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Evaluating a small deposit next to an economically viable gold mine in West Africa from the points of view of the mining company, the government and the local community

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ABSTRACT

This paper addresses the question of evaluating how much the different stakeholders stand to gain from a mining project. By carefully analysing the breakdown of the cash-flows generated, we were able to estimate the amounts received by the local community and by the national community (outside the mining area), the taxes and royalties received by the government and the profits made by the mining company. A real options framework was used to take account of the inherent uncertainty on the commodity price and the reserves, and the operating flexibility (that is, the possibility for the company to stop mining if the commodity price drops and/or the reserves prove to be lower than that had been envisaged). A synthetic case-study of a gold mine in West Africa was used to illustrate how this procedure could be applied in practice. By using the real option framework we were able to envisage scenarios for developing an extension to a deposit as a function of future values of the commodity price. The procedure proposed should provide governments and NGOs with more objective data for making policy decisions.

Introduction

The question of whether mineral resources are a curse or a blessing for resource-rich countries has been widely debated by academics and by international organisations such as the United Nations, the World Bank and the African Union. In a review paper, Davis and Tilton (2005) noted that many empirical studies over the preceding 25 years ago had cast doubt on the traditional wisdom that mining promoted the development of countries with mineral wealth. Opponents of mining cite the cyclic boom-and-bust nature of markets, Dutch disease, and the misuse of rents as reasons why mineral-rich countries develop more slowly than other countries. Some go as far as suggesting that developing mineral-rich countries would be better off to leave their mineral wealth in the ground. In summing up the arguments put forth by both sides, Davis and Tilton conclude by saying that the appropriate policy question is not whether we should promote mining in the developing world, but rather where should we encourage it and how can we ensure that it contributes as much as possible to economic development.

In a study on 71 local government areas in Australia, Hajkowicz et al. (2011) found no evidence of systematic negative associations between quality of life and the gross value of mineral production. Instead they found that mining had a positive effect on incomes, house affordability, communication access, education and employment across regional and remote Australia. However they commented that the benefits at a regional scale may mask negative localised inequalities and disadvantages. They conclude that "*there is a need to better understand these impacts and more importantly, the types of policy mechanisms government and industry can adopt to mitigate or avoid them*". The latest International Study Group Report on Africa's Mineral Regimes (United Nations Economic Commission for Africa (UN-ECA), 2011) devotes one chapter to the problem of how to share the revenue generated by mining. The report notes that *Governments are pulled in different directions in providing sufficient incentive for companies to invest in exploration, development and production while collecting adequate revenue for socio-economic development. A properly structured fiscal regime seeks to balance these objectives.* The report concludes by saying that: *The experience of the Lagos plan of action reminds us that policy design works best when instruments are available to carry it out.*

Recent work on sustainable development and corporate social responsibility (CSR) in the extractive industries (Hilson, 2012), echoes similar concerns. After defining sustainable development as being the combination of enhanced socio-economic growth

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and development, and improved environmental protection and pollution prevention, Hilson and Murck (2000) comment that it is becoming increasingly unclear how mines and mining companies can contribute to sustainable development. They note that costs and benefits must be *determined from the perspective of all stakeholders, and not just the shareholders and stakeholders with political influence*. This brings us to the question of how to evaluate those costs and benefits.

The aim of this paper is to provide a procedure for evaluating the profits that will be made by the company, the taxes and royalties that the government will receive if the project goes ahead and the benefits accruing to the local community over the life of the project. One difficulty when evaluating projects is the uncertainty on the commodity prices in the future and on the grades in the deposit itself. This means that a mining project with a positive NPV at the feasibility stage may prove to be much more profitable, or alternatively may make a loss. Secondly a standard NPV analysis assumes that the mine plan has been fixed, thereby ignoring managerial flexibility. As real options were developed to take this flexibility into account when evaluating projects, we propose an evaluation procedure within a real option framework taking into account the uncertainty on both the commodity price and the reserves in the deposit. The commodity prices are modelled using a geometric Brownian motion (via a binomial tree); geostatistical simulations are used to model the uncertainty on the reserves.

We focus on applications in West Africa because of the increasing importance of mining in the economies of ECOWAS countries[1] since the mid-90s and because the first author has first-hand knowledge of the area.

At the outset, the mine has to pay the initial capital expenditure in US dollars for heavy equipment, expert services, etc. Often the company takes out a loan to cover these expenses. Our underlying hypothesis is that after making loan repayments the remaining revenue generated by the mine can be split into four categories:

(1) costs incurred in local currency which correspond to wages and salaries for employees, and for services paid to companies within the country;
(2) costs incurred in foreign currency which correspond to services provided by foreign companies;
(3) taxes and royalties paid to the government and
(4) profits that go to the company (and which leave the country in most cases).

Following Mbodj (2009, 2011) and Diallo (2009), the employees of the mine can be divided into three broad classes: expatriates, highly qualified nationals and unskilled workers. The first two groups prefer to live in cities where the services are better. In cases where the mine is organised on fly-in-fly-out lines, they reside in the capital city, and so very little of their salaries is spent in the mining locality. In contrast to them, the unskilled workers are usually recruited locally. So the local community benefits directly from their wages and from part of the operating expenses in local currency. However as the services provided by the government are shared over the whole country, they benefit only indirectly from tax revenue. Splitting up the revenue into these different streams allows us to carry out the financial evaluation from four points of view:

- That of the mining company which wants to be sure to make a profit;
- That of the government which receives taxes and royalties from the mine;
- That of the local community around the mine which benefits from the income generated in the local currency in the form of workers′ wages and of services paid for locally; and
- That of the national community which benefits from the income generated in the local currency in the form of salaries and services paid for in local currency.

[1] Economic Community of West African States (ECOWAS): Benin, Burkina Faso, Cabo-Verde, Cote d'Ivoire, Gambia, Ghana, Guinea, Bissau Guinea, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo.

Case-study on a marginal satellite deposit

To illustrate the procedure we evaluate a small marginally economic deposit adjacent to a larger gold deposit which is to be mined over a 7 year period. In 2009 when this study started, the average gold price over the previous year had been about $800. Given the grades in the main deposit and with a gold price of $800, the company could make a comfortable profit by mining it. However this was not the case for the satellite deposit which had lower grades. Moreover as there were fewer drill-holes, it was a much riskier prospect. Additional drilling would be required to prove up the reserves in the satellite deposit which could then be mined over a 5 year period if the grades were high enough and if the gold price 7 years later was high enough. If the mining continues, the same equipment and infrastructure would be used as for the main mine so there would be no additional capital expenses to pay. In addition, the same workforce would be used.

We chose to focus this study on the satellite rather than the main deposit because the higher financial and geological uncertainty leads to more contrasting results than for the main deposit which is richer and better known. Secondly it illustrates how a strategy that is low risk for the company can be used to develop reserves that might otherwise be abandoned. A similar situation arises in the oil industry in mature areas such as the North Sea: as the infrastructure required has already been paid for, marginal satellite fields can be exploited profitably.

The strategy that is proposed here consists of carrying out the additional infill drilling while the main mine is being exploited, and then mining the richer parts first. At the start of each year when the company has to decide whether to continue mining or to abandon the mine, it would know the gold price and the reserves that could be mined in the following year, as shown in Fig. 1. As the gold price is volatile and as the deposit is marginal we assume that if the company intends to keep mining, it would hedge the next year′s production at the current price thereby locking in a profit. We also assume that the cost of the infill drilling has been paid during the first 7 years, and that provision has already been made for the decommissioning costs.

We are not the first people to recognise the optionality embedded in many projects. It was first noted soon after Black and Scholes (1973) and Merton (1973) discovered how to price financial options (Kester, 1984; Mason and Merton, 1985; Brennan and Schwartz, 1985). Sequential options arise in many types of industries notably pharmacy and biotechnology where new drugs can only go on to the next stage of development if they successfully pass the previous one; otherwise the project is abandoned. (Geske, 1979; Gamba and et Micalizzi, 2002; Duan et al., 2003; Kellogg et al., 1999). The situation is very similar here but there is one important difference between the case studied here and most applications of real options in mining such as Brennan and Schwartz (1985) in that we take account of uncertainty on the gold grades, as well as on the commodity price.

In order to carry out a real options analysis we need to be able to model the price uncertainty (using a geometric Brownian motion and a binomial tree) and the geological uncertainty (using geostatistical conditional simulations), in addition a strategy for