Microgeneration of Solar Photovoltaic Energy in a Forest Nursery: Real Options Approach

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Abstract: Photovoltaic solar energy presents itself as an alternative to the growing demand for electricity because it is a sustainable energy source. However, in Brazil, investment projects with this technology can be considered incipient, so they are under uncertain conditions. Therefore, we analyze whether microgeneration of photovoltaic solar energy for a forest nursery through the Real Options Approach (ROA) is economically viable. The forest nursery is located in the state of São Paulo, Brazil, characterized as sectorized with installed production capacity for 30 million seedlings per year of the *Eucalyptus* genus, which consumes approximately 200 thousand kW of electric energy annually. The capital expenditure for the installation of the system included 422 photovoltaic panels and 8 Grid-Tie inverters, therefore, the investment was USD 99,073. We built a dynamic evaluation model in which we incorporated options to defer the capital expenditure, expand the nursery energy coverage by 25% in the 5th year, abandon or continue the investment project. The traditional net present value, discounted at the weighted average cost of capital of 6.56% per year, was USD 119,352. Then, executing the Monte Carlo simulation, a volatility of 0.75 was obtained. Finally, an expanded net present value of USD 159,274 was obtained. It was concluded that the installation of photovoltaic solar energy for microgeneration of photovoltaic energy in the forest nursery is an economically viable option and the exercise of the combined real options increases the value of the investment project by 74.94%.

Keywords: *Eucalyptus*, sustainable energy, economic viability, forestry, managerial flexibility.

1. Introduction

The demand for the development of quality seedlings in forest nurseries encourages the use of new technologies in their production system. In this perspective, solar photovoltaic energy stands out because it is considered a clean, abundant, and renewable source. Bhattacharya et al. (2014) emphasize that due to the increased use of this energy source, there is growing interest in understanding its economic viability.

However, Kim and Park (2017) emphasize that traditional economic evaluation is not suitable for supporting decision-making regarding investments, especially, in renewable energy because it does not consider volatility and flexibility. Therefore, to capture volatility and compute managerial flexibility, Trigeorgis and Tsekrekos (2018) propose the use of the Real Option Approach (ROA).

ROA allows estimating and representing the value of flexibility, risk management, and uncertainty of an investment project (ANDALIB et al., 2018). Therefore, it is able to assist decision makers as new information becomes available (KIM et al., 2017).

According to Brandão et al. (2012) one of the main parameters in modeling decisions in embedded option investments is project volatility. The consideration of volatility in the energy market is of utmost importance, given its intermittent nature and environmental factors (WANG et al. 2018).

In order to foster consumer market growth to solar photovoltaic energy, the disclosure of cost estimates and associated benefits is important (RELLA, 2017). That said, we analyze whether microgeneration of solar photovoltaic energy for a forest nursery through the Real Option approach is economically viable.

2. Methods

The study was based on technical-economic coefficients of a forest nursery located in the Midwest region of the state of São Paulo, whose main activity is the production of exotic seedlings of the genus Eucalyptus.

The nursery production considered was between 15 and 18 million Eucalyptus seedlings per year, however, the installed capacity was for 30 million seedlings per year. The average annual electricity demanded for the current production was 200,000 Kwh, based on the amount of electricity consumed during a 12 month period.

Therefore, the quantity of 422 photovoltaic panels and 8 Grid-Tie inverters were dimensioned. In view of this, the Capital Expenditure (CAPEX) demanded for the acquisition of the photovoltaic panels and inverters was USD 99,073, with average depreciation values of USD 146 and USD 4,649, respectively.

2.1. Cash flow of the investment project

The cash flow was projected for a twenty-five-year horizon, determined by the useful life of the equipment. In view of this, the expenses for the acquisition of this equipment and revenue through electricity savings were weighted. Therefore, the opportunity cost of the investment project was estimated using the Weighted Avarage Cost of Capital (WACC) methodology according to Miranda et al. (2017).

2.2. Asset modeling

The estimation of the future volatility of the investment projects' value was by simulating the Monte Carlo method, with the assistance of the software @Risk Copyright © 2020 Palisade Corporation (PALISADE, 2020), which allowed the generation of 100,000 pseudo-random numbers, resulting in a probabilistic present value, according to Brandão et al. (2005).

Accordingly, the asset was modeled following a binomial tree model developed by Cox, Ross, and Rubinstein (1979), using the dynamic programming software Decision Programming Language (DPL), Copyright © 2020 Syncopation Software (SYNCOPATION, 2020).

After modeling the underlying asset, we considered the deferral regime of the initial investment from year 0 to year 1, for effective project implementation. Similarly, we considered the option of expanding 25% of the energy coverage of the forest nursery at the end of year 5 and consider the option of abandoning the investment project in years 10 or 20, because in unfavorable market conditions, losses would be incurred with its continuity.

3. Results

In order to update to the focal date, the cash flows of the investment project, a spread of 2.40% was weighted, which allowed estimating the cost of third-party capital of 7.73%. Using the risk-free rate of 5.33%, the systematic market risk of 3.61%, and the country risk of 4.01%, the cost of equity capital of 8.49% was obtained. Finally, the opportunity cost rate resulted in 6.56%. Therefore, a traditional net present value of $119,352 was obtained.

When considering ROA, a volatility of 0.75 was determined with return values after Monte Carlo simulation (Figure 1). It is worth noting that the volatility of the investment project exceeded 50%, which reflected a project under risky conditions, and thus became a determining factor in its weighting in the forecasts.

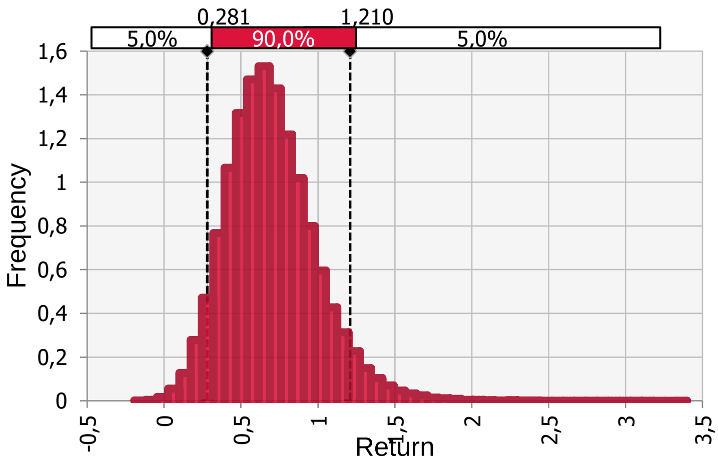

Figure 1 - Return on investment project.

Thus, knowing the net present value obtained using the traditional method of investment appraisal and knowing the option value of the project, the expanded net present value was obtained and was USD 159,274.

As observed in Pringles et al. (2020) and in agreement with this project, the use of ROA in solar PV was able to add value to the investment since it incorporates project uncertainties, volatility, and managerial flexibility for forest managers.

Therefore, with the generation of the optimal investment project policy (Figure 3), it was observed that the options of deferral in year 0 and investment in year 1 occurred in 100% of the cases. Similarly, the option to continue with the investment project, tested in Year 5, returned a probability of 100% occurrence, followed by 0% expansion. However, in Year 10, the probability of continuing with the investment project was 26%, with a 74% chance of abandonment.

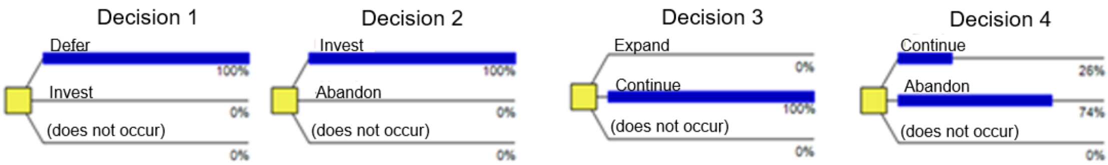

Figure 1 - Optimal Policy Tree.

Furthermore, it was possible to observe that, as a result of the concatenation of options, the volatility of the investment project directly impacts the increase in the expected present value (Figure 4). Zhang et al. (2020) complement the importance of observing the volatility spectrum, as it becomes possible to reflect on the circumstances that investors are likely to accept during the investment period.

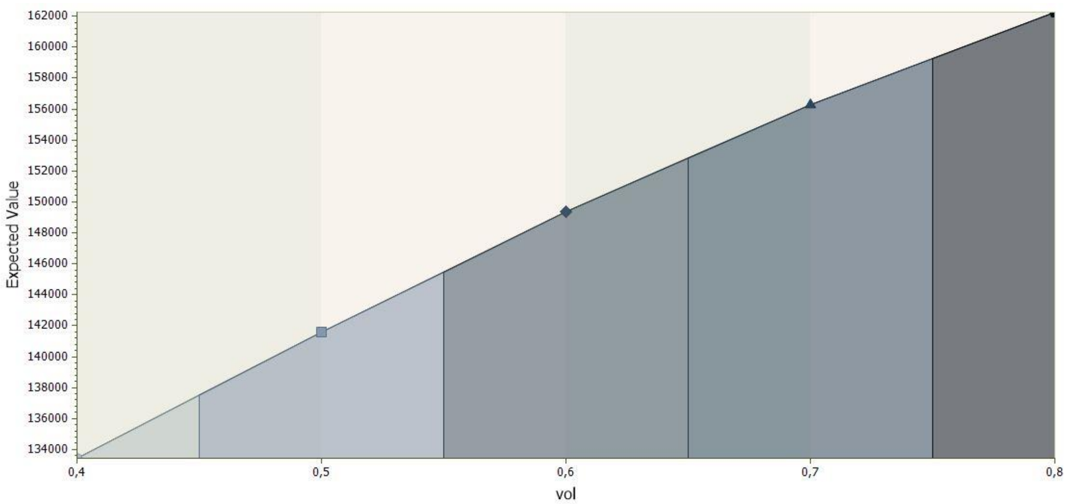

Figure 4 - Expanded present value of the investment project as a function of volatility.

4. Conclusions

The installation of a photovoltaic system to generate electricity in a forest nursery adds value to the investment project through the Real Options Analysis.

The exercise of the combined real options increases the value of the investment project by 74.94% when compared to the traditional investment evaluation method.

The optimal investment decision using the combined options suggests 100% for the expansion of the investment project in the fifth year of the investment project's life.

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