Investments in Pinus elliottii Engelm. Plantations

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Investment projects in Pinus elliotti plantations that contemplate the land purchase analyzed through the real options analysis present higher financial returns than those that consider land lease, inverting the result provided by the traditional analysis.

biological assets | managerial flexibility | forest management | binomial model | silvicultural practices | net present value

1. Introduction

The forest plantations require important financial contributions because they are being long-term projects, usually under conditions of uncertainty, with managerial flexibilities that can be exercised over the useful life of the biological asset. In addition to the financial aspect, the forest plantations provide multiple ecosystem services like supporting (e.g., nutrient cycling), provisioning (e.g., wood and non-wood forest products, and fresh water production), regulating (e.g., local climate regulation, carbon sequestration and storage, and preventing soil erosion), and cultural (e.g., aesthetic values, recreation, and eco-tourism) when compared to previously deforested lands [1][2][3][4].

The planting of homogeneous forests has been increasing in order to meet the growing demand for wood in world markets [5]. In Brazil, the area of forest plantations totals 9.6 million hectares. Of this total, 19.0% represents *Pinus* spp., with 1.8 million hectares [6].

Forest management integrates silvicultural practices and business concepts, as economic alternatives, in order to better achieve the investor's objectives [7]. The analysis of a forest investment involves the use of techniques and criteria that compare costs and revenues inherent to the project, aiming to verify whether or not it should be implemented [8].

The commonly used methods for the financial evaluation of forest investment projects are those based on performance metrics, among which is net present value (NPV). However, NPV does not incorporate uncertainties and ignores the value related to flexibility, that is, management is not able to adapt and review decisions in response to changes in market conditions [9][10][11]. The forest investment projects have a higher cost in the first months of planting and revenues, in general, occur at the end of their useful life. Traditional methods of financial

evaluation do not provide the necessary flexibility in the face of inherent uncertainties of the forest sector and can present an obstacle to new business [12].

The price of wood, for example, has associated uncertainties that culminate in price fluctuations mainly due to the volatility of wood demand in the forest sector [13]. Reliable price and wood production estimates, as well as the calculation of criteria that include uncertainty, are necessary to make the decision-making process more robust [14]. The stochastic methods of investment analysis contemplate investors with possibilities that add value to the project, exploring uncertainties and, consequently, managerial flexibilities.

When considering managerial flexibility, managers can better evaluate project alternatives and allocate capital resources more efficiently [15]. The value of flexibility allows the decision-maker to decide what to do after some of the uncertainties related to the future are at least partially resolved [16][17][18].

The real options analysis makes it possible to capture the value of managerial flexibilities in investment projects [19][20][21][22] by means of options available throughout the life of the project, increasing its value and return. This is possible when management uses real options as a way to limit possible losses and enhance or protect positive results [23][24][25] in environments with irreversibility and uncertainties, like the forest sector [26][27][28][29][30].

A real option is a right, not an obligation, to execute a particular investment project or to make certain decisions in more advanced stages of the project [25][31][32][33] at a predetermined cost called the exercise price of the option. The real value of an investment project can be assessed by combining the value provided by real options of this investment with the value of the result of traditional static NPV [34][35]. However, as real options are usually not traded in the market, each one is exclusively defined by its context and needs a personalized assessment [36].

2. Current Insights

2.1. Deterministic Ecoomic Model

The present value of the land lease project was USD 723, which when added to the project's CAPEX resulted in a traditional NPV of USD 371. Likewise, the present value of the project that included land purchase was USD 4083, and the NPV was -USD 610.

The investment project with the land lease was viable. However, the investment project with the land purchase was not viable, as the NPV was less than zero since disbursements were not recovered over the life of the project and managers only decide to invest if the project creates value, that is, if the NPV is positive. Therefore, by the traditional analysis of investment based on discounted cash flow, the project with land purchase would be neglected and an investor would look for alternatives with a positive NPV to allocate his capital.

Although the project with the land lease was feasible, it presented a lower present value compared to the project with land purchase, as the annual expenditures were higher due to the cost of the land lease. On the other hand,

even with a higher present value, the project with land purchase had a lower NPV since its CAPEX, due to the acquisition of land, was considerably higher than the project with the land lease.

It is noteworthy that a traditional NPV ends to undervalue the value of an investment project, and this makes it unsuitable for risky projects [37][38] and with long planning horizons, as is the case of *Pinus elliottii* plantations. Thus, when accepting or rejecting investment projects based only on current information and not considering future uncertainties [39][40], inherent in the forest sector, the NPV did not reflect the potential value of the investment projects analyzed.

These weaknesses related mainly to the non-approach to flexibility by the traditional model which can cause inaccurate estimates regarding value generated by cash flows and, consequently, can lead to a devaluation of investment projects [41][42][43].

Thus, the investment project with land purchase should not be immediately discarded, since the value related to managerial flexibility should be accounted for and added to the deterministic value of the project. With this, the manager would have information with values that better represent the potential of projects and, consequently, could make the best decision on whether or not to invest in the projects presented.

2.2. Stochastic Model

In econometric tests for the analysis of the stochastic process, the null hypothesis of normality of data was accepted with a *p*-value of 0.49, 0.60, and 0.14 for the price historical series of resin, thinning, and clearcutting standing trees, respectively. The null hypothesis that the price series had no trend was rejected, with a *p*-value of less than 0.05 for the three price series. The null hypothesis that the series had a unit root was rejected, so the price series were non-stationary.

In addition, with the linear regression test, the authors found that the price was significantly influenced by the price of the exactly previous period. The null hypothesis that residues had a normal distribution was accepted, with a *p*-value of 0.36, 0.57, and 0.26, for the price of resin, thinning, and clearcutting standing trees, respectively.

Thus, the main characteristics of GBM could be observed in the historical price series analyzed, which supported the choice of GBM as the stochastic process in the price modeling of uncertainties considered in investment projects. The authors obtained through the MCS the values of 91.25% and 79.87% for the volatility (σ) of the investment project for land purchase and land lease, respectively.

When the authors conditioned the expectations of the present values from the second to the twenty-first year, the volatility of the projects was characterized by the standard deviation, a measure of dispersion, of the returns of the first year considering the expected values of the following years. From this, the volatility was considered constant throughout the life of the project.

When executing the model with the deferral option, the land lease project showed appreciation, becoming more attractive than the deterministic model when presenting higher ENPV. The land purchase project, previously considered unfeasible because it had an NPV inferior to zero, became viable with the value added by option, since the ENPV was positive.

Thus, the premium for the deferral option was higher for the land purchase project and, consequently, the percentage valuation and ENPV were greater. The volatility of the project with purchased land was greater, and according to [44], with increased uncertainty, the option to defer becomes more valuable. This happens because that uncertainty generates a risk premium for waiting to obtain more information, which is the value of the option to defer. According to the authors of [45], this relationship shows that a higher level of uncertainty results in a higher value of deferral option.

In the execution of the binomial model, both investment projects would not be implemented immediately. The option to defer would be exercised, which would postpone the decision to invest for year two of the binomial tree, that is, within the term of the option's maturity.

When designing an investment, its feasibility will depend on the planning and analysis of financial impacts. When solving expected cash inflows and outflows, it is expected that a well-informed forest manager has an awareness of market risks and fluctuations in projected profitability.

Incorporating the real options analysis into forest investment projects promotes the investor's perception of risk and managerial flexibility by strategically guiding decision-making. Negotiating the right of deferral does not necessarily impose on the forest manager, when the project is implemented, its feasibility, but rather configures a perspective of opportunity for, if feasible at the time, its assimilation.

The deferral option concatenated to the underlying asset modeled the implementation of the project, aiming to improve profitability by postponing the investment until, according to [46], the emergence of favorable market conditions. Essential in conducting uncertain scenarios, this option provides high quality in management decisions [47][48].

In this period, the greatest probability would be that an investment should occur for the land lease project, mainly because the project already has a positive NPV. On the other hand, the greatest probability would be that the option was expired, and no investment occurred in the project with land purchase. As the uncertainty increases, the probability of the project being implemented at that moment decreases [49].

In relation to the land lease investment project, the expansion option was one that added the most value and, consequently, made the project more attractive. The expansion option was one that least contributed to the valuation of the project with land purchase. Despite this, the option added value and made the project viable, as the ENPV was greater than zero

The option to expand the project should only be exercised when the market presents favorable conditions, which allows a greater investment to increase production [50][51]. Thus, the real probability of exercising the expansion option demonstrated that projects should be expanded only in the best scenarios

In the project with land purchase, the low probability of exercising the option to expand (8%) explained why valuation was lower compared to the other options. When indicating non-expansion, it means that the present value of the project's expected cash flows, if expanded, would not exceed the additional disbursement needed to finance the expansion [52]. This means that when the project has a negative value, it does not obtain any value from the option to expand.

With the expansion option, the forest manager has to allocate a budget to increase link capacities, assuming some cost function with a capacity parameter [53]. The overall costs of expanding capacity are therefore given by the sum of the investment costs. However, as with deferral, managers have the option, but not the obligation, to expand if conditions prove favorable, considering inclusively a management problem due to different cutting and harvesting times.

The abandonment option was one that added the most value to the project with land purchase. As the abandonment option is more valuable when residual value is more attractive [54], this higher valuation in the project with land purchase occurred due to the cost of land purchase being recovered when abandoning the project if the scenario was not favorable. On the other hand, the amount spent on leasing land would not recover if the project was abandoned, that is, it was an irreversible cost.

Another reason was the fact that the project with land purchase showed greater volatility. According to the authors of [55], the abandonment option has a more considerable value the greater the uncertainty about the project.

An abandonment option is only exercised if the gain is greater than the present value of expected cash flows until the end of the investment project's useful life [52]. Thus, real probabilities of the abandonment option being exercised were considerably higher for both investment projects, which demonstrated that, with greater probability, the value generated by projects' cash flows did not exceed the value of abandoning them.

The value of combined options corresponded to 83% and 72% of the sum of the values of individual options for the projects with lease and purchase of land, respectively. Therefore, the value of the combined options was less than the sum of the values for individual options. According to the authors of [35], the value of multiple options does not normally equal the sum of the same options analyzed individually, as the interactions between the options can be negative or positive and do not occur in a linear way. In addition, interactions depend on a combination of factors, such as type of options (buy or sell), and time separation of their respective exercise dates, among others [56]. Thus, it is imprudent to simply add the values of each real option [57], as the results showed that the interaction between the options analyzed occurred in a negative way.

Although the option values cannot be merely added together, the flexibility of combined options can be significant [58]. When analyzing the three real options together in the model, the options' value was higher when compared to the real options' value analyzed individually. With a greater number of choices available through multiple combined real options, managerial flexibility provided to the manager was more expressive [59][60], as shown by the modeling results. Consequently, with more choices available, it was possible to add greater value to the projects, and in effect, increase their attractiveness.

In this way, as well as in the individual options, the project with land purchase was considered viable when it applied the three real options in a combined way. This showed that the value of managerial flexibility, provided by the options' premium, was responsible for the viability of the project with the land purchase, since this occurred only with the value of the ENPV which represents the stochastic analysis approach.

According to the authors of [61], the flexibility generated by the evaluation model with all the combined options provides a more accurate estimate of the real value of the project as to the isolated options. Thus, the combined options performed better when analyzing investment projects, in which the value of the combined options was equivalent to 35% of the present value of the project with flexibility with land lease, and 51% with land purchase.

Although the project with the land lease was 100% likely to be executed and the project with land purchase was 54%, the percentage increase in value from the traditional NPV to ENPV was considerably higher for the project with land purchase .

Therefore, it is possible to affirm that real options had a better influence on the project with land purchase, since it presented a higher traditional present value and volatility, in addition to offering a greater residual value in case of abandonment. Considering the option of abandonment in a planning horizon makes forest managers develop flexible strategies, acting proactively against the uncertainty that impacts investment over the projected horizon.

Managing through the real options analysis means effectively exercising its options, which, in real contexts, are already related without prior planning. Anticipating in the perspective of options trading promotes the redemption of the option premium when the abandonment has the benefit of interrupting operational loss flows, which can be aggravated over time. Even so, maybe after a few years, the market situation could be more favorable again. With strategic alignment, abandonment can be optimized by a temporary stop, until negative flows can be reversed. As they are empirical tasks, the assimilation of the real options analysis needs to be dynamically validated in the provisioning and strategic adequacy exercises.

Thus, although both investment projects are viable in the dynamic model when applying the real options for investment in *Pinus elliottii* plantations, it is advantageous to choose the project that contemplates the purchase of land, since the ENPV was superior.

As the real options analysis provides a theoretical framework for understanding the impact of uncertainty on irreversible investment [45], the volatility of the project performs a fundamental role in the behavior of value added by the options. That way, it was possible to verify the sensitivity of the real options' values as to the volatility variation of the project with lease and land purchase.

In this way, real options associate uncertainty with flexibility and consider that volatility is the potential value-adding factor to the project [29], as the option values are directly linked to the volatility of underlying asset values [62]. Therefore, real options are favorable in environments with irreversibility and uncertainty [26], characteristics present in investment projects in *Pinus elliottii* plantations.

By demonstrating that the use of managerial flexibility added value to investment projects and made them more attractive, the application of real options may be of interest to the forest sector. Thus, this research indicates an understanding of the managerial flexibility role and the structure of the real options analysis as a tool capable of providing the potential value of investment projects in *Pinus* spp. plantations.

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