Evaluating Cash Benefits as Real Options for a Commodity Producer in an Emerging Market

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Abstract

The amount of cash a firm should maintain is an old problem tackled by finance literature. The recent advances in finance, mainly in the derivatives area, has opened the opportunity to revisit this subject. Cossin and Hricko (2004) studied the benefits of cash holdings using the Real Options approach. We follow their ideas extending the problem to a specific commodity producer firm in an emerging economy. We evaluate the benefits considering that raising capital takes time (timing benefit) and also the benefit of avoiding the issue of securities at unfavorable moments (underpricing benefit). We use numerical procedures to solve the problem. Despite the fact that the results are not totally intuitive, we verify that the timing benefit is much more relevant than that of avoiding the underpricing benefit and that firms in emerging economies have greater advantage holding cash than those in developed economies. There is empirical evidence of this last result in the literature.

Keywords: real options; cash holdings; commodity producer; emerging markets.

JEL codes: G13; G32.

Resumo

A quantidade de recursos em caixa que uma firma deve manter é um antigo problema analisado na literatura de finanças. Os recentes avanços, principalmente na área de derivativos, abriram uma oportunidade para rever tal problema. Cossin and Hricko (2004) estudaram os benefícios das empresas possuírem caixa usando a metodologia de opções reais. Estendemos seu modelo para o caso de uma firma produtora de commodity em um mercado emergente. Avaliamos os benefícios considerando dois aspectos: o benefício relacionado ao fato de que a obtenção de recursos financeiros demanda tempo (benefício temporal) e aquele relacionado ao fato de que a obtenção de tais recursos pode acontecer em um momento desfavorável (benefício de subavaliação). Foram usados procedimentos numéricos para resolver o problema. Não obstante os resultados não sejam completamente intuitivos, verificamos que o benefício temporal é muito mais relevante que o benefício de subavaliação.

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1. Introduction

How much cash should a firm maintain? Kester (1986) reported that the average ratio of cash plus liquid securities to total assets was 8.6% in 1983, for a sample of 452 U.S. manufacturing firms. Kim et al. (1998) found 8.1% for a broader sample of 915 U.S. industrial firms during the period between 1975 and 1994. Baum et al. (2004) reported a ratio of 8.7% for small firms and 14.3% for large firms and an overall average of 11.9%. Finance researchers have been working on this subject trying to explain why firms have these levels of liquid assets. One reason is related to the precaution against unfavorable conditions of external financing such as an increase in interest rates or tightened credit. Cash holdings can be viewed as an option acquired by managers that will be exercised when capital markets become restricted to finance the firm.

Keynes (1936) addressed the reasons a firm would maintain cash as: (i) transaction cost – the firm should have cash to meet its daily transaction needs; (ii) precautionary – the firm should have liquid assets to avoid raising capital at unfavorable moments; (iii) speculative – the firm should have cash to take advantage of opportunities that arise in its current business.

Myers and Majluf (1984) analyzed how asymmetric information (when managers know more about the value of assets than outside investors) affects a firm financing decision. The model is based on some assumptions about management objectives under asymmetric information. The model responds to many different aspects such as (i) external financing of debt is better than financing by equity, (ii) the model suggests a policy under which the dividends are highly correlated with the managers’ assessment of the value of the assets, (iii) when equity is issued, the stock price will fall, but when issuing debt through default-risk-free, the stock price will not fall.

Opler et al. (1999) examined the determinants of cash holdings. They found that firms with strong growth opportunities and riskier cash flow hold relatively more cash. Firms with access to capital markets and with higher credit ratings tend to hold lower cash. Their sample for this empirical study was publicly traded U.S. firms in the 1971-1994 period. Following the same idea Pinkowitz et al. (2003) investigated the value that investors assign to the liquid assets of a firm. Should one dollar cash be valued by shareholders at a premium or at a discount? They claim that the main determinants of the value of the liquidity are the growth options of the firm, the volatility of the investments and the magnitude of stockholder-bondholder conflicts. They found that firms with poor opportunity of investments, those with a less volatile portfolio and those nearer to financial distress have their cash valued at a significant discount to book value.
Baum et al. (2004) argued that the amount of liquid assets a firm should have is not only related to specific-firm variables but also to macroeconomic aggregates. The volatility in macroeconomic conditions can influence the policy a manager should follow. They found a negative relationship between the variance of cash-to-asset ratios and the conditional variance of real gross domestic product.

Cossin and Hricko (2004) used the advances of finance literature claiming that the subject needs further development. The authors used derivative pricing to evaluate the benefits of cash holdings. They modeled the problem as the valuation of two different options: (i) timing option – the firm needs a certain amount of capital to invest in a real project but this capital is not at hand and it takes time to raise in the market; (ii) underpricing option – raising capital not only takes time but also can occur when the firm is undervalued. Then the authors measured the benefits of holding cash by valuing these options. In the end they combined both options to solve simultaneously the whole problem. Some unexpected results were shown. They will be discussed in section 2.1. In this paper we followed the same approach of that study, extending the problem to a specific case where the firm is a commodity producer and is located in an emerging market. These extensions are based on different assumptions for the stochastic processes followed by project value and by the level of security undervaluation. In this text the word “benefit” is used in the same sense of that in the paper mentioned above. It means the opportunity cost of not having enough cash to undertake the investment.

The paper is organized as follows: Section 2 details Cossin and Hricko’s model. Section 3 deals with the extended model to evaluate the cash benefit for a commodity producer firm in an emerging market. Section 4 concludes the paper.

2. Cossin and Hricko’s Model

Consider a firm that has an opportunity of investing a fixed amount in a real project. At time zero it has to choose the source of capital. It can increase its cash or raise the funds in the capital market. If the funds come from the market, the firm could use equity or debt issues. In both cases it takes time to have the capital ready to invest in the project. The authors assumed that the funds would be ready at time $T$. Relying on outside financing could be suboptimal since the optimal time for investment should be before $T$. The authors divided the benefits of having cash in two different forms. First they evaluated the option of having funds and investing in the project before the time required to issue securities. Second, $T$ can be a moment when the firm is undervalued (for any reason its stock is being negotiated at lower values than managers believe would be the fair price). In this case they evaluated the option of having cash and avoiding the issuance of underpriced securities. In this situation the project can only be undertaken at time $T$. The complete problem is the combination of these two options: the firm using cash can invest at any time and simultaneously avoid underpricing issuance of securities.
2.1 The timing option

The timing option is the benefit of having cash and investing in the project before the time required in case of issuing securities. The authors started with the model first developed by McDonald and Seigel (1986) in which the value $V$ of the project evolves like a geometric Brownian motion (GBM).

\[
\frac{dV_t}{V_t} = \alpha dt + \sigma_V dW_t
\]

where $\alpha$ is the drift of the process; $\sigma_V$ is volatility of the value ($V$) of the project, and; $dW_t$ is the increment of the standard Wiener process. Let $K$ be the fixed investment to undertake the project. So the $NPV$ (Net Present Value) of the project today is $V - K$. Also let $d$ be the loss for waiting to undertake the project. This value represents what the firm will lose if competitors undertake the project before them. It can also be interpreted as a decreasing value of the project since its costs can rise. Thus $d$ is a percentage loss per period. Similar to derivative pricing in the finance literature, $d$ is the analog of the dividend yield of a stock.

If the firm decides to finance the project with cash, it can take part of this cash, $K$, and invest in the project to get the value $V$. And this can be done at any time until $T$. This is equivalent to an american option, more specifically to an american call option in which the investor can exercise his or her rights to buy the stock at $K$ (the exercise price) any time before the maturity. On the other hand, if the firm decides to raise external capital that will be available only at $T$, it has a european call option (the option to undertake the project can only be exercised at time $T$ when the funds are available). Thus at the time when the decision is made (finance the investment with cash or raise external funds), the benefit of having cash is the difference between an american and a european call option:

\[
B_t = C_t(T) - c_t(T)
\]

where $B_t$ represents the timing benefit measured at $t$; $C_t(T)$ is the american call maturating at $T$ and evaluated at $t$, and; $c_t(T)$ is the european one. This last option is evaluated by the standard Black and Scholes formula. To calculate the american option the authors used the Barone-Adesi and Whaley (1987) approximation. We used the least square Monte-Carlo (LSM), presented in Longstaff and Schwartz (2001), to calculate the american option at time $t = 0$. The results we found are quite similar to theirs (our result was compared to what was shown in the graphics in the original paper). Figure 1 shows the value of the benefit with the loss rate for different volatilities (or uncertainties across the value of the project). In our calculation we used the same values for the

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1Antecedents of the McDonald and Seigel (1986) include Myers (1977) and Tourinho (1979) as pointed out by Dixit and Pindyck (1994).

2In the risk neutral measure this process is written as $d\frac{V_t}{V_0} = (r - d)dt + \sigma d\tilde{W}_t$. 

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variables the authors used, which are $V_0 = 100$, $K = 90$, $r = 0.08$ (8% per year) and $T = 0.25$. Here $V_0$ is the value of the project at time zero and $r$ represents the risk free interest rate. It was assumed that the time required to raise external funds is 3 months. To proceed with the calculation using LSM we generated the paths in the risk neutral measure as usual in derivative pricing theory.

As can be observed from Figure 1 the benefit of having cash increases as the loss for waiting increases, this is a natural result. The other conclusion one can reach is related to the fact that as volatility increases the benefit decreases. It does not seem intuitive since for riskier projects firms will have less benefit having cash. Although counterintuitive, thinking of the investment as an option, the decision to postpone has value. In other words, it can be better not to invest now but wait, unless the project is deep in the money. The option to wait has more value when the volatility of the underlying is higher. Higher volatilities (riskier projects) imply more likelihood that one should wait and the consequence is less need for cash. The other reason for this result is related to the fact that the investment is modeled as deterministic. Should it be stochastic this effect would be mitigated. This argument is consistent with the real option ideas. The more volatile the investment is, the more valuable the option of cash holdings would be. So including stochasticity in the investment will reduce the effect of volatility ($\sigma_V$) on the project value obtained. This last concept is empirically verified in Opler et al. (1999) and in Pinkowitz et al. (2003).
2.2 The underpricing avoidance benefit

The underpricing avoidance benefit comes from the fact that the firm can issue securities at $T$ when its shares are undervalued by the market for some reason. The authors consider that the amount of undervaluation $X$, is given by a mean-reverting process

\[ dX_t = a(b - X_t)dt + \sigma_X dW_{X_t} \]

where $a$ is the mean reverting speed; $b$ is the long run amount of undervaluation; $\sigma_X$ is the volatility of undervaluation and $dW_{X_t}$ is the increment of the standard Wiener process. Also the processes given in equations (1) and (3) are correlated, then \( \rho dt = dW_{V_t} dW_{X_t} \). If there is no undervaluation, raising money at time $T$ and investing in the project means that the firm has a European option. On the other hand if at time $T$ the firm’s securities are undervalued, raising the capital and investing in the project means the firm has a European option with payoff given by $\max(V_T - K - X_T, 0)$. This is an option with stochastic payoff. Indeed the firm will have a decrease in the project value by an amount of $X$. It can be expressed as

\[ B_t = c_t(T) - c_{t}^{\text{under}}(T) \]

where $c_t^{\text{under}}(T)$ stands for the European option maturing at time $T$ and evaluated at $t$ under the condition of underpricing. We proceed as above implementing numerical calculations with simulations taken under the risk neutral measure. Again, the results (we used the same parameters of the previous case and included the following parameters for this case: $a = 0.2, b = 3, \sigma_X = 0.5, \rho = -0.2$) are similar to those found by Cossin and Hricko. It is worth noting that here the benefit decreases as the loss rate for waiting increases, not a very clear result. Also the result implies that the underpricing avoidance benefit is smaller than the timing benefit.

2.3 The timing and underpricing avoidance benefits

The combination of both risks can be interpreted as: holding cash allows the firm to undertake the project any time before $T$ and eliminates the problem of raising money at unfavorable moments. The first one is an American option maturing at $T$ and the second is a European option with underpricing risk and the same maturity. Then it can be written that

\[ B_t = C_t(T) - c_{t}^{\text{under}}(T) \]

where $C_t(T)$ stands for the European option maturing at time $T$ and evaluated at $t$ under the condition of underpricing. We used numerical procedures and found that the benefit decreases as volatility increases, a result explained above. Also the benefit increases with the loss rate for waiting, $d$. It behaves as if the timing benefit dominates the underpricing counterpart.
3. The extended model

In this section we extend the previous model replacing the stochastic processes used earlier to focus on a commodity producer in an emerging economy. We are going to do this in two parts: first the project value $V$ for a commodity will be a mean-reverting process; and second, the process for the undervalue amount $X$ will have a jump component.

3.1 The timing option

The use of GBM covers the classical problems in Real Options. If we think of a more specific model for a commodity we need another approach to describe the evolution of the value of the project. Dixit and Pindyck (1994) pointed out that in specific cases the mean-reverting process is an alternative to the GBM. The value of the project is then expressed by $dV_t = \eta(\bar{V} - V_t)dt + \sigma V_t dW_t$. This type of evolution is appropriate for situations where the variable evolves stochastically around the long run average $\bar{V}$. There are others possibilities to model the mean reversion. It is a well known fact in finance that commodity prices typically follow this type of process. If the value of a project is roughly linked to the process product price, the process for $V$ would be a mean-reverting one in the case of a commodity. In this point we are following the same argument as in McDonald (2000) who mentioned that is plausible to think of the $NPV$ evolving as a mean-reverting process (for natural resources projects, for example). We adopted the same type of mean-reversion described in Schwartz (1997), to model the value of a project of the commodity industry.\(^3\) Let $V$ be given by

$$dV_t = k(\theta - \ln V_t)dt + \sigma V_t dW_t, \quad (6)$$

where $k$ is the speed of reversion, $\theta$ is the logarithm of the long term value of $V$ ($\theta = \ln \bar{V}$), $\sigma$ is the volatility of $V$ and $dW_t$ is the increment of the standard Wiener process. To make calculations easier we write $Z_t = \ln V_t$ and using Ito’s lemma we get a more tractable expression related to the value of the project

$$dZ_t = k(\delta - Z_t)dt + \sigma V_t dW_t, \quad (7)$$

where $\delta = \theta - \frac{\sigma^2}{2}$. Now we are going to evaluate the benefit related to the timing option as before. The value of the benefit of having cash and investing in the project at any time before maturity is given by equation (2). We are facing the problem of calculating the american and european options for the process considered in equation (6). We used the LSM algorithm to calculate the american option.

\(^3\)One can choose another type of mean-reversion process (see Dixit and Pindyck (1994)). Our choice was based on the fact that this type is well known in the finance literature, see also Clewlow and Strickland (2000) and Eydeland and Wolyniec (2002). It is obvious that the conclusions of this study are fundamentally attached to the hypothesis we used.
and simple Monte-Carlo simulation for the case of the European option. All the paths were generated in the equivalent martingale measure. To change equation (7) to the martingale measure it is necessary to introduce the market price of risk for $V(\lambda_V)$ to obtain $dZ_t = k(\delta^* - Z_t)dt + \sigma_V d\tilde{W}_V$, where $\delta^* = \delta - \lambda_V$ and $d\tilde{W}_V$ is the increment of the standard Wiener process in the equivalent martingale measure (Schwartz, 1997, see). Figure 2 is the result of the simulation.

Figure 2
Timing benefit

The benefit increases as the volatility $\sigma_V$ decreases and as the loss rate for waiting increases. We used the same values as before, i.e. $V_0 = 100$, $K = 90$, $r = 0.08$, $T = 0.25$, $k = 2$, $\lambda_V = 0.02$ and $\theta = 4.45$. Here we emphasize that we followed the directions in the original work of Cossin and Hricko (2004) regarding the use of parameters. We did not calibrate the processes previously. The main purpose of this study is far from being used for practical purposes at this stage. The main goal is to analyze according to this new methodology an old problem in finance. For practical issues we firmly recommend the calibration of stochastic processes as a first step. On the other hand, even adopting theoretical parameters, we believe that we can have useful insights in how much cash a firm should maintain. One can observe that for a loss rate of 25% and volatility of 35% the benefit

In this work, for the LSM and Monte-Carlo simulations, we used ten thousand paths without antithetic variables. For the LSM algorithm we used standard polynomials and also the Laguerre polynomials, in both cases they are of second degree. The results when we changed the type of polynomial are similar, which is in accordance with Longstaff and Schwartz’s result.
is approximately $5.5. This is a significant value compared, for example, to the NPV of the project, of $10 if immediately undertaken. We conducted sensitivity analysis with the speed of mean-reversion k and the result follows in subsection 3.3.

3.2 The underpricing avoidance benefit

If the firm decides to issue securities we have seen that there is a possibility of doing it when its shares are undervalued. Despite this fact, raising funds to invest in the project can be worthwhile. It depends on how robust the project is. Nonetheless, there is an advantage of having cash and avoiding raising capital. The previous modeling established that the amount of undervaluation $X$ follows a mean-reverting process. Now we are going to consider the case where the firm is in an emerging economy. In this situation, the firm is in a more volatile environment. For example, a foreign crisis in equity markets could cause a contagion in the country where the firm is based. And in general this effect is amplified in an emerging economy, making the economic environment more volatile. Another situation is an internal crisis, and in this case capital withdraws from the emerging economy. This movement of capital is common in a global economy making the emerging markets more volatile than developed economies. Whatever the reason, the undervaluation process needs to capture this effect (increased volatility). In the finance literature (see Das (1998) among others) this is done in two ways: (i) considering that volatility is time-varying through GARCH (Generalized Autoregressive Conditional Heteroscedasticity) models or stochastic volatility models, (ii) considering the inclusion of jump components in the process. Furthermore one can consider both simultaneously. The second one makes the model more parsimonious. Here we are considering the introduction of a jump component in equation (3) to describe the $X$ evolution. Now the model is written as

$$
dX_t = a(b - X_t)dt + \sigma_X dW_t + Y dq_t
$$

(8)

where $Y$ is the magnitude of the jump and is given by $Y \sim N(\mu_J, \sigma_J^2)$. $\mu_J$ and $\sigma_J^2$ are the mean and variance of jump size, respectively. $dq_t$ represents the Poisson process with intensity parameter $\xi$. All others parameters in equation (8) were previously defined in equation (3). Also there is no correlation between the Poisson process with the diffusion process of $X$ nor with the diffusion of $V$. The correlation between $V$ and $X$ is given by $\rho dt = dW_V dW_X$.

The benefit of underpricing avoidance is given by equation (4). We need to calculate two european options: the first is based on equation (6) where the payoff is given by $\max(V_T - K, 0)$ and the second is the option with stochastic payoff based on equations (6) and (8) and given by $\max(V_T - K - X_T, 0)$. Both options were calculated using Monte-Carlo simulation considering the risk neutral measure. We considered that the risks related to the jump component (jump size and intensity) are completely diversified. Figure 3 presents the results.
The parameters in this simulation, for process $V$, are: $V_0 = 100$, $K = 90$, $r = 0.08$, $T = 0.25$, $k = 2$, $\lambda_V = 0.02$ and $\theta = 4.45$. In the $X$ process we used: $a = 0.2$, $b = 3$, $X_0 = 0$, $\sigma_X = 0.5$, $\mu_J = 0.9$, $\sigma_J = 0.6$ and $\xi = 0.5$. The correlation between both is $\rho = -0.2$. We can observe that the benefit of avoidance of issue of securities is much smaller than that resulting from the timing benefit. As the mean of jump size $\mu_J$ increases the benefit also increases. And the same is true for the intensity of jumps $\xi$; the sensitivity using the simulation confirmed these results. We observe the same behavior of the previous model in which the benefit decreases as the volatility $\sigma_V$ increases and the same for the loss rate for waiting. Comparing the processes of $X$ with jumps and without jumps (using the above figures) we conclude that the inclusion of jumps makes the option $c_{\text{under}}(T)$ less valuable and hence increases the benefit. So, having cash to avoid undervaluation risk seems more interesting in emerging economies than in the developed countries. Although this is an intuitive result it is worth mentioning that it is aligned with empirical findings. Almeida et al. (2004) studied the firm demand for liquidity. They developed a model to measure the cash flow sensitivity of cash using a large sample of manufacturing firms (the data encompasses the period between 1971 and 2000). They found that constrained firms will have a higher cash flow sensitivity than unconstrained firms since the former are more dependent on cash flow for investment. Also, the research of Pinkowitz et al. (2003) shows that

\[ \text{The variable } V \text{ decreases as } X \text{ increases, hence both processes are negatively correlated. In all sensitivity analysis we considered } \rho < 0. \]
firms in countries with more risk and with poor protection of investors’ rights hold more cash, and that the agency theory is prevalent in explaining such behavior.

### 3.3 The timing and underpricing avoidance benefits

The next step is to combine both benefits as done earlier. So the equation of the total benefit is given in equation (5). We have to evaluate the american option based on the dynamics given in equation (6) and the european option under the risk of underpricing which involves computing the dynamics given in equations (6) and (8). We proceeded with calculations as before and Figure 4 shows the results.

![Graph showing the timing and underpricing avoidance benefits](image)

**Figure 4**
The timing and underpricing avoidance benefits

As expected, given the magnitude of these two types of benefits, the result is almost the same as that presented in Figure 2. The benefit decreases with the volatility and increases with the loss rate for waiting to invest. We proceeded with sensitivity analysis for parameter $k$ (speed of reversion) in process $V$. We observed that as $k$ increases the overall benefit decreases.

### 3.4 Portfolio analysis

We are going to analyze a situation where a firm does not have only one project, but a portfolio. For practical reasons let us consider two different projects. Project one has value $V_1$ and its dynamics are given by
\[
\frac{dV_1}{V_1} = k_1(\theta_1 - \ln V_1)dt + \sigma_{V_1} dW_{V_1}
\]

Project two has a similar dynamic given by

\[
\frac{dV_2}{V_2} = k_2(\theta_2 - \ln V_2)dt + \sigma_{V_2} dW_{V_2}
\]

Both projects are correlated to \(X\): \(\rho_1 dt = dW_{V_1} dW_X\), and \(\rho_2 dt = dW_{V_2} dW_X\). There is no correlation between the diffusion in equation (9) and the jump process in equation (8). The same is valid for equation (10). It is worth noting that, although correlated through Brownians, these two projects are physically independent. This means that they can be undertaken simultaneously, i.e. labor and equipment are not shared between them. In Figure 5 we have the result of the overall benefit, which is the timing and underpricing avoidance benefits for the portfolio. The calculations were done as before and the parameters for both projects are: \(V_{10} = 100\), \(K_1 = 90\), \(k_1 = 2\), \(\lambda_{V_1} = 0.02\), \(\theta_1 = 4.45\) and \(V_{20} = 80\), \(K_2 = 60\), \(k_2 = 2\), \(\lambda_{V_2} = 0.03\) and \(\theta_2 = 4.09\).

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure5.png}
\caption{Overall benefit for the portfolio}
\end{figure}

If the portfolio is undertaken now, the \(NPV\) is $30. Considering the volatility in both projects to be 35% and a rate loss of waiting equal to 30% we get a total benefit of approximately $18, which is a significant amount compared to the project \(NPV\).
4. Conclusion

In this paper we evaluated the benefits of holding cash for a commodity producer firm in an emerging economy through Real Options analysis. First we analyzed the Cossin and Hricko (2004) model through numerical procedures (using the same parameters) and got similar results. Then we extended their model by incorporating the considerations of a commodity producer in an emerging economy. We modeled the dynamics for the project value (for a commodity producer firm) as a mean-reverting process. On the other hand, the risk of raising funds when the firm’s securities are undervalued is increased in an emerging economy. For this reason we added a jump process in the amount that represents the undervaluation dynamics. In all these frameworks we observed that the benefit is greater when the uncertainty in the economy is lesser (the same result that was achieved in the original article). This not so intuitive result comes from the fact that more uncertainty means more value for the option to wait. On the other hand modeling investment as stochastic would mitigate this result. We used a fixed investment. The parameters used in the jump process, that amplify the undervaluation, behaved as expected: (i) the higher the jump size means the higher the benefit, (ii) the same for the jump intensity. Also, a firm within an emerging economy should have a greater benefit of holding cash compared to one in a developed economy. There are empirical evidences for this fact in Almeida et al. (2004) and Pinkowitz et al. (2003). Finally, we analyzed a more practical issue of the benefit a firm has from financing a portfolio of projects with cash. One can observe that the timing benefit is much higher than the underpricing avoidance benefit. The directions for future research follow as (i) considering the optimal time to invest, which is an important task in the Real Options framework that was not taken into account, (ii) modeling the investment as stochastic would lead to a less counterintuitive results, (iii) calibrating the stochastic processes for practical purposes.

References


