Real Option in Capital Budgeting for SMEs: Insight from Steel Company

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Abstract. Complex components of investment projects can only be analysed accurately if flexibility and comprehensive consideration of uncertainty are incorporated into valuation. Discounted cash flow (DCF) analysis has failed to cope with strategic future alternatives that affect the right value of investment projects. Real option valuation (ROV) proves to be the right tool for this purpose since it enables to calculate the enlarged or strategic Net Present Value (\textit{ENPV}). This study attempts to provide an insight of the usage of ROV in capital budgeting and investment decision-making processes of SMEs. Exploring into the first stage processing of steel industry, analysis of alternatives to cancel, to expand, to defer or to abandon is performed. Completed with multiple options interaction and a sensitivity analysis, our findings prove that the application of ROV is beneficial for complex investment projects independently from the size of the company and particularly suitable in scenarios with scarce resources. The application of Real Option Valuation (ROV) is plausible and beneficial for SMEs to be incorporated in the strategic decision making process.

Keywords: Real Option Valuation, Capital Budgeting, Flexibility, Strategic Decision Making and SMEs

1. Introduction

Option theory in real investment analysis, real option valuation (ROV) has received great attention in natural resources related projects, land and real estate development, electric sector, construction of large-scale infrastructures and energy-generating plants, pharmaceutical and biotechnological industries, research and development strategies, start-up ventures, Internet companies, capital intensive industries (such as airlines and railroads) and other industries subject to volatile demand (consumer electronics, toys, machine parts) or supply (oil and electric power facilities, chemicals, crop switching), among others, due to its ability to value flexibility\textsuperscript{[14]}. The approach allows managers to price different alternatives throughout the project’s life before formulating their path of strategy in investment activities.

Real option valuation (ROV) extends the valuation of the Net Present Value (\textit{NPV}) based on discounted cash flows (DCF) to the Enlarged (or Strategic) Net Present Value (\textit{ENPV}). Although many decisions in capital budgeting are dominated by the \textit{NPV}, it is obvious that this method is
insufficient to capture the whole complex nature of investment projects[5], let alone to provide tools to value managerial flexibility. Real option valuation takes care of these flaws by adding into the traditional NPV the value of flexibility calculated as the value of one or several real options.

\[ \text{ENPV} = \left[ \text{NPV} + \text{Real Option(s)} \right] \]

As managerial flexibility is important and complex, several issues are being highlighted especially in the valuation methodology. Pindyck[6] emphasizes the issues of irreversibility and uncertainty into investment valuation while McDonald and Siege[7] incorporate microeconomic theory of valuation.

When real option valuation has been applied to price strategic components of complex projects, these were specifically large-scale investments undertaken by multi-national enterprises (MNEs). The same approach then is simulated in the first stage processing of steel industry, an activity undertaken by SMEs worldwide, a sector heavily connected with natural resources. The unique characteristic of this sector is that both input and output prices follow random walks, which implies that firms do not have (total) control over them. Furthermore, more firms are managing their operations in small scale according to mini-mill systems. More and more small firms are participating in the supply chain networks, hence creating a significant percentage growth of the whole SMEs involvement in the industry.

Therefore, besides an attempt to apply real option valuation into a specific sector of industry that has not attracted the interest of researchers (and practitioners) up to now, this study is also tackling ROV for small scale sector, might it be a business unit, subsidiary or SME. The case study approach of the research applies a valuation methodology that does not differ from ROV applied in the analysis of large-scale investments when discrete-time treatment is used. The objective is to show that real option analysis is also feasible for SMEs managers. Thus the convenience to apply ROV does not depend on the size of the company undertaking the investment project but on the degree of complexity of the project itself by answering three basic questions. Firstly, in the evaluation of projects undertaken by SMEs, how can the high degree of uncertainty about input and output prices as well as reserves quantity be incorporated appropriately? Secondly, why does NPV fail to cope with strategic decision-making valuation of small-scale investment projects in the steel industry? Finally, how do real option valuation (ROV) and the enlarged NPV (ENPV) contribute to access the optimal policy approach to continue, expand, defer or abandon natural resource investments.

The case used in this study is on a mini-mill iron smelting project, potentially being carried out by small businesses in the steel industry, has been chosen as a subject of study.

2. Literature review: real option and capital budgeting

The discounted cash flow (DCF) method that leads to the calculation of the traditional NPV is the approach that dominates capital budgeting analysis[5]. However, due to the inability of DCF to capture the whole nature of complex projects, often these calculations lead to undervaluation of investments in different economic sectors. New proposals to deal with these problems started to appear in the 1980s, once option pricing of financial assets had been consolidated during the previous decade.

The key year for the inception of option theory is 1973, with the publication of the Black-Scholes model to value European options and the Merton model to price American options. Afterwards, more researchers enriched option theory. The introduction of fundamental economic principles of option pricing by arbitrage methods and simple numerical procedures for valuing options have been made by Cox and Ross[8] and Cox, Ross and Rubenstein[9]. The design of more complex option contracts, known as non-standard options or exotic options, enlarged the scope. Some exotic options such as i) compound options – which are options on options[10] ii) Asian options – where the payoff depends on the average price of the underlying asset during at least some part of the life of the option[11] or iii) options to exchange one asset for another, also referred to as exchange options[12], do not only play an
important role in financial option strategies but have also proved to be extremely useful in real option valuation (ROV).

ROV incorporates the financial assets valuation approach into the evaluation of investments in capital budgeting analysis. As stated in equation (1), the enlarged $NPV (ENPV)$ – calculated as the sum of the traditional $NPV$ discounted at the risk-adjusted rate of return plus the value of the real option(s) involved in the project’s nature – becomes the right measure to be taken into account by managers.

Besides being applied in investments related to natural resources, many other economic fields also profit from ROV methodology. Just to quote some contributions, among many others: Kellogg and Charnes\[13\] in valuing a biotechnology company, Schwartz and Moon\[14\] pricing an Internet company, Grenadier and Weiss\[15\] valuing investments in technological innovations, Alonso, Azofra and de la Fuente\[16\] studying an electric company, and Willigers and Hansen\[17\] analysing a pharmaceutical industry and still expanding.

All the above suggest the possibility of applying real option analysis in the first stage processing sector of the steel industry. However, few studies have been conducted in this economic field. Cortazar, Schwartz and Salinas\[18\] have conducted a very close case study of options available for steel industry. Their study in a smelter plant identified options to expand, to close and open a plant based on maximum capacity, to temporary closing as well as to contract. In order to identify the possible suitable options available for this particular sector, it is important to first analyse the nature and characteristics of a business before incorporating real option valuation, which has been the base of the study as illustrated in detail under the introduction chapter as Research Setting A.

3. Methodology

The research conducted in this study follows a stylized fact case study approach as exploratory research following Cooper and Slagmulder\[19\]. The approach is similar to other studies in the field of real options, such as Brennan and Schwartz\[20-21\], Dixit and Pindyck\[3\] and Trigeorgis\[4\], in the case of natural resource activities. This approach requires of the construction of a base case with various sources of information representative in a worldwide scenario.

The project chosen for the evaluation is an investment in first stage steel processing, a mini-mill smelting project as per Research Setting A in Chapter 1. To sum up, there is a new proposal of building up an iron smelting plan based on new process innovation, mini-mill iron smelting. The investment requires €10 million, €6 million in $t_0$ and €4 in $t_1$. By investing this amount, the firm will have a mini-mill plant with capacity of producing 182000 tons per year. However, due to Kyoto Protocol, the plant is allowed to produce only up to 75% of its capacity in order to maintain emission and effluent at minimum level.

The investment has an expected useful life of 10 years. 2 years are dedicated for construction and the rest 8 years are operational. Volatility is forecasted to be $\sigma = 30 \%$. Two discount rates are employed which are 5% of risk-free rates and 12 % of adjusted-risk rate. Holding to this information, discounted investment cost is $I$, is €9.81 million while discounted net cash flows, $V$ is €9.25 million resulting in NPV of €-0.56 million (negative NPV).

Analyses conducted have added 4 individual options to the case. Instead of investing €9.81 million and getting return of NPV €-0.56 million (negative NPV), the investment is now embedded with option to defer, option to cancel during construction, option to expand and option to abandon. The scenario is illustrated as per Figure 1.
The analysis and calculation done follows the log-transformed binomial lattice approach developed by Trigeorgis. Calculation is performed by software DerivaGem.

4. Analysis and Results

4.1. Individual Options

The real options involved in our case study are built up based on the characteristics and nature of a standard mini-mill iron smelting plant. The four options are developed as follows:

Option to defer is valued as an American call, where the strike price is the required outlay if the investment is made in the future. This option allows project initiation to be delayed to the next year, , The projected net cash flows will remain static but the cost of investment will increase by 5%. Real option value of this option is €1.485 million, representing about 16% of the gross project value. The ENPV of the project is €0.925 million.

Option to cancel during construction, which is valued as a compound option of a call on a put. In the case where the commodity price is unfavourable, construction can be cancelled at any time without any penalty. The firm might earn any invested amount, being discounted at the adjusted-risk rate of 12%. Once cancelled, the project cannot be deferred, expanded or abandoned (i.e., the other three options considered). The amount disinvested is taken as the strike price since it represents the saving due to discontinuation of the project. Real option value of this option is €0.17 million, representing nearly 2% of the gross project value. The ENPV of the project is €-0.39 million (negative ENPV).

Option to expand is valued as a European call. This is the option to make further investment and increase production output if future conditions are favourable. The strike price of the call option is the cost of creating the additional capacity discounted over to the time of exercising it. Two years after operation, i.e. at , the firm has the opportunity to increase capacity by 25% without being penalized for polluting the environment according to the Kyoto protocol. Real option value of this option is €3.22 million, representing about 35% of the gross project value. The ENPV of the project is €2.66 million.

Option to abandon is valued as an American dividend paying put. This is an option to sell down or close a project where the put value is on the project’s value. Meanwhile, the strike value is the liquidation (or resale) value of the project after deducting all closing down costs. At any time during operational years, the project can be abandoned for alternative use and enjoy a salvage value of, in principle, 50% of accumulated capital outlays net of 10% average annual depreciation, being discounted at adjusted-risk rate of 12%. Real option value of this option is €1.17 million, representing about 13% of the gross project value. The ENPV of the project is €0.61 million.
4.2. **Multiple Interacting Options**

Besides the four individual options above, there is possibility of two or more options being combined together. Therefore, it is important to analyse the sequence of options in order to identify any possibility of combining several real options embedded in the nature of an investment project. Smit [23], for example, has identified the stages in a petroleum offshore concession project before valuing it.

In our case study, four possible options have been identified for the purpose of strategic investment valuation. Based on this base case, first, the firm has an option whether to invest now or defer investment. By choosing an option to invest, it opens up to more options. After investment is undertaken, the firm may choose to cancel it during construction. However, by exercising this option, it closes the opportunity of incorporating other options later. If construction proceeds, investment has the options to expand and/or abandon in later time. Figure 2 shows possible option combinations for the investment according to the sequence proposed.

![Diagram of Option Combinations](image)

**Figure 2:** Combination of Options Embedded in the Investment According to the Proposed Sequence - Viewed in a Tree Diagram.

To comment briefly, the option to expand and abandon is valued at €1.81 million, resulting in **ENPV** of €1.25 million. The options combined together are negatively interacting with individual options to expand and to abandon by €4.14 million.

The next combined option is to defer and cancel, valued at €0.23 million, resulting in an **ENPV** of €0.33 million (negative **ENPV**). The options combined together are negatively interacting with individual options to defer and to cancel by €1.42 million.

The third combination joins together the most possible options available for the project, which are the options to defer, to expand and to abandon. This option is valued at €2.37 million, resulting in an **ENPV** of €1.81 million. The interaction among individual options is negative €4.14 million.

The fourth option combination is to defer and to expand, valued at €2.12 million, resulting in **ENPV** of €1.56 million. The options combined together are negatively interacting with individual options to defer and to expand by €2.58 million.

Finally, is the option combination to defer and to abandon, valued at €1.63 million, resulting in an **ENPV** of €1.07 million. The options combined together are negatively interacting with individual options to defer and to expand by €1.58 million. Table 1 summarizes the results of valuation for both individual options and multiple interacting options.
Table 1: Values of Options, ENPV and Interactions in € millions.

| Item | Value of Option | ENPV | Interaction a |
|------|----------------|------|---------------|
| 1 option | | | |
| Defer | 1.48 | 0.92 | |
| Cancel | 0.17 | -0.39 | |
| Expand | 3.22 | 2.66 | |
| Abandon | 1.17 | 0.61 | |
| 2 options | | | |
| D&C | 0.23 | -0.33 | -1.42 |
| D&E | 2.12 | 1.56 | -2.58 |
| D&A | 1.63 | 1.07 | -1.58 |
| E&A | 1.81 | 1.25 | -2.58 |
| 3 options | | | |
| D,E&A | 2.37 | 1.81 | -4.14 |

a The value of the combined options minus the sum of separate values

5. Discussions

5.1. Impact of ROV into Project Valuation

Referring to Table 1, on individual options, cancellation during construction option illustrates an example where adding up the value of real option does not necessarily make an investment attractive. In this case, if the investment is cancelled during construction once is has been undertaken, the ENPV of the project ends up being negative -€0.39 million. Yet, having an option to cancel reduces the loss.

For the rest of options, individually embedded in the project, the value of ENPV is positive. The most significant difference between NPV and ENPV appears when an expansion plan is considered. The expansion option gives the highest option value available for this project, which is €3.22 million and results in an ENPV of €2.66 million.

Combinations of multiple options may result in additive or non-additive value [31]. Based on the case study, it is found out that the interaction among multiple options is all non-additive. The biggest interaction as stated in Table 1 is noted when deferral, expansion and abandonment options are considered simultaneously causing a negative effect of €-4.14 million. It is identified that the cause of these negative interaction among all groups of multiple options is due to the different types of option, the period of exercising the options and the types of option being exercised earlier.

5.2. Sensitivity Analysis

Sensitivity analysis is a powerful complementary management tool in strategic decision-making. In this subsection we study the effect of changes in volatility and risk-free interest rate towards each option. Volatility is based on the average annual standard deviation of price fluctuation of outputs that
are being traded in terminal commodity exchanges. Volatility being 30% in the base case is assumed in the sensitivity analysis to fluctuate by +/- 5% to 25% and 35%.

The second parameter, the risk-free interest rate, is based on the future prevailing yield on two- to four-year Treasury bonds. In the base case, the risk-free interest rate is 5%. Changes analysed consider the risk-free interest rate sinking to 3% (2.95588% continuously compounded) or rising to 7% (6.765865% continuously compounded).

For individual options, higher volatility results in higher option values while effects of changes in the risk-free interest rate depend on the type of option. Increases in the risk-free interest rate result in higher values of deferral and expansion options, denoting that both are call options. On the contrary, option values fall in cancellation during construction and abandonment reflecting the put option nature of these two real options.

For multiple options, the sensitivity analysis considered must reflect all the factors interacting during valuation. These factors depend on the types of options and the degree of overlapping of exercise regions. It has been identified that the cause of these negative interactions among all groups of multiple options is due to the different types of option, the period of exercising the options and the types of option being exercise earlier which are consistent with finding of Trigeorgis[30].

The whole sensitivity analysis is performed with other variables held constant, and only considering only changes in volatility and the risk-free interest rate. The result is presented in Table 2. From Table 2, it is found that the movement of option values depends on the final nature of options being exercised. For example, in deferral and cancellation, it can be seen that the values are increasing with increment of volatility rate but decrease when risk-free interest rate falls.

Table 2: Sensitivity Analysis on Individual Strategic Options to Reflect Changes of Volatility and the Risk-free Interest Rate. (€ in millions)
It should be noted that the changes of option value towards volatility and the risk-free rate indicate its minimum value regardless of any changes in volatility or the risk-free interest rate. In the combination of deferral, expansion and abandonment options, when the risk-free interest rate is at 7%, any volatility below 32% will not affect the option value. The option value is affected when volatility grows above 32%. When risk-free rate is 5%, option value starts to be constant at €2.29 million as volatility falls below 28%. Meanwhile, the option value started to be constant at €2.29 million as risk-free rate is 3% once the volatility falls below 23%. Figure 3 illustrates this condition, where the asymptotic behaviour of the real option value functions becomes evident.

Figure 3: Effect on Option Value to Defer-Expand-Abandon When Changes in the Risk-free Interest Rate and Volatility Occur.

6. Conclusion

The complexity of real option valuation may intimidate managers, in particular those of SMEs, and deter them from applying it. This complexity may give the impression that this method is suitable only for large firms with complex activity. Steel industry also bears the same complexity compared to other economic fields, such as mining \cite{18, 20-21}, oil and gas concession \cite{29}, Internet companies \cite{14} or pharmaceutical research and development activities \cite{31}, just to quote some examples.

Bearing the advantage for SMEs that activities can be staged out and carried by different smaller entities, strategic investment decision making becomes crucial in the steel industry under various circumstances. However, it is more crucial during recession because resources are scarce for all companies, particularly for SMEs especially in their attempts to have access to new financing funds. The attractiveness of steel industry arouses the interest of additional SMEs \cite{32} to invest, but such investment requires careful and meticulous analysis before decision is made, as SMEs do not have the same capacity to absorb losses as large firms. Furthermore, a collapse of one member in the supply chain will most probably trigger the fall of other as this industry is capital intensive and industry specific \cite{33}. Therefore, measures have to be taken to prevent as much as possible wrong investment decisions. In other words, the complex characteristics of the production activity in the first stage processing of the steel industry, mainly undertaken by SMEs worldwide, offers the opportunity to prove how convenient (if not necessary) ROV happens to be for the investment analysis in this industry.
Embedding options into the enlarged $NPV$ ($ENPV$) through real option valuation (ROV) contributes interestingly to strategic management of any company and, as shown in this chapter through a case study analysis in the steel industry, of SMEs too. Uncertainty and flexibility of steel industry have to be incorporated into investment decision-making, a goal that this methodology achieves. By being capable of reflecting the complex nature of steel industry, ROV becomes a highly valuable tool to support managers in their strategic investment decisions. Contribution of ROV does not only reflect the market value of the project comprehensively. It also helps managers of small businesses in steel industry to decide upon the convenience of undertaking an investment, deferring it, altering the production conditions or abandon the business activity, i.e. a wide array of situations, since this methodology is capable of pricing flexibility and strategic resource allocation accurately.

It is important for managers, especially in SMEs, to understand that flexibility has its value when it comes to investment analysis. ROV values this flexibility as options embedded in the investment project before combining them to result in $ENPV$. Yet, the traditional valuation method through discounted cash flows is not totally discarded, in fact it is being enhanced. The stylized approach applied in this chapter should be a stepping-stone for SMEs’ managers to realize the scope of the benefits of ROV. Furthermore, the existence of different software programmes easily available in the market – like DerivaGem used in this chapter – turn applying ROV into a feasible decision making tool for SMEs’ managers.

ROV provides solutions to managers’ dilemmas about capital budgeting decision-making and helps them efficiently in the evaluation of alternative future scenarios in any conditions – growth or contraction, market boom or recession, even at any point of the firm’s learning curve. The advantages are not linked to the size of companies but to the complexity of the investment projects that are being analysed, making it more attractive, competitive and meaningful compared to the traditional $NPV$.

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