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Optimal resource extraction contract with adverse selection ☆

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Abstract

This paper studies the design of a mining concession contract as a multi-period adverse selection problem where production is the depletion of a non renewable resource. Compared with symmetric information, we show that overproduction is optimal in the terminal phase of the resource extraction program. Moreover, asymmetric information lengthens the contract duration but reduces the scarcity rent.

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Introduction

Nonrenewable resource extraction often involves a bilateral exchange between the mine owner and the mining operator. More precisely, the relevant modality is a concession contract in which the owner delegates the extraction of the resource to a mining firm in return for payment. For example, see Babusiaux et al. (2004) in 1998, 38% of crude oil production agreements worldwide were drawn up under concession regimes and the ratio reached 49% for natural gas.

For the last years, concession contract analysis has focused on the aspects of bilateral relations raising the problem of asymmetric information between the owner (the principal) and the firm (the agent). Clearly, the mining firm is selected for its specialized performance which is not completely apparent for the owner. In other words, the firm has private information. For example in contrast with owners, mining firms have greater experience in evaluating the in-ground reserve potential, the quality of deposits, and thus the operating expenditures related their mining activity.

In order to allow the principal to get around this problem in a optimal way an incentive contract must be conceived. Moreover, since the extraction is carried out over several periods, an ongoing relationship has to link the contractors. Thus time implies a natural asymmetry between their present and future relationships.

At a very general level, a complete analysis must take into account the following stylized facts concerning non renewable resources:

- the mining firm is privately informed on its efficiency directly affecting extraction costs;
- the firm has access, to more information than the owner about the resource stock level and the quality of the resource;
- the firm's efficiency can evolve over the periods and can be correlated over time;
- extraction costs can be greatly influenced by stock effects: as the resource deposit is depleted, the in situ

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reserve diminishes and the extraction cost rises owing to the increasing difficulty of mining;
- finally, the principal's specific context, for instance where there is an imperfect judicial system or an election in progress, raises the question of the principal's commitment: is the principal able to commit himself to the concession contract proposed to the agent?

In view of all stylized facts, it is a very difficult task to conceive the optimal contract. So particular settings are necessary to advance in the analysis as in the works of Gaudet et al. (1995) and Osmundsen (1998). The former assumes the absence of stock effects and commitment. In their framework, the asymmetric information issue lies on the mining firm's efficiency, which is supposedly independently correlated over the periods. The latter assumes the existence of stock effects and full commitment. By contrast, the mining firm is privately informed on the resource stock level. In short, compared with the symmetric information setting (where the firm has no private information) these analyses have shown that asymmetric information leads to distortions in both the extent and the pace of resource depletion. A well known interpretation is that distortions arise in order to diminish the informational rent, that is, the rent that the principal must be left to the agent so that his private information is elicited. So, we have a rent-efficiency trade-off because the principal weighs up his desire to reach allocative efficiency obtained with symmetric information against the costly information rent given up to induce information disclosure.

This paper aims to study the optimal resource extraction in the presence of adverse selection on the firm's efficiency,[1] full commitment, perfect efficiency correlation over the periods and no stock effects. As in Osmundsen (1998) we consider the private information parameter (i.e. the firm's efficiency in our paper) to be perfectly correlated over time. So, assuming noncommitment would make the analysis considerably more due to the ratchet effect. If the firm is efficient at the beginning of the extraction, the owner can infer that achieving efficiency is not too difficult and will consequently want to reduce informational rent at the end of the extraction (see Laffont and Tirole, 1988). Pooling equilibrium thus emerges: the contracts targeted for each firm's efficiency coincide.[2] Hence, assuming full commitment helps us to define an upper limit as to what can be achieved without the threat of the ratchet effect. Nevertheless, it must be noted that the contract that emerges from full commitment is not renegociation-proof: the owner could use the information learned in early periods to propose a renegotiation of the initial resource extraction contract in order to improve the terms of the rent-efficiency trade-off. Clearly, assuming full commitment implies that the trade-off between ex-post efficiency and ex-ante incentives favours the latter. One can motivate this full commitment assumption by referring to the energy resource sector, where countries are often resource dependent, their social–economic development relying on long term incomes linked to binding mining concession contracts.[3] This perfect stability can be achieved by means of a full commitment behavior of the natural resource ministry.

Perfect correlation is not restrictive either. The analysis can be justly generalized to imperfect one as long as full commitment remains valid (see Baron and Besanko, 1984). In fact, the imperfect correlation should be used by the principal to relax the cost of initial period incentives as the firm's report at a given period can be viewed as an informative signal useful for improving future period contracting.

We can justify the absence of stock effects by the following arguments. Osmundsen (1998) assumes a smooth stock effect technology, where total and marginal costs decrease relative to the remaining reservoir level. This allows one to consider that the private information parameter is the initial reservoir size. Moreover, as noted by the author, this approach considerably simplifies the analysis because it implies a non-binding resource constraint at the end of the final period. As a result, distortions in the mining (shadow) rent and the terminal period (or contract duration) exist but are ambiguous. To clarify these distortions, we drop this stock effect assumption by considering a simple linear technology[4] and an endogenous terminal period. Hence in our approach, we assume the private information type is defined as an efficiency parameter.

In one sense, we consider an intermediary, but enhanced, case compared to the two previous studies which enables us to completely characterize the optimal concession contract. We show that distortions are still valid in our context, but we can precisely determine the direction of these distortions.

Firstly, we show that asymmetric information postpones the exhaustion date and therefore the contract duration. Indeed, in this way, the principal prolongs the extraction schedule, leading to a lower discounted shadow value of each unit extracted, the so called *scarcity or mining rent,* becomes lower. Finally, this distortion alleviates the informational rent.

Secondly, compared with the symmetric information outcome, we show that overproduction is optimal at the end of the contract. When the mine owner designs a non renewable resource mining contract, he aims at two targets in the asymmetric information case. As the principal, the

[1]The asymmetric information problem is characterized by adverse selection when the agent holds some private knowledge about his cost unknown to the principal. However we do not address the moral hazard issue, as the agent can take an action unobserved by the principal.

[2]Although Gaudet et al (1995) assume noncommitment over two periods, they also assume temporally independent private information parameters implying that the ratchet effect no longer exists.

[3]However, see Wantchekon (1999) for contrary arguments.

[4]Those cost structures are often employed in exhaustible economics and Sweeney (1993) refers to them as "Hotelling cost structures".