On the trade-off between the leverage effect and real options thinking: A simulation-based model on metal mining investment

Jyrki Savolainen, Mikael Collan *, Kalevi Kyläheiko, Pasi Luukka

School of Business and Management, Lappeenranta University of Technology, Skinnarilankatu, 3453851, Lappeenranta, Finland

ARTICLE INFO

Keywords:
Real options
Financial structure
Temporary closing
Metal mining
Optimal leverage

ABSTRACT

This paper studies the effects of financing conditions to managerial flexibility and project value and focuses on the point of view of the equity holder of a mining company. Simulation based analysis is performed with a dynamic system model of a metal mine investment. The leverage effect of the equity holder's discount rate change as a function of the debt/equity ratio is separately modelled. Our empirical results show that the choice of a financing structure is important for the value maximization for the equity holder, since different debt/equity ratios differently condition the management's ability to make operational decisions, such as temporary shut downs, which could raise the value of the mining project. The trade-off between the leverage effect (decreasing need for equity) and real option flexibility (increasing need for working capital) will be scrutinized both theoretically and by using simulation-based analysis for numerical results.

1. Introduction

In this paper we will study the ex-ante planning of mining investment profitability from the point of view of project financial structure, project real options, and from the point of view of the project equity holder.

What is specifically of interest here is how the choice of the financial structure (i.e., the debt to equity ratio) affects the profitability of a metal mining project by conditioning the use of available operational real options, such as temporary shut downs. To scrutinize this issue we will study the leverage effect that the choice of financing has on the value of a metal mining investment by way of conditioning/restricting the management's ability to use a temporary shut-down option to maximize the value for the owners. Furthermore, we study metal mining project profitability from the point of view of the project owner that is, the equity holder, and analyze the effect of leverage on the project value for the equity holder.

Metal mining investments are large sunk investments with long economic lives, whose profitability is crucially dependent on the mined metal's world market price. To maximize the profitability managers actively exercise operational flexibilities offered by the mine, such as the temporary shut-down option (Brennan and Schwartz, 1985a, 1985b; Moel and Tufano, 2002). Previous studies, e.g., Abdel Sabour and Poulin (2006); Coldwell et al. (2003) indicate that the value adding effect of the ability to temporary close a mine will be highlighted, when profit margins are small.

Traditionally, mining investments have been analyzed by means of simple discounted cash-flow based methods suitable for “bond type” projects with rather easily foreseeable cash-flows (Bhappu and Guzman, 1995; Moyen et al., 1996; Smith, 2002). There is, however, a trade-off between a real world fit and simplicity in using simple models (Bengtsson, 2001). Complex investments, such as mining projects, however, require tools that are able to deeper model the real world complexity and can, for example, take into account the link between the capital structure of projects and equity risk (Eady, 1999). Matching real world complexity with model complexity is commonly referred to as “requisite variety” (Ashby, 1958).

Economic feasibility of mining projects is most often evaluated by using the net present value (NPV) analysis (Bhappu and Guzman, 1995; Moyen et al., 1996; Smith, 2002). However, already 1985 Brennan and Schwartz (1985a, 1985b) suggested that a mine should in fact better be valued as an option to obtain the cash-flows from the excavated metal by creating a risk-free valuation under the pretext of hedging production with commodities (metal) futures and studied the open-close policy of a mining investment. Option valuation of mining investments has also been studied by Abdel Sabour (2001), who managed to show that the maximum shut-down period of a mine is also dependent on the remaining ore reserve. Abdel Sabour and Poulin (2006) used the least squares Monte Carlo (LSM) method to simulate the value of open-close flexibility in a multi-metal mine. Effect of managerial flexibility on the value of (gold) mining companies was discussed also by Baur (2014).

© 2017 Elsevier B.V. All rights reserved.
based wisdom says that the choice of financing does not matter in value of assets in terms of the cash-flows and thus the value they generate. However, we propose that when the choice of financial structure effectively conditions managerial actions it may have a considerable effect on the cash-flows and also on the project value. This kind of conditioning may be in the form of contracted fixed loan amortization payments that force the management to keep a mine open, while the optimal decision would be to keep the mine at shut-down. In this vein, the approach taken in this paper is to first study the effect of different financial structures (i.e., debt/equity ratios) on the value of a metal mining project.

A suitable way to analyze the said effect is to study the whole mining system, ceteris paribus, with different financial structures. In our paper we have selected three structures: full equity, 50% equity, and full debt financing. Importantly, we expect that the debt-financing cases will have rigid pay-back schedules for the borrowed capital. It is this assumption that is the core of the main results obtained in this paper. The three financial structures are studied for cases with and without the temporary close-open option. Under these circumstances the proper way to study the value of the real option is to study the project with and without the option and to compare the results. This approach was formulated by Tri-georgis (1993) as:

\[
\text{Value of real option } = \text{Expanded NPV } - \text{Passive NPV} \tag{1}
\]

where, "Expanded NPV" is the project value (to the owner) with real options and "Passive NPV" is the project value (to the owner) with no real options that is, in our case under continuous production without any shut downs.

Secondly, we take the point of view of the project owner (equity holder) and study the effect of leverage on the value of the metal mining project to the equity holder per percent of equity.

In this second part of the investigation, our approach differs from the majority of the above mentioned earlier studies, for in most previous research the focus has been on the overall value of mining investments. Because the focus is on the equity holder, the different debt-ratios that a project faces (during its lifetime), the risk faced by the equity holder and thus the discount rate used for the equity will be time-varying. This leverage effect-based reasoning implies that as the loan capital is paid back the discount rate for the equity holder will also change as a function of time. We will model this leverage-based equity discount rate change with a stylized function, whose value increases with the debt to equity ratio. The approach used is similar to what is previously presented in a general “traditionalist” case, for instance, by Bresley and Myers (1996). However, interestingly, this way of modelling has not been often applied in the real options literature, perhaps because the equity holder perspective has been rare.

The type of mine studied in this paper is what is commonly in the mining industry called a “high cost” mine, where the ore quality or other attributes of the project are such that the operation is conducted on the borderlines of profitability. The analysis will be conducted with the help of a rather realistic and detailed system dynamic (SD) model of a metal mine that is used as the basis for simulation analysis (the SD model used has been previously used in Savolainen et al. (2015); Savolainen, Collan and Laukka (2016a), (2016b). Fig. 1 illustrates the structure of the analysis procedure used in this paper. First, distributions of possible outcomes from which pseudo-random outcomes are drawn are constructed (1), by using these initial values are drawn and fed into the SD-simulation model (2). The SD-model is run using a selection of debt ratios with and without the managerial flexibility to temporarily close operations. The means of the from the simulation resulting NPV-distributions (3) are compared to attain the real option value of the flexibility to temporarily close operations for each tested configuration (4).

The results obtained show that the existence of the temporary option to close and reopen the mine really adds value to the project under all studied debt to equity ratios. This result confirms earlier findings, which show that it is advisable to utilize real options thinking in case of mining projects.

Interestingly, the absolute value from the investment diminishes, when the debt to equity ratio increases. This has to do with the growing inability to take benefit of the option to temporarily close the project and indicates a clear trade-off between debt-financing and the obtainable value from operational real options. One important finding that supports this analysis is that as the use of debt increases the number of months that the mine has been “forced” to stay on average open in order to cover debt repayments (amortizations), increases while the set stopping rule has signalled it to stay at shut-down, because of low metal prices. In other words, having more debt will cause the management to run the mine while the optimal policy would be to keep it at shut-down and this causes the overall NPV of the operating cash-flows to be lower with debt than without debt. This result indicates that the choice of the financial structure has a tangible and evident effect on the operational management of the mine and thus an effect also on the overall value created by the mine.

Furthermore, the results show that an optimal debt ratio that

\[\text{Feed forward loop} \hspace{1cm} \text{Feedback loop} \hspace{1cm} \text{Matlab® workspace}\]

Fig. 2. Structure of the system dynamic model.
دریافت فوری متن کامل مقاله

امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
دانلود فوری مقاله پس از پرداخت آنلاین
پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات