the more complicated, costlier, and less common responsive model may be the better alternative. If instead the shareholder values are similar, the unresponsive model may be superior because it requires less insight, takes less effort, and is widely known.

Very few papers in petroleum tax research use truly responsive models (Smith, 2013, Table 2). This fact is probably due to the difficulty of building economic models that capture the field's physical production process in a realistic, comprehensive, and analytically tractable way. We implement the responsive approach using a model recently developed by Smith (2014), which seems particularly well suited for our purpose. The model reflects a field's design characteristics quite accurately, transforms them into cash flows and net present values, applies to any tax system, is straightforward to build and solve in a spreadsheet, and generates field designs that are close to those observed in the industry (Smith, 2014, p. 149).

Specifically, the shareholders in our responsive model choose the combination of a recovery rate, extraction rate, and enhanced recovery (i.e., design effects) that generates the expected after-tax cash flow having the highest net present value (i.e., value effects). This menu of design variables seems richer than what other models can offer. For instance, Zhang (1997) allows the firm to choose the starting date of production (i.e., timing), but not the investment (i.e., scale) and not the shape of production (i.e., profile). The EMTR/EATR approach to measuring tax system efficiency (Daniel et al., 2010; Chen and Perry, 2015) assumes the firm responds by investing more or less capital (i.e., changing scale) rather than reoptimizing the use of capital across different design characteristics (i.e., changing timing, profile, and scale).

We report four results. Using the responsive model, our first result is that the taxpayer responds to the lower uplift rate by reducing capex, reducing the extraction rate, and by postponing the startup of enhanced production. The typical magnitude of these design effects of the tax shock is 15%, while cumulated production volume (reserves) drops by only 3%. The latter response is moderate because the reduced tax benefit of investing for early extraction induces the firm to move production to later years and to prolong the production period.

Our second result is that the design effects are larger in more capital-intensive fields. This finding confirms the intuition that optimal field design responds more strongly to capex-related tax shields such as uplift the higher the capex needed to produce a certain volume.

The third result is that the shareholders' value loss is about 12% regardless of capital intensity. This finding suggests that the value loss caused by the reduced capital uplift rate is considerable, but also that this loss is robust to field design.

Our fourth result is that, despite the large design effects (typically 15%), the ability to reoptimize design rather than not respond after the tax shock is worth only about 1.5% of shareholder value. This minimal effect of re-optimized design on shareholder value happens because the value loss is similar in both the responsive model and the unresponsive model (typically 12%), making the difference between the losses correspondingly small. Therefore, assuming no behavioral response does not seriously bias the estimated value effect of the tax shock. This impression is confirmed when we assume exogenous design in the 68 planned fields that cover a wide range of field types. The average loss of shareholder value is close to the 12% loss we find when assuming responsive design in the two stylized fields. This consistency

[1] The public economics setting Poterba refers to uses the effect of taxes on cash flow before taxes to analyze the tax system's efficiency (neutrality, non-distortive) property. Although we will not address efficiency, any such effect must be driven by decisions related to the after-tax cash flow we use to determine how the tax change affects shareholder wealth and behavior. Nystad (1985) is an early example of efficiency studies in petroleum taxation, estimating the distortive effect on design characteristics in general and on recovery rates in particular.

[2] Lund (1992) uses contingent claims valuation and Monte Carlo simulation to compare the Norwegian petroleum tax systems in 1980 and 1987. He considers design effects and value effects, but studies efficiency properties of the two tax systems rather than the assumption of response vs. no response. The 1987 tax reform changed the uplift rate, royalty rate, production allowance, starting date of depreciation, and the tax rate, but Lund does not analyze the efficiency effect of the uplift rate separately.

[3] “In effect, only the initial decision to undertake the project (if after-tax cash flows meet the break-even conditions) or terminate production (when marginal after-tax returns become negative) are under the investor's control. Thus, it is possible to estimate how a given regime will affect the break-even price required for investment, or the minimum economic field size (assuming there are economies of scale), or the minimum required cost of capital, or the terminal flow rate that would trigger abandonment. It is not possible, however, to gauge the effect of the tax system on the intensity of initial development, the speed of production and/or subsequent decline rate, or the timing and magnitude of any secondary investments undertaken to enhance recovery—because these factors are all pre-determined” (Smith, 2013).