Effects of decline rate uncertainty and financial security obligations on the decision to decommission offshore oil and gas installations: a UKCS case study

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Overview

The decision to cease production and begin decommissioning of offshore oil and gas installations is becoming a major issue in mature hydrocarbon basins. In the United Kingdom Continental Shelf (UKCS), it is expected that £16.6 billion will be spent on decommissioning over the next decade (OGUK, 2021). Decommissioning will also help economic recovery in the basin as the skills required are transferable to other offshore activities (Green Recovery Commission, 2020).

Nevertheless, deciding on the optimal timing to begin decommissioning is not straightforward (Kemp, 1998; Abdul-Salam, 2021). Physical properties of the fields as well as economic considerations affect the decision. One overlooked physical determinant is the production decline rate of oil and gas fields. In an ideal world a production profile will exhibit a build up phase in the early periods until it reaches a plateau, then decline begins until the economic limit is reached and the decision to cease production is taken. However, several factors affect the outlined behaviour. Common below ground constraints are reservoir pressure, external fluid injection, manipulation of the fluid properties, compressibility and maintenance. Above ground constraints like underinvestment, production quotas, damage to infrastructure or politics also impact the decline path (Hook et al., 2014). Such uncertainty in the decline phase directly impacts the decision to cease production because the economic limit will be reached at different points in time depending on the decline path.

An economic factor affecting the decision to decommission is the substantial amount of financial resources required. The Oil & Gas Authority (OGA) estimates that the cost to decommission the full inventory of UKCS offshore installations amounts to £46 billion (OGA, 2021). The government has powers to require licensees to provide decommissioning security to protect funds in case of insolvency. Commonly used instruments are letters of credit and trust funds. The result is that financial security adds pressure to operators' cashflows and will impact decision making.

In this paper, we analyse the combined effect that production decline rates and financial security obligations have on the decision to cease production and begin decommissioning of offshore oil and gas installations. The study contributes to the literature in two ways. First, it provides a method to introduce decline rate uncertainty in three commonly used decline rate models: exponential, hyperbolic and logistic. Second, we explore how financial security obligations relate to decline rate uncertainty. The results are valuable for policy makers as well as licensees to: acquire a comparative understanding of the different decline models and financial security instruments, and what effect they have on the optimal timing to cease production and begin decommissioning.

Methods

The study is undertaken in two stages. First, three decline rate models (DRM) are calibrated from real world data on UKCS fields of recent vintage and Monte Carlo methods are used to simulate production profiles. The decline rate approach was first introduced by Arps (1945, 1956) more than half a century ago and has become standard practice to forecast production DRM are capable of modeling future production assuming that depletion is the mechanism underpinning production decline (Hook et al., 2014). From the Arps framework we consider the exponential and hyperbolic decline rates. In addition, in the UKCS, Kemp and Kasim (2005) have shown that logistic decline rates best describe the production behaviour of several oil fields. Clark et al. (2011) successfully used the logistic model to forecast production of tight oil reservoirs in the Bakken and Barnett shale plays in the U.S.

Second, a discounted cash flow (DCF) model is built to analyse investment decisions of five oil fields designed to be representative of the UKCS. The simulated production profiles from stage one are used as inputs in the financial model. The DCF model incorporates financial security obligations by modelling two instruments letters of credit and trust funds. The analysis centres on the following economic indicators for each field: net present value,

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cessation of production date, total cost of the security instrument ,and the number of years paying security. Special emphasis is made on the economic limit and changes to decommissioning decisions.

Results and discussion

Early results suggest that faster decline rates are associated with lower values of NPV. However, it appears that the sensitivity of NPV to decline rates is lower the larger the field size. This means that the effect of faster decline rates does not necessarily result in lower NPV values after a certain threshold. This behaviour remains the same no matter the declime model used.

With regards to the decision to cease production (CoP), the effect of decline rates is steeper compated to NPV. For larger sized fields, a small change in the decline rate results in significant changes to CoP. Hyperbolic models exhibit delayed CoP dates compared to exponential or logistic decline.

Turning to the relationship between decline rates and the cost of financial security instruments, the results suggest that faster decline rates increase the cost of financial security. This makes theoretical sense because a faster decline rate means the trigger date is reached earlier due to the impact in remaining net present value. However, the second highlight is that the increase is not continuous, it is rather in steps. A possible explanation is that the cost of security is rather determined by the number of years paying. Consequently, the underlying theorized relationship is that: decline rates affect the number of years paying security which in turn impact the cost of the instrument.

When looking at the effect on number of years paying security the results point out that as the number of years paying security increases the costs are reduced. This behaviour is more evident for the Trust Fund than the letter of credit (LoC). The impact is stronger the larger the field size. Closer inspection of the data shows that time value of money is the factor explaining this behaviour. A faster decline rate means that the security trigger date will take place at an earlier point so the security expense will be higher in present value terms. Second, faster decline rates accelerate CoP so contribution to a Trust Fund will be divided between fewer years. For the LoC and Trust Fund, the cost of the fee will be higher because it is based on the present value of the decommissioning costs at each year paying security times a contingency factor. The conclusion is that the cost of security is determined by a complex relationship between the variables that affect the trigger date for security payment and the number of years paying security.

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