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RESEARCH ARTICLE

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ARE FINTECHS WORTH INVESTING? CASE STUDY FOR STARTUP USING REAL OPTION THEORY

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ABSTRACT

Investments in startups have grown significantly in recent years. From the investor's point of view, startups are very attractive due to their great potential for growth. However, as they are highly innovative and early-stage companies, the low data availability makes it difficult to properly analyze and make strategical investment decisions and risk management. Those factors make traditional methods of valuing companies, such as Discounted Cash Flow analysis, insufficient. In this context, Real Options Theory emerges as an important method for evaluative purposes, especially the Integrated Method for Option Evaluation, alleviating the uncertainties and subjectivities involved in the process. This article describes the application of this method to a new *fintech* company. Our results showed that the optimal investment alternative, given the investor's risk tolerance profile, is to make an initial investmentto test the firm's viability and then make subsequent investments in a phased approach.

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INTRODUÇÃO

A startup, according to the Brazilian Startup Association (2015), is defined as "a technology-based company with a repeatable and scalable business model, which has elements of innovation, and operates under conditions of extreme uncertainty". According to Corder and Salles-Filho (2006, p. 37) "venture capital is a financing mechanism that proposes to finance innovation and, in this sense, differs from traditional finance options". Typical characteristics of startups include the high-risk nature of the business, coupled with the difficulty in securing loans from the financial market. As a result, financing does not normally involve banks but venture capital instead (Chorev, 2006). Startup founders do not seek debt-generating financing, but rather investors who want to participate in the business, due to the perceived attractiveness of the company (Colombo, 2002).
According to the Brazilian Association of Private Equity and Venture Capital ABVCAP (2014), the national market has seen remarkable contributions from angel investors, these being autonomous individuals who choose to invest their own financial resources into private companies (Osnabrugge, 2000; Bacher & Guild, 1996).The low survival rate for this type of company has been statistically demonstrated time and again (Arruda et al. 2014), as they are typically short-lived.

For Rencher (2012), startups will normally undergo a period known as the "Valley of Death", which is the period between the creation of the company and the moment when its cash flow becomes positive. Venture capital is one of the main contributing factors in aiding the company to cross this threshold. Among the traditional methods for business valuation, the most widely used is the Discounted Cash Flow method (DCF), which assumes that investment planning will be followed without considering any potential unforeseen events. However, a better approach should incorporate all of the uncertainties inherent to the business (Minardi, 2000). Similarly, Hartam and Hassam (2006) have indicated the Real Options appraisal model as being the most recommended when evaluating high-risk projects or companies. As a result, this paper will apply the Real Options framework as the main analysis tool, considering the investor's tolerance for risk. In this way, the objective of this study is to identify, from a financial viewpoint, the best alternative among investment decisions for a startup. To this end, a company valuation method is applied in order to support the investment decision, and to simulate the decision-making process, considering both market variations and an investor's risk tolerance. This article consists of, in addition to this section, the second section, which presents the existing definitions for startups and their funding cycle. The third section presents the study's methodology, while the fourth section describes the target company of the case study. The fifth section deals with the application of the evaluation method along with the resulting data analysis and describes its results. Lastly, the conclusion of the study is described in detail.

RELATED LITERATURE

Real options theory incorporates managerial flexibility by allowing the possibility of investment opportunities taking into account future uncertainties, which are treated as static in traditional techniques such as net present value (NPV). In this way, the real options approach provides a more realistic picture to conduct the valuation of investment projects and corporate strategies (Kulatilaka and Marks, 1988). The classic work of Quigg (1993) indicated the existence of an opportunity cost to invest, favoring the use of pricing models based on real options. Analogously, the recent paper by Chi et al (2019) discussed the application of real options theory in international businesses and summarized the main contributions of this theoretical approach is three main points: the strategic definition of the timing and scale of entering/exiting the market, the operational definition of governance structures, and the functional analysis of multinational networks. For a compendium of recent scientific studies on real options theory and its applications in finance and corporate decision-making, see Trigeorgis and Reuer (2017) and Trigeorgis and Tsekrekos (2018). The empirical application of this paper are startups, specifically fintechs (startups focused on financial services and innovative technologies, hence the name). The main definitions for a startup are described in Table 1:

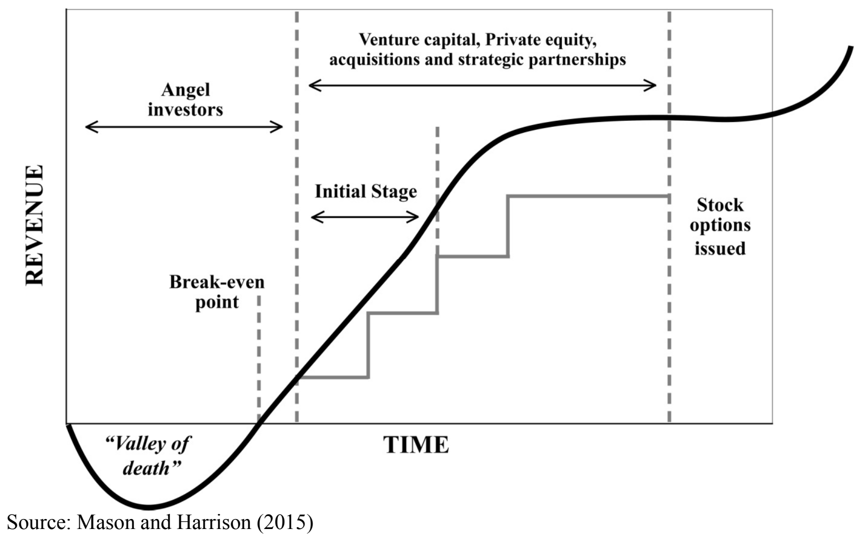
evaluated period. Another financing source is venture capital, which is a temporary investment mechanism available to emerging companies with clear growth potential. In Brazil, there was a 50% growth in venture capital investments in startups from 2010 to 2016 (Tunguz, 2017).From the investor's perspective, venture capital investments are considered as being high-risk due to their low liquidity, as any divestments are usually not possible at fair market price, in addition to the appreciation risks that are typical for startups (Meirelles, Pimenta Junior & Rebelatto, 2008). These venture capital alternatives are intrinsically related to the startups' financing cycle. Mason and Harrison (2015) approach this relationship through the concept of the "financing escalator", which observes that as a first step, the company will typically search for investor capital within the "FFF" (Family, Friends, and Founders) environment. After this step, angel investors are sought, followed by other venture capital and private equity sources.

Ultimately, shares are issued on the stock exchange via an IPO (Initial Public Offering). This investment flow is structured as shown in Figure 1. Lee and Shin (2018) discussed the role of Fintechs in a broader management paradigm regarding innovative technologies, emphasizing the advantages of applying real options theory in investment decisions on this new segment, as well as challenges involved in this kind of startups. Particularly concerning Fintechs, empirical applications of real options theory include studies such as Wibowo and Fujiwara (2016), which analyzed the survival of supply chain startups in the Indonesian market.

Table 1. Startup definition examples

Reference	*Startup* definition
Longhi (2011, p. 1)	"Startups are small-scale, home-based, or college-based businesses, which receive small capital contributions. They exploit innovative areas of a particular sector (most commonly technology), having a very high growth rate in their first few months of existence, due to investments made by specialized investment funds. "
Taborda (2006, p. 6)	"It is a company which is still in its embryonic stages, usually in the process of implementing and organizing its operations. It may not have begun marketing its products or services, but it is already operational, or at least in the final stages of setting up its internal process. "
Ries (2011, p. 4)	"A startup is a human institution designed to create new products and services under conditions of extreme uncertainty."
Gomes *et al.* (2012, p. 422)	"It is comprised of a group of people looking for an innovative, scalable, low-cost, fast-growing business model, that can generate significant revenue in a short timeframe."

Note: Source: elaborated by the authors



Source: Mason and Harrison (2015)

Figure 1. Financing cycle for startups

The "Entrepreneurship in Brazil" report, elaborated by Global Entrepreneurship Monitor in 2015, indicated that Brazil presents entrepreneurship rates that surpassed all other BRICS countries, as well as the United States and Germany. Similarly, a survey from investment promotion entity Anjos do Brasil (2015) indicates that Brazil has seen growth in this type of investment, from R$ 450 million in 2011 to R$ 784 million in 2015, an increase of 74% in the

METHODOLOGY

Discounted Cash Flow (DCF): The work presents two valuation methods based on discounted future flows: the Discounted Cash Flow (DCF) and Real Options (RO) methods. The valuation of discounted cash flows can be defined as the process of valuing an investment by discounting its future cash flows (Kaplan, 2012). Given the fact that a startup company is at an early stage of its life cycle, it is understood that it will probably not be closed in the foreseeable future. Thus, the formula below represents the DCF approach for both before and after the period of explicit projection:

$$V = \sum_{i=1}^{n} \frac{E(FC)projection}{(1+k)^n} + \frac{E(FC)post-projction}{K-g} \quad (1)$$

Where:

E(FC) = cash flow equivalent;
K = cost of capital and g = growth rate.

As such, the DCF is composed of three basic points: (i) the expected cash flow projection E (FC); (ii) the estimated discount rate, or cost of capital, which reflects the risk assumed by the cash flow holder (K) and (iii) the expected growth rate (g) (Kaplan, 2012).

Real Options – RO: One of the main advantages of Real Options valuation is the fact that it takes into account factors such as volatility, investment timing, and management flexibility, which are all too common in many projects (Souza, Rocha & Souza, 2018). The Real Options Theory (ROT) is derived from the existing financial options theory (Bouchaud & Potters, 1999) and presents similar mechanics, though it aims to evaluate companies' business options (projects) (Riihimaki, 2007).Most importantly, ROT does not reject the DCF but complements it by adding the options' value. Therefore, according to Minardi (2000) and Trigeorgis (1995), this complementarity requires a rule for an expanded NPV that reflects both components: the traditional (passive or static) NPV, and the value of the option.

$$ExpandedNPV = Static(passive)NPV + Optionvalue \quad \text{.......(2)}$$

Among the methodologies for calculating Real Options, two stand out: the proposal by Black and Scholes (1973) and the proposal by Cox, Ross & Rubinstein (1979), which adopts an evaluation by means of a binomial decision tree. The methodology proposed by Black and Scholes (1973) concludes that the static NPV should be calculated using the DCF, while the option's value should be calculated using the following formulas:

$$C = S\phi(d_1) - Ke^{-rT}\Phi(d_2) \quad \text{................(3)}$$

$$d_1 = \frac{ln\left(\frac{S}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} \quad \text{...............(4)}$$

$$d_2 = \frac{ln\left(\frac{S}{K}\right) + \left(r - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T} \quad \text{................(5)}$$

Where

S = present value of expected future cash flows;
K = initial capital;
r = risk-free rate (opportunity cost);
t = time period for retaining the rights to the project;
ϕ = cumulative normal distribution function;
σ = the project's volatility;

The methodology proposed by Cox, Ross & Rubinstein (1979) incorporates decision tree analysis. In the decision tree step, the upward calculation is given by equation (6), and the downward calculation is given by equation (7), where $\vartheta 0$ is the asset's current value; σ is the volatility, and dt represents the time interval.

$$\vartheta_{up} = \vartheta_0 e^{\sigma\sqrt{dt}} \quad \text{................(6)}$$

$$\vartheta_{down} = \vartheta_0 e^{-\sigma\sqrt{dt}} \quad \text{................(7)}$$

The integrated option valuation method assumes that the investment decision maker has access to two types of investments: the project or a marketable asset, consisting of a portfolio of companies with similar characteristics, and a risk-free asset. The decision lies between two hypotheses, which maximizes the consumption's expected utility. Consumer preferences for consumption x(t) can be represented by an exponential utility function, given as:

$$U\big(x(0), x(1), \dots, x(T)\big) = -\sum_{t=0}^{T} k(t) exp\left(\frac{-x(t)}{\rho(t)}\right) \quad \text{........(8)}$$

Where p(t) represents the risk tolerance of the investor within period t, and k(t) represents the decision maker's time period preferences (Smith & McCardle, 1998). The integrated method combines the advantages of decision trees and financial options, aligning them to public and private risks. Public risk corresponds to the likelihood that the market will be favorable or unfavorable to business development in the coming years, by analyzing binomial trees (Luenberger, 1998). On the other hand, private risks are analyzed through subjective probabilities obtained through Monte Carlo simulations (Borison, 2005). Therefore, the integrated method provides for a separate analysis of the risks (public and private) involved in investment decision making. The private risks inherent in the business itself correspond to the last nodes of a decision tree, and so they are the first to be evaluated, due to the backward induction process.

Private Risks: In this article, two sources of private risk were determined. In the first hypothesis, the company might not obtain positive test results, and so its operations may be shut down, leading to a loss of all previous investments. The second risk is related to the likelihood of different market share possibilities. This risk will be quantified by means of Monte Carlo Normal Distribution simulations, resulting from a process of estimation and definition of subjective assumptions (Brás, 2015). In the integrated method, private risks are first analyzed by subjective estimates and assumptions. After this process, they are updated and positioned in the last nodes of the decision tree, by incorporating the investor's utility function. These steps replace the subjective values obtained by certainty equivalents, thus making the market complete. The certainty equivalents result from inverting the investor's utility function, by applying the following formula:

$$EC = \frac{-\rho(t)}{(1+r_f)^t} ln\left[p_1 exp\left(\frac{w_1}{\frac{-\rho(t)}{(1+r_f)^t}}\right) + p_2 exp\left(\frac{w_2}{\frac{-\rho(t)}{(1+r_f)^t}}\right) + \dots + p_n exp\left(\frac{w_n}{\frac{-\rho(t)}{(1+r_f)^t}}\right)\right] \quad \text{...........(9)}$$

Where p(n) (n = 1,2, ...) corresponds to the probability of the value obtained for cash flow in the nodes corresponding to the private risk assessment moment, ωn (n = 1,2, ...), r_f is the risk-free interest rate, and n corresponds to the number of different possible scenarios for the discounted cash flow (DCF) value.

Assumptions: Usually, this calculation involves the estimation and definition of assumptions for the following variables in the DCF: Revenues, Taxes, Costs, and Expenses, among others. Once the variables are defined, one must then estimate the growth rates for revenue, costs, and expenses. In order to do so, multiple linear regression is utilized to analyze companies from the same sector as the researched company. For the evaluated period, the effect over time of several macroeconomic factors on the observed growth rates is analyzed. Subsequently, the expected scenario from these factors is evaluated, in order to then estimate the growth rate for the cash flow's projected time period. Regarding market share, at least three scenarios that directly influence the projected cash flow should be defined. For projecting revenue, taxation, costs and expenses are estimated, and thus Monte Carlo simulations are applied in order to identify several cash flow possibilities. Once the cash flows are defined, public risks are analyzed via the backward induction process.

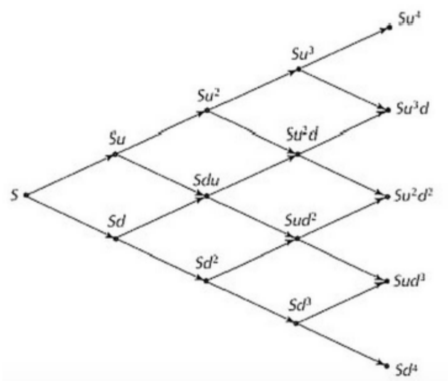
Public Risks: The objective of analyzing public risk is to measure whether market probabilities are seen as favorable or unfavorable to the company's development. According to Smith & McCardle (1998), this analysis must be in accordance with the assumptions of "free will" and a "partially complete" and efficient market. Public risk must be determined through binomial trees, which are built using two tradable assets: a risk-free asset and a replica asset. The latter is a portfolio of listed companies that offer a service similar to the company in question. The main objective of building this portfolio is to maximize the Sharpe Index for binomial tree construction. The Sharpe Index, created by William Sharpe, is a financial indicator that measures the surplus return of a financial investment relative to another risk-free application of the same investment. That is:

$$Max_{wi}SR = \frac{E(R_p)-R_f}{\sigma_p} \quad \text{…………(10)}$$

Subject to,

$$\sum_{i=1}^{n} w_i = 1 \quad \text{……………(11)}$$

Where, R_p corresponds to the portfolio's return, σp to the portfolio's standard deviation, Rf to the risk-free rate (in this case, the CDI index) and Wi to the weight of each company within the portfolio. Once the representation of each company within the portfolio is defined, it is possible to calculate its daily price, which is the base variable for public risk analysis. According to the binomial tree model, once the value of the investment at the period's beginning is known, the price of the next period is given as one of two possibilities defined as multiples of the price in the previous period: a multiple for up movements, or a multiple for a down movement (Brás, 2015). The general shape of the tree is as follows:



Source: Luenberger (1998)

Figure 2. Binomial Tree with 4 moments

Therefore, the following equations are utilized:

$$\upsilon_p = E[ln\left(\frac{S_t}{S_0}\right)] \quad \text{………………….(12)}$$

$$\sigma_p^2 = var[ln\left(\frac{S_t}{S_0}\right)] \quad \text{………………….(13)}$$

Where Vp represents the portfolio's growth rate and σ_p corresponds to its standard deviation. Moreover, the values for each movement are given as:

$$u = e^{\sigma_p\sqrt{t/n}} \quad \text{………………….(14)}$$

$$d = \frac{1}{u} \quad \text{………………….(15)}$$

$$p = \frac{e^{\vartheta p * t}-d}{u-d} \quad \text{………………….(16)}$$

Where *n* corresponds to the number of steps in the tree, *t* to the projected cash flow's time horizon, *u* to the up movement, *d* to the down movement, and *p* to the probabilities linked to each of these movements (market states).

CASE STUDY

The company which served as the target of this study is named Ligo, a *fintech* (or financial technology) peer-to-peer (P2P) startup, which offers personal loan services through more accessible, simplified, and innovative processes.In Brazil, the P2P fintech lending market is still in its infancy, and is currently composed of only six companies, as shown in Table 2.

Table 2. List of Brazilian P2P *Fintechs*

Fintech	Borrowing public
BIVA	Small and Medium Enterprises (SMEs)
IOUU.	Small and Medium Enterprises (SMEs) and Low-income, Nano Entrepreneurs
NEXOOS	Small and Medium Enterprises (SMEs)
MUTUAL	Small and Medium Enterprises (SMEs)
MEEMPRESTA	Individuals
KAVOD LENDING	Small and Medium Enterprises (SMEs)
TUTU DIGITAL	Small and Medium Enterprises (SMEs)

Note: Source: elaborated by the authors

Evidently, most of the companies are focused on lending to SMEs, rather than individuals. This is precisely the market gap that Ligo seeks to fill. Therefore, this study seeks to analyze the best investment alternative in Ligo, from the perspective of an investor. As the company is still in the R&D phase, it seeks an initial investment to carry out and complete the development of its products. The investment can be made immediately or in two distinct phases. The first phase of investments would be performed before testing the algorithms and servers, which takes approximately 1 year. The company requires R$ 136,000 for these initial activities. The total investment required for the company, considering a time horizon of 5 years, is presented in Table 3.

Table 3. Total required investments in a 5-year time horizon (in R$ thousands)

	Year 1	Year 2	Year 3	Year 4	Year 5
Total investment	136	30	100	15	0

Note: Source: elaborated by the authors

The investor, in this context, is presented with three alternatives: investing the full amount to complete the product's development; investing in the option, that is, in the first phase, and waiting for the test results in order to decide whether or not to continue with the investment and, lastly, do not invest in the company.

ANALYSIS AND RESULTS

The application of the integrated method of option evaluation involves segregating the analysis in three moments. Initially, the private risk is analyzed by estimating the company's cash flow and subsequently replaced by certainty equivalents. Next, the public risk was evaluated, by estimating the probability of the market being favorable or not to the service or product being provided by the company. Finally, the decision tree is assembled, and thus, through backward induction, the final result of the analysis is reached, represented by the best investment alternative.

Private Risk Analysis: Private risk is related to the possibility that the algorithm and servers will not function after the first year of testing, thus resulting in the company's project being abandoned. According to the company's developers and experts, the probability of negative test results is 25%, which is the probability applied in the next steps.The second private risk relates to the company's market share, as well as the 5-year time horizon for FCF (Free Cash Flows). Three variables are estimated: revenue, taxes, and costs and expenses.Once the FCF projections are defined, these projections are transformed into certainty equivalents, thus including the investor's assumptions and tolerance of risk, making the market complete.

Revenue: The projection of the cash flow revenue module, in the case of Ligo, involves three main variables: the average demand, the growth rate of demand, and the loan rates charged by the company. Through these variables, it is possible to calculate the company's gross revenue. To calculate demand, it was necessary to understand the value of the credit market in Brazil and how this market grows over the years. The Brazilian credit market for individuals granted R$ 1.874 trillion in 2017. The longest-running Brazilian lending P2P startups account for an average market share of approximately 0.002% of the sector. However, the credit market for individuals is influenced by several macroeconomic factors, such as the Brazilian GDP, the unemployment rate, the value of the dollar, and local index rates such as the IPCA, INPC, and Selic, among others. Thus, to estimate the variation of this market over the years, the correlation of each of these macroeconomic variables was evaluated against the market of credit granted to individuals in Brazil between 2013 and 2017. Subsequently, a linear regression was calculated, considering the variation in the credit market for individuals as a dependent variable, and the change in Brazilian GDP as the independent variable. Based on the projections for Brazil's GDP made by the local banks Itaú BBA and Bradesco, the regression model considers the growth rate of loans to individuals in Brazil, when projected over the 5-year time horizon, for two scenarios: a favorable and an unfavorable market. As Ligo is an upcoming company in the Brazilian credit market, it is assumed that it will not begin its operations possessing the same market share as established companies. Through probabilities and determined scenarios, the market share of similar companies with longer market times was estimated. The estimated scenarios and probabilities are shown in Table 4.

Table 4. Market share percentage growth evolution

	Year 1	Year 2	Year 3	Year 4	Year 5
Optimal scenario	5%	15%	37%	73%	100%
Intermediate scenario	3%	8%	18%	36%	60%
Worst-case scenario	1%	4%	13%	25%	40%

Note: Source: elaborated by the authors

The justification for these scenarios is directly related to the company's own characteristics. The best-case scenario is one in which the company achieves high growth in its market share already in the first 5 years. In addition, probabilities were assigned to the three scenarios (Table 5):

Table 5. Probabilities for each scenario in a favorable and unfavorable market

Situation	Optimal Scenario	Intermediate Scenario	Worst-case scenario
Favorable	25%	60%	15%
Unfavorable	5%	70%	25%

Note: Source: elaborated by the authors

From the data of the national personal credit market, its growth over the years, and the estimated market share for the company, it is then possible to calculate the startup's average lending demand and its standard deviation (Table 6):

Table 6. Credit evolution - average and standard deviation in favorable and unfavorable markets

Credits offered to P2P individuals (in R$ millions)	Year 1	Year 2	Year 3	Year 4	Year 5
Favorable	0,97	3,04	8,03	17,42	29,51
Standard deviation	0,50	1,51	3,78	8,21	11,30
Unfavorable	0,75	2,26	5,88	12,38	20,87
Standard deviation	0,49	1,49	3,81	7,99	10,16

Note: Source: elaborated by the authors

Lastly, in interviews with managers, the average annual rate charged by their main competitors was identified (Table 7): Therefore, Ligo's loan rate is within the range of a minimum rate of 24.5% to a maximum rate of 94.5% per annum. Gross revenue over the first 5 years is:

$$Revenue = Demand * LoanRate \qquad \text{……………….(17)}$$

Table 7. Lending rates from P2P fintechs

	Minimum	Maximum
KAVOD LENDING	23,9%	125,2%
BIVA	28,3%	120,2%
IOUU.	16,8%	138,2%
NEXOOS	26,8%	52,9%
TUTU DIGITAL	26,8%	52,9%

Note: Source: elaborated by the authors

Taxes: As it is a newly created company, Ligo is part of the Simples Nacional tax regime, which is calculated by the following formula:

$$DAS = \left((RBT12 * Rate) - Deductible\right) \div RBT12 \qquad \text{……(18)}$$

The values of the rates are defined from tables according to the sector of the company. Since Ligo is a financial and technology company, it is included in Annex V of the Federal Complementary Law No. 123, from 2006.

Costs and Expenses: The costs and expenses related to startups have increased over the years, mainly due to the high growth presented by such companies in their early years of operation. In this case, two main types of costs stand out: those that are directly related to the value of loans granted and those that involve the company's operations, such as personnel costs. As Ligo is a P2P-based startup, a significant portion of its gross revenue is returned to the platform's investors. The company expects a rate of return for investors in the range of 16.5% to 45.2% per annum. Another significant cost is related to hiring credit insurer services. The rate charged by the insurer ranges from 1.5% to 2.0%. Regarding the growth rates of costs and expenses related to the company's operations, during the first year, these are estimated to total R$ 90000, distributed among three main cost categories: personnel, data processing, and services rendered. Table 8 defines the likelihood of these costs and expenses over the following 5 years, considering favorable and unfavorable scenarios. In a favorable market scenario, it is believed that the company will grant a larger amount of loans over the years, approximately 60%, with higher growth rates. Other costs and expenses are expected to be lower until the company achieves maturity.

Results of the Simulation and Values for Certainty Equivalents: Once the initial assumptions were defined, the FCF was obtained through Monte Carlo simulations. 10,000 simulations were performed, and values for 90% of the identified results FCFs with 5% certainty extremes. The FCF values for each year are presented in Table 9. Subsequently, the company's NPV was calculated for the following 5 years, and the investment in the option is considered. For this calculation, the discount rate of a risk-free asset is used, in this case, the CDI index rate of 6.40% (Equation 1).The NPV values are thus converted via the tasks of estimating and defining the subjective assumptions in certainty equivalents, which are calculated by inverting the investor-specific utility function (Equation 11), which is dependent on the investor's risk tolerance (p). In terms of risk analysis, a value of p = 200 is applied (representing a risk-averse investor). The replacement of the values obtained by NPV with its certainty equivalents means that the inefficiency of the market in relation to private risks will be resolved in order to make it complete. Figure 3 presents the complete assessment of private risks in decision tree format. The first two branches of the tree correspond to the outcomes resulting from the investor opting for a full investment in the startup. The last two branches as the results of the investor choosing to invest in the option, retaining R$ 136,000 for a later date. From the previous figure, it is possible to draw some conclusions about private risks. Firstly, acquiring the option is always superior than the total investment value, due to the mitigation of risks associated with a negative outcome during the testing phase of the algorithm and servers. Furthermore, it is concluded that if the tests are positive, the best decision is always to make the remaining portion of the investment in the second phase, regardless of whether the market is favorable or not.

Table 8. Growth rate of costs in a favorable and unfavorable market

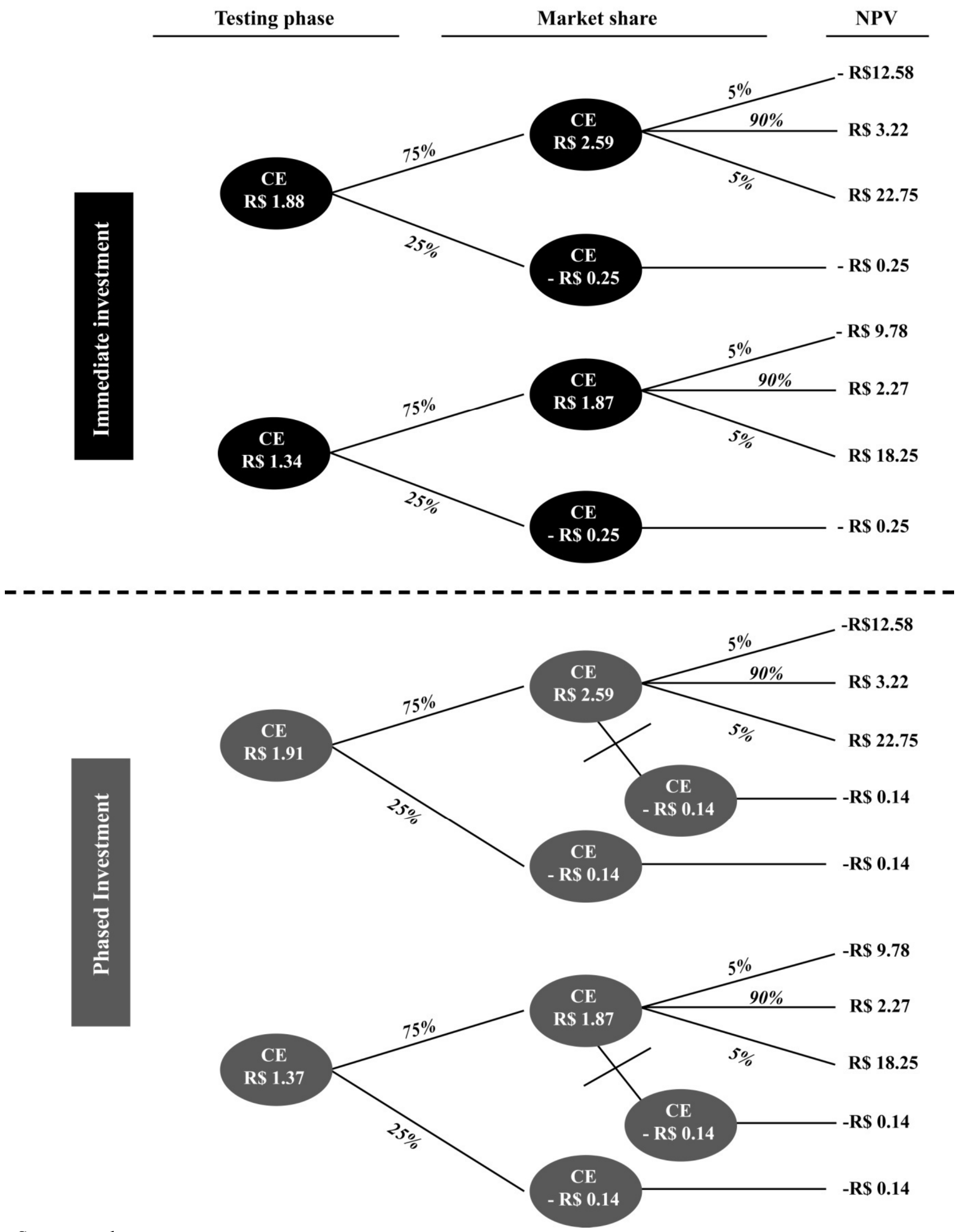
Cost growth rates in the market	Year 1	Year 2	Year 3	Year 4	Year 5	Probability
Personnel - favorable	-	50%	20%	3.5%	3.5%	30%
Data processing - favorable	-	100%	30%	20%	5%	60%
Rendered services - favorable	-	12%	8.5%	3.5%	3.5%	10%
Personnel - unfavorable	-	50%	12%	3.5%	3.5%	45%
Data processing - unfavorable	-	70%	18%	10%	5%	45%
Rendered services - unfavorable	-	10%	7.2%	3.5%	3.5%	10%

Note: Source: elaborated by the authors

Table 9. FCF values obtained in a 90% certainty simulation, for extremes in favorable and unfavorable markets (R$ million)

Favorable	Year 1	Year 2	Year 3	Year 4	Year 5
5%	-0,30	-0,85	-2,05	-4,93	-7,84
90%	0,06	0,27	0,65	1,27	2,24
5%	0,58	1,89	4,01	8,96	14,27
Unfavorable	Year 1	Year 2	Year 3	Year 4	Year 5
5%	-0,26	-0,68	-1,69	-3,71	-5,98
90%	0,02	0,18	0,49	0,97	1,59
5%	0,51	1,63	3,40	7,31	10,99

Note: Source: elaborated by the authors



Source: authors

Figure 3. Private risk assessments and conversion to certainty equivalents (R$ Million)

Analysis of Public Risk: Public risk involves the likelihood that macroeconomic conditions may or may not be favorable to the services or products offered by Ligo. For this analysis, it is assumed that it is possible to replicate this market risk through binomial trees, and thus calculate the probability related to a favorable market.

Replica Portfolio Construction: A replica portfolio is a group of companies that have shares on the stock market, in this case, on BM&F Bovespa, with characteristics similar to Ligo. The portfolio created for analysis consists of the following companies: Itaú, Bradesco, Santander, and Banco do Brasil. The four companies correspond to the largest banks listed on the BM&F Bovespa and are major players in the national individual credit market. Once the portfolio companies were defined, auction data from October 2013 to October 2018 was extracted. Equations 13 and 14 maximize the portfolio's Sharpe return-to-risk ratio, in order to find the optimal share of these companies in the portfolio. The values found by this maximization are presented in Tables 10 and 11.

Table 10. Results from maximizing Sharpe's ratio

CDI rate	6.40%
Portfolio return (5 anos)	11.2%
Portfolio Standard Deviation (5 anos)	15.8%
Portfolio's Sharpe index	71.0%

Note: Source: elaborated by the authors

Table 11. Representation of each company in the portfolio, based on the maximization of the Sharpe Index

Company	Itaú	Bradesco	Santander	Banco do Brasil
Weight	91.9%	0.0%	8.1%	0.0%

Note: Source: elaborated by the authors

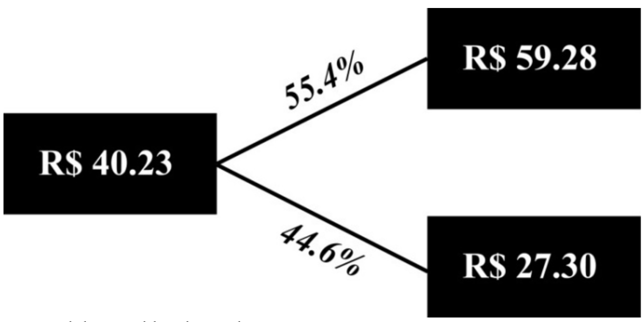
Taking into account the weights attributed to each of the companies, the starting price of the portfolio on 10/26/2018 is R$ 40.23. Factoring the portfolio's price, rate of return, and standard deviation, it is possible to build the portfolio's resulting binomial tree, and thus calculate the probabilities of the market state.

Table 12. Parameters for the portfolio's binomial tree

Number os steps (n)	1
Period (t)	1 year
Up movement (u)	1.47
Down movement (d)	0.68
Favorable market probability	55.4%
Favorable market probability	44.6%

Note: Source: elaborated by the authors

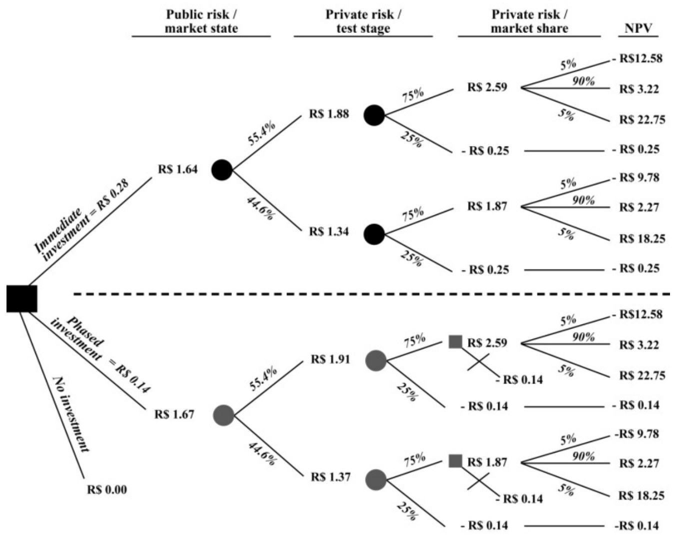
The resulting binomial tree is shown in Figure 4. As can be observed, a share of the replica portfolio at year 1 can be valued at either R$ 59.28 or R$ 27.30.



Source: elaborated by the authors

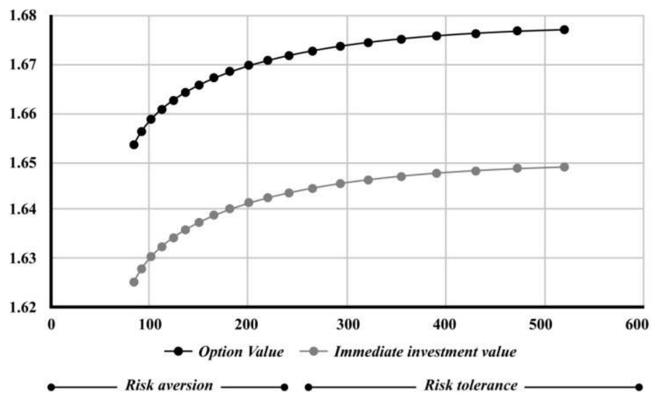
Figure 4. Possible portfolio share values at 1 year

Decision Tree: Once the risks are analyzed, the decision tree is developed. Initially the public risk is analyzed, followed by the two private risks.The first moment is the one in which the investor must decide whether to immediately invest all the amount necessary for the development of the company, or to make an initial investment of R$ 136,000, accounting for approximately 48% of the total investment value. This moment is considered to be moment zero, and occurs before the activities of testing the algorithm and servers. The third option would be not to invest in the company. The second decision moment occurs after the completion of the company's tests (1 year later). At this stage, the investor must decide whether to increase their capital interests in the company, or to abandon the investment, resulting in a loss of R$ 136 thousand. According to the private risk analysis, if the test results are positive, the best alternative for the investor is always to add the remaining capital, independent of the market situation.



Source: elaborated by the authors

Figure 5. Complete decision tree, subdivided by risk type (R$ Million)



Source: elaborated by the authors

Figure 6. Company's value for both strategies and different *ρ* values

In Figure 5, the last nodes represent the company's NPVs, defined through subjective estimates and probabilities based on interviews and observations with industry experts and company managers. At the time of assessing the first private risk, these values are converted to certainty equivalents by introducing investor risk assumptions and preferences (Equation 9), so that the incomplete market becomes a complete market. Once the certainty equivalents are calculated, the values of the following nodes are calculated by taking into account the probabilities of each of the branches, and are thus designated as expected certainty equivalents. With the completion of the backwards induction process, the decision tree evaluation is complete, and the company's values represented by the first branches of the tree. Both investment strategies have a positive net present value. Thus, the alternative of not investing in the company is not attractive. In addition, the company's value for the alternative of investment in the option (R$ 1.67 million) is higher than the total investment (R$ 1.64 million), since by investing in the option, the investor mitigates their risks, unlike the total investment alternative in the first phase of financing.

Sensitivity Analysis for the Risk Tolerance Parameter: In the integrated option-based assessment method applied in this paper, it was assumed that investor assumptions and risk preferences would remain constant with a value of 200, that is, of low-risk tolerance.However, a sensitivity analysis was also performed, seeking to broaden the study in question by making it possible to analyze how the variation of the investor's risk tolerance parameter (parameter ρ) impacts the final value of the decision alternatives. Figure 6 is the result of this analysis. In evaluating it, it can be stated that in all risk tolerance states, be they aversion, neutrality, or tolerance, the value of the option is greater than the value of the immediate investment. These results are partly explained by the difference between the value of the immediate investment option, as the option represents only 48% of the total immediate investment. It is further noted that the value of the alternatives increases as the parameter ρ changes from a risk-averse situation to a level of risk tolerance. However, after a certain point, the values of the alternatives remain constant.

Conclusion

Startup companies, over the last few years, have become an attractive investment alternative for independent, or angel, investors. It is in this context that this paper seeks to identify the best investment alternative for such an investor, based on financial analysis, since the financial return is the main driver in the decision-making process. This financial analysis is guided by business valuation methods that seek to estimate the value of a company. The combination of the high subjectivity involved in this process, along with high innovation, makes it extremely difficult to determine which appraisal method to use. Therefore, this paper sought to analyze the complementarity between the Real Options and the Discounted Cash Flow (DCF) methods. This is due to the fact that the latter does not recognize managers' administrative flexibilities, especially in situations of uncertainty, which may contribute to serious distortions in the obtained results. Real Option valuation methods are able to capture and quantify the flexibilities or options that arise during the life cycle of a company or project. This is especially true for companies that are in their early stages of operation and have little historical data available for analysis. The Integrated Method for Option Evaluation applied in this study has the advantages of separately analyzing and segregating a company's risks into public and private risks, as well as integrating the decision tree method into the analysis, and including investor preferences for determining the company's value.In the case of Ligo, the interested investor is faced with two alternatives: investing the full required amount immediately, or investing through phases, with the first taking place prior to algorithm and server testing. The optimal investment choice, given as the phased investment alternative, was identified according to the investor's risk tolerance profile. It is also possible to conclude that two investment options are financially more favorable than not investing. Furthermore, given positive test results, the best option will always be to invest the remaining value regardless of the state of the market.Lastly, a sensitivity analysis of the investor's risk tolerance (ρ) parameter was performed, in order to verify whether the immediate investment alternative would be more financially favorable for more risk-tolerant investors, which was not proven by the obtained results.

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