Start-ups Defined as Portfolios of Embedded Options

Pascal BOTTERON
Institute of Banking and Finance, HEC-University of Lausanne and Ernst & Young Ltd.

Jean-François CASANOVA
Strategic Risk Management

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University of Geneva, HEC
40 bd du Pont d'Arve
1211 Genève 4
Tel: +41 (022) 705 8122
Martin.Hoesli@hec.unige.ch

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Pascal Botteron*
Jean-François Casanova**

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* Institute of Banking and Finance, HEC Lausanne, 1015 Dorigny-Lausanne, Switzerland and Ernst & Young Ltd, Binzmühlestrasse 14, 8050 Zurich. Tel + 41 79 460 97 16. E-mail: pbotteron@hotmail.com
** Strategic Risk Management, 52, rue de Ponthieu, Paris, France. Tel + 33 6 15 38 64 08. E-Mail: jcasanova@riskvalue.com

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Start-up Defined as a Portfolio of Embedded Options

Abstract

In this paper we show the advantages of staged investments for venture capitalists. We develop an option-pricing model that enables to evaluate the flexibility acquired by a venture capitalist when he stages his investment process. Instead of investing a fixed amount at the beginning of the investment, the venture capitalist proceeds to a staged investment (one first investment and a second investment). The second investment will be triggered by a successful achievement of the first investment. Should the first investment be unsuccessful, the second investment will not be executed. Staging the investment in two phases enables the investor to reduce its uncertainty at the beginning of the project. As it will be demonstrated in the paper, the decision to proceed to the second investment can be modelled as a portfolio of a call option and a binary option.

Keywords: real options, staged investments, structured products, embedded options.

JEL classification: G12, G30, G31, G32, G34, M13

Executive Summary

Pascal Botteron*
Jean-François Casanova**

Applying option pricing techniques to real asset valuation appeared in the middle of the eighties under the name of real options. Real options have been initially used to price natural resource investments such as gold mine, oil leases and more recently to price e-business strategies, patents, IT infrastructure and manufacturing systems. This paper focuses on the valuation of start-ups considered as a portfolio of real options.

The objective of this research is to show a new facet of real options, which is the solving of investment conflicts between investors and entrepreneurs. When negotiating capital raising, entrepreneurs usually seek to optimise the couple cash-in versus firm control and, under this constraint, to maximise their flexibility trying to raise as much money as they can up front in the form of a one time fixed amount. This strategy brings more stability to the management of the start-up but is perceived as more risky by venture capitalists because if the project fails, the whole investment is lost. A possible solution lies in a staged investment financing. This type of investment can be cut in several phases. Each investment is triggered by objectives reached by the entrepreneur. Should the start-up go to bankrupt, the investor loss would be lower. The key point is to define up-front the value of the company at the different forecasted stages of investments. Fixing this value will define the exercise price of the option to invest offered to the investor and in connection the value of time, which will be calculated in relation to the volatility of the expected cash flows.

This paper decomposes the value of a start-up as a portfolio of options. In function of the information available on the start-up the venture capitalist can optimise its investment policy by staging its investment in the start-up. Instead of making one full investment at the

* Institute of Banking and Finance, HEC Lausanne, 1015 Dorigny-Lausanne, Switzerland and Ernst & Young Ltd, Binzmühlestrasse 14, 8050 Zurich. Tel + 41 79 460 97 16. E-mail: pbotteron@hotmail.com
** Strategic Risk Management, 52, rue de Ponthieu, Paris, France. Tel + 33 6 15 38 64 08. E-Mail: jcasanova@riskvalue.com

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beginning, the venture capitalist will stage its investment in the start-up into two investments. The venture capitalist invests the first fraction for a testing period. If the start-up is successful after the testing period, the venture capitalist will exercise an option to proceed to the second investment. In particular, the optimisation of the value of this portfolio allows the venture capitalist and the entrepreneur to find an agreement on the set up of an optimal investment policy.

This approach offers many applications for the valuations of the different parts of the project constituting a start up and as ever is pertinence relies a lot on the quality of the retained assumptions retained to build the evaluation model. The set up of the portfolio allows to optimally structure investment decisions in function of the investor and the entrepreneur preference. We show that, independently of all the other factors, that staging investment provides superior value for the investor. The fact that the value can be the same in different investment conditions enables the entrepreneur to optimally negotiate with the investor about the shares of the company he will sell him.

Start-up Defined as a Portfolio of Embedded Options

1. Introduction

Investing in a start-up is a venture, often an attractive adventure, but certainly a risky business. Statistics show that chances of success (finding a prosperous exit strategy) are low. Obviously, these chances are low because risks for failure are high. There are numerous risks attached to the development of a start-up. Economic environment, Market perspectives, Offer (products/services) fitting with Market demand, Project structuring including Financial structure, Risks management procedures and overall Quality of Team and Management. In the absence of historical data on which the investors should base their judgement, the uncertainty associated to all these factors strongly impacts the valuation process start-up. One way to increase the chances of success is to manage these risks and to assess the impact of these risks on the value of the start-up. The solution usually adopted is to develop a revenue model that accounts for all the risky parameters. The most common valuation methodology is the Discounted Cash Flow (DCF). The objective of this methodology is to estimate the future cash flows that will be generated by the start-up and then to discount these future cash flows by a discount rate that reflects the start-up's risks. Generally the discount rate used reflects the probability of default observed in the market place or in the investor portfolio for the same type of investment. This valuation process is by nature robust, conservative but usually reflects nothing more than a gambling behaviour. For instance a 50% interest rate chosen to discount the expected Cash Flows means by comparison with a risk-free rate of 5%, a risk premium of 45%. This high value for the risk premium spreads over the reliable forecasting time horizon (never more than two to three years) means a probability of default of 45% + 55%*45% = 69%. This probability of bankruptcy is so high that it doesn't justify the investment for a non gambler (to be compared with D rating). Very often this type of investment is part of a portfolio spreading the risk over several investments, playing the diversification effect, without a clear analysis of the intrinsic value of the project. An other common way of analysis consists to look at the "comparable" which means to relate the value of the project to comparable valuation realised for the same type of projects but more generally with quoted companies which have to be further discounted because they are not at all at the

same stage of development. The purpose of this paper is to define a different way of start-up valuations by beginning from the start-up project itself, identifying the different risks and opportunities which are implicitly part of it and valuing them as different options constituting of an options portfolio making the valuation process much more sound and reliable.

The application of the options approach offers new perspectives in the valuation of start-ups as it allows assessing the value of adjusted risk management within a start-up investment. Evaluating a start-up with a DCF methodology, avoids:

- "learning effects", after 3 months of activities additional information on the probability of success of the investment arrives. This new additional information allows the investor to re-adjust its future investment strategy
- "path dependency", risk changes over time and, for example, if good sales have been generated in the 3 first months of activities, future sales will be more promising
- "positive volatility of CF", cash flows fluctuate over time and it is very difficult to put a value on future cash flows
- "investment timing optionality", DCF assumes a "now or never" investment decision. The non-inclusion of timing flexibility (now or later) may leave significant value and information for making effective decisions.

A theory called "Real Options" that applies option-pricing theory to real life investment decisions offers new solutions in terms of investment analysis. This approach considers all the issues mentioned above. The computation of the project value is similar, except that, in addition to the traditional approach, as for the discounted value methodology we start to calculate the expected present value of future cash flows, using Monte Carlo simulations to define the risk premium to be chosen in relation to their relative probability of occurrence, to define the theoretical value of the start-up, we define the exercise price of the Real option as the expected investment cost of the project, our time to expiration is the period of time during which we can invest, the volatility is given by the expected project value return's volatility and the cost of keeping the investment opportunity alive is a good proxy for a dividend on stock , at least the risk free interest rate is adjusted to be relevant with the process. This approach offers many applications for the valuations of the different parts of the project constituting a start up and as ever is pertinence relies a lot on the quality of the retained assump-

tions retained to build the evaluation model. Nevertheless it offers an elegant approach for analysing in depth the different components of a project, start-ups are nothing else than a project, and to make a much more informed decision.

As an application of the real options theory we propose to consider, in this paper, its contribution to the investment decision process to be realized by a Venture Capitalist. We show how this investment decision should be structured and timed. Doing so obviously offers an apparently objective toolkit providing results, which could be valuable to the start-up promoters during the negotiation.

The possibility to evaluate this flexibility of choosing the optimal time to execute an investment is a major argument in favour of real options vis-à-vis to DCF. The advantages of this approach are presented in academic papers and books such as McDonald and Siegel (1986), Paddock, Siegel and Smith (1988) or Dixit and Pindyck (1994) as well as in books destined to practitioneers such as Copeland, Koller and Murrin (1996). For example, real options models have been developed to quantify the time-value of reporting an investment, to evaluate the strategy of shutting down a mine temporarily, to evaluate the opportunity to resell equipment if the project fails, to evaluate the opportunity to switch the inputs or the outputs in a production system or to quantify growth opportunities. See Trigeorgis (1996) for a detailed discussion of the different types of real options and for a detailed literature survey.

Several authors have already applied real options in a similar context. Grenadier and Weiss (1996) analyse innovations with real options. They model a strategy of investment as a sequence of embedded options. The model allows the analysis of the firms' optimal migration strategies under technological uncertainty. The importance of real option valuation in research and development (R&D) projects has been mentioned by Schwartz and Moon (1994) who apply a real option approach to value a pharmaceutical R&D project. To perform a precise valuation of such a project they took into account three different types of uncertainties: the investment costs during the project, the future payoffs and the success of the project. Then the value of the R&D project is shaped as a contingent claim on these three stochastic variables. In practice real options model are also used to evaluate pharmaceutical projects. Nancy Nichols (1994) describes how the option pricing theory is used to evaluate uncertain

pharmaceutical projects at Merck and Copeland, Koller and Murrin (1996) describe an application of a pharmaceutical R&D project evaluation with a discrete time real option model.

The objective of this research is to show a new facet of real options, which is the solving of investment conflicts between investors and entrepreneurs. When negotiating capital raising, entrepreneurs usually seek to optimise the couple cash-in versus firm control and, under this constraint, to maximise their flexibility trying to raise as much money as they can up front in the form of a one time fixed amount. This strategy brings more stability to the management of the start-up but is perceived as more risky by venture capitalists because if the project fails, the whole investment is lost. A possible solution lies in a staged investment financing. This type of investment can be cut in several phases. Each investment is triggered by objectives reached by the entrepreneur. Should the start-up go to bankrupt, the investor loss would be lower. The key point is to define up-front the value of the company at the different forecasted stages of investments. Fixing this value will define the exercise price of the option to invest offered to the investor and in connection the value of time, which will be calculated in relation to the volatility of the expected cash flows.

In this paper we model the valuation of a start-up from both the venture capitalist and the entrepreneur perspectives when the financing of the start-up is made with a staged investment. We show, in particular, the advantage of conducting staged investments over one-shot investments. The remainder of the paper is organized as follows. Section 2 presents the main assumptions of the model. Section 3 develops the real option model to determine a monopolistic firm's decision to introduce an innovation in the market when it faces uncertainty on the demand level and thus on the introduction timing of the innovation. In section 4, we discuss the application of our model and in Section 5, we conclude by summarising the main results of this real options approach.

2. Assumptions

Start-up X seeks to raise an amount I to start its activities at date $t = t_0$. A venture capitalist (hereafter the 'investor') is interested in investing in the start-up. The start-up has a value V_t. The environment can be characterised by the following assumptions:

A1. The investment I will be divided into two parts.

- the first investment I_0 (the "Seed Capital investment") which allows start-up X to launch its activity at t_0 and conducts its activities during the period $[t_0, t_1]$. In exchange of I_0 the investor will get a fraction a of the company (i.e. the investor gets aV_0), with $0<a<1$.
- if start-up X can carry out its objectives (detailed in assumption A4), the investor will invest a second block (the "Venture Capital investment") allowing start-up X to further develop its activities after t_1. At $t=t_1$, In exchange of I_1 the investor will get a fraction b of the company (i.e. the investor gets bV_1), with $0<b<(1-a)$.

A2. Start-up X will consider only I_0 and I_1 as a unique source of financing. The investor has the exclusivity for the second investment.

A3. Both the investor and the entrepreneur determine at time $t = t_0$ the allocation of the investment between I_0 and I_1. The allocation will be set following the preferences of both the investor and the entrepreneur.

A4. We assume that both the investor and the entrepreneur will jointly fix an objective K to be reached at $t = t_1$. The objective is measured in terms of start-up value V. If this objective is reached ($V \geq K$), the investor will trigger the remaining investment I_1 in exchange of an additional fraction b of the start-up.

A5. We assume that the start-up value V_t is obtained following the discounted cash flow methodology. We further assume that the future cash flows are discounted at a risk-adjusted discount rate.

A6. Let r be the constant risk-free interest rate and suppose that there is no inflation.

A7. We assume that the agents are risk-neutral and thus that they discount their payoffs at the risk-free rate. This assumption is valid as long as the options to invest are owned by well-diversified investors. The diversification may lead the investor to get a global payoff for which the return is the risk-free rate. Thus, he can evaluate the globality of his projects at the risk-free rate. As mentioned by McDonald and Siegel (1986), "assuming that investors are well diversified describes publicly owned corporations in the United States and simplifies the computation of the options value".

A8. We assume that Start-up X acts in a "perfect" world with features like perfect anticipation, symmetry of information and without strategic consideration. Thus we exclude dumping strategies, alliances and mergers.

3. The Model

The objectives set at $t=t_0$ are defined in terms of cash flows. These cash flows are determined following the characteristics of the start-up and the market environment where it operates. Features such as growth expectation of the target market, competitors, forecasts of the prices of products, forecasts of the economic situation (growth rate of the country, perspective of evolution of the interest rates and etc) all influence the future evolution of future cash flows. We assume that the start-up value V_t is determined by discounted cash flows. The effect of the discount rate makes the short-term cash flows more important in terms of impact on V_t. Thus, good sales results before t_1 will positively impact V_t and then V_1. In this perspective, the decision to proceed in the second investment is formalized so that at $t=t_0$, jointly the investor and the start-up set one objective K to be reached by V at time $t=t_1$. The

objective is a level of cash flow corresponding to an expected value at $t=t_1$.[1] If $V_1 \geq K$, the second investment will be executed. If the reverse case occurs, the second investment will not be executed.

In the framework of the assumptions, the investor invests I_0 at $t = t_0$. This investment will reward him with a fraction a of the start-up value, thus aV_o. In association to this first investment, the investor gets the exclusivity to invest I_1 at time $t = t_1$ in the start-up in exchange of a fraction b of the companies value. Thus, the investor holds the right but not the obligation to invest a second block I_1 if the objectives fixed in $t=t_0$ are reached at t_1.

Thus, in t_1, the investor who holds the option to invest I_2, gets the following pay-off:

- If $V_1 < K$, the investor will not further invest and will not get any pay-off.
- If $V_1 \geq K$, the investor will invest I_1 and will get in exchange of this investment a fraction b of the start-up value.

The pay-off of the investor can be rewritten as follows:

$$\text{Payoff}_{t=t1} = (bV_1 - I_1)$$

$$= (bV_1 - bK + bK - I_1)$$

$$= (b\,(V_1 - K)) + (bK - I_1)$$

The start-up value can thus be decomposed into two European Option Values.

$C_1 = b\,(V_1 - K_1)$ and $C_2 = (bK_1 - I_1)$

The first option, C_1, whose price is influenced by the fraction b, is a plain vanilla European option with the following characteristics:

- Underlying is the value of the company: V_t
- Strike price: K

[1] For example, V can be modelled as a function of the number of goods sold during a fixed period of time. If the "sales rate" increases, thus the value of the startup V_t increases.

- Volatility: s
- Time to Maturity: $[t_1 - t]$

Assuming a risk-neutral environment with an underlying liquid market, the option value C_1 can be evaluated with the Black and Scholes formula (1973):

$$C_1 = VN(d_1) - Ke^{-r(t_1 - t)}N(d_2)$$

with

$$d_1 = \frac{\ln(V/K) + (r + s^2/2)(t_1 - t)}{s\sqrt{t_1 - t}}$$

$$d_2 = d_1 - s\sqrt{t_1 - t}$$

The second option, C_2, has the characteristics of a European binary call option as its pay-off is not directly linked to V_1:

- Underlying: Value of the company V_t
- Strike Price: K
- Pay Off: $bK_1 - I_1$
- Volatility: s^2
- Maturity = $[t_1 - t_0]$

In a risk-neutral environment with an underlying liquid market, the option value C_1 can be evaluated with the following formula (See Willmot (1999) as a reference):

$$C_2 = Ke^{-r(t_1 - t)}N(d_2)$$

Thus, the investor's value E of its investment at $t = t_0$ is the following:

$E = aV + C_1(b) + C_2(b, I_1) - I_0$.

with C_1 and C_2 that are the price, in t, respectively of the European and binary options described here above and I_1 is the investment to be realised in t_1.

4. Application of the model

The reader can verify that without time flexibility ($t_0 = t_1$) the investor would get the following pay-off:

$E = (a + b)\, V - I_0 - I_1$

In Figure 1, we see that the possibility to stage investments enables the investor to gain more value. This strategy has more value in the presence of risks. In Figure 2, we observe that the higher the volatility, the better the inclusion of risk effects in the analysis.

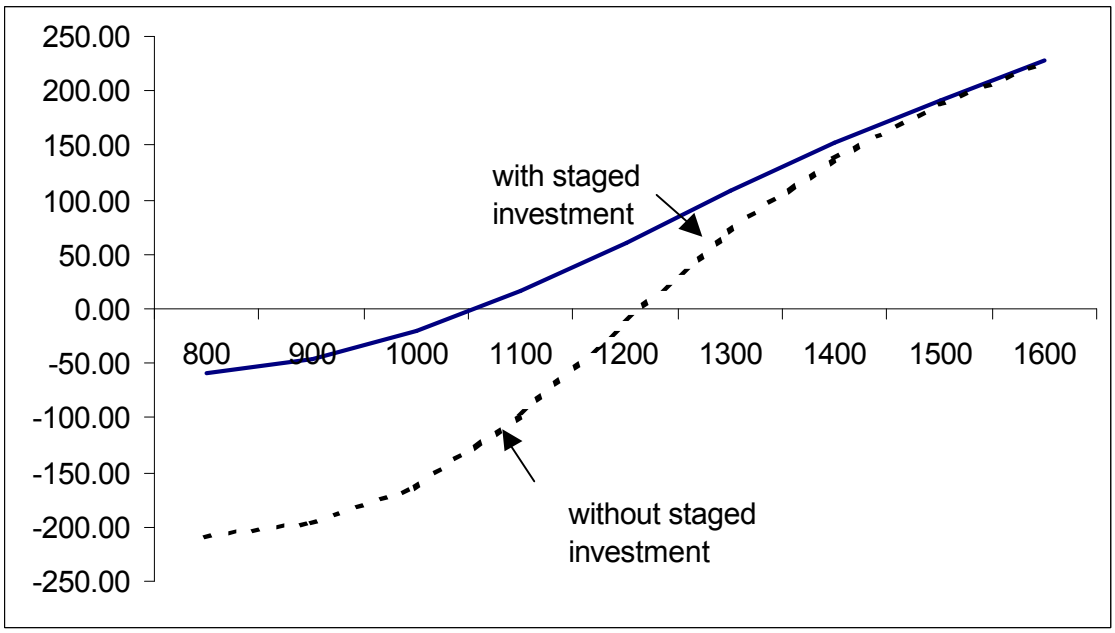

Figure 1: Value of the Investment Strategy for Different Values of Vo with Io=100, I1=150, a**=5%,** *b***=25%, K=1200, s=25%, r=5%, T-t=0.5**

The model helps to show the value of a risk management strategy in a start-up investment. This value stems from the flexibility to cancel the second investment if the value of the start-up does not reach the objective at time $t=t_1$. For example, for a fraction a of the company held at time $t > t_0$ (I_0 has already been invested), the investor holds the right to invest I_1. The option portfolio's price is affected by all the traditional factors influencing the price of an option and also by the percentage of the value negotiated to be taken if the investor decides to invest the second block.

Thus at time $t = t_o$, the investor can determine the minimum fraction a to negotiate in order to make its investment "in the money" when he decides to invest in the first Phase of the project. The advantage for the investor is the possibility to choose between a, b and $I_1/(I_1+I_o)$. For example, the three scenarios below provide him with the same economic value but his risk-preferences will lead him to choose one precise scenario:

Several applications can be mentioned. For example, at time $t > t_o$, the investment value E is the following:

$$E=e(a, b, I_1, I_0, K_1, s) = aV_{(to)} + C_{1(to)}(b) + C_{2(to)}(b, I_1)-I_o$$

The investor holds continuously a net portfolio value influenced by four parameters (a, b, $I_1/(I_o+I_1)$, K_1) that are linked.

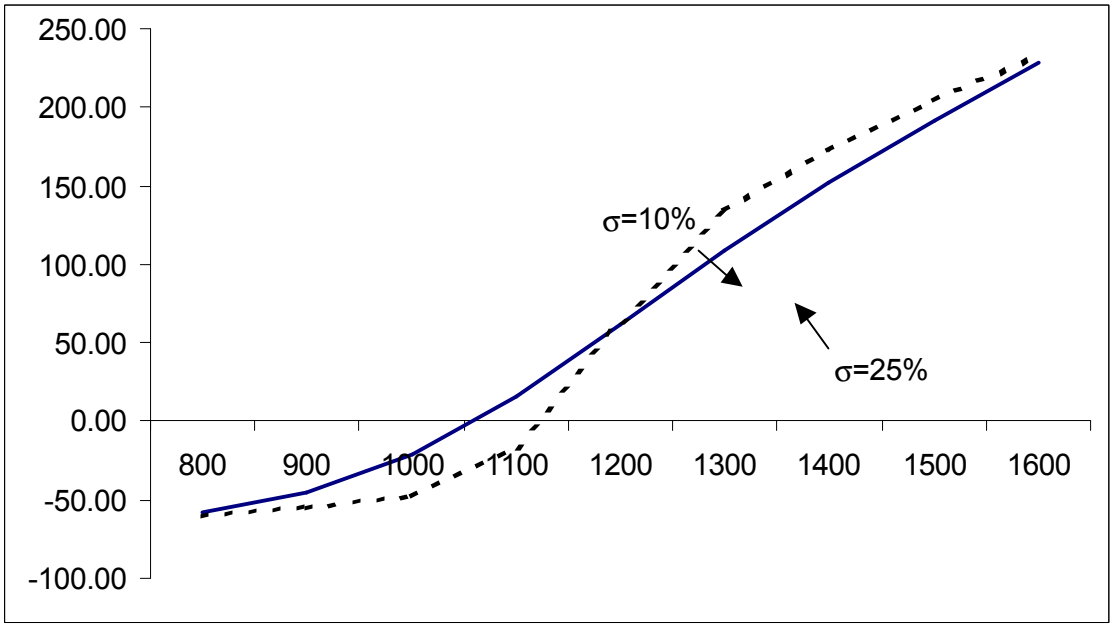

Figure 2: Value of the Investment Strategy for Different Values of Vo with Io=100, I1=150, a**=5%,** *b***=25%, K=1200, r=5%, T-t=0.5**

In function of his preferences, the investor can fix three parameters and bargain on the base of the remaining parameter. For example, depending on his preferences, he can play on the allocation between $I_1/(I_1+I_2)$ and $a/(a+b)$. As an example, two strategies (scenario 1 and scenario 2 in Table 1) that offer different characteristics have the same value for the inves-

tor. In function of its risk preferences, there is a high probability that he prefers one strategy to the second one.

	Scenario 1	Scenario 2	Scenario 3
Total Investment I	250	250	250
Io	125	75	150
I_1	125	175	100
α	10%	5%	13%
β	20%	25%	17%
Value of the Startup (V)	1200	1200	1200
Objective (K_1)	1200	1200	1200
σ	25.00%	25.00%	25.00%
r	5.00%	5.00%	5.00%
T-t	0.5	0.5	0.5
Strategy Value	73.28	73.32	75.71

Table 1: Three different scenarios of investment returning the same value for the investor

Thus, this tool helps to clarify both the positions of the investor and the entrepreneurs. In function of the start-up structure as well as of the investor preferences, the bargaining process between the investor and entrepreneur can be structured in a different way following the risk preferences of the investor. When the investor targets a net situation that is nil, he sets:

$$E=e(a,\ b,\ I_1, I_0,\ K_1,\ s) = aV_{(to)} + C_{1(to)}(b) + C_{2(to)}\ (b,\ I_1)\text{-}I_o=0$$

In this context, if the investor is risk-adverse, he can set the conditions regarding size of the second block to be realized in t_1 either to:

- demand a minimum fraction b to be held in t_1 so that his "net situation" is at least nil.
- demand a maximum investment I_1 in t_1 to be realized so that his net situation is at least nil.

If the investor is risk-lover and is persuaded that he will invest in t_1, he can demand a minimal fraction a to be held in t_0 so that his net situation is at least nil.

5. Conclusion

The objective of this paper was to show how a "structured product" which is a combination of options could help to optimise start-up investments. The flexibility provided by such a structure is extremely advantageous for both the investor and the entrepreneur. For the first one, he can manage his risks by acquiring 'for free' the option to invest in a good start-up by staging his investment in the start-up. For the entrepreneur, if he is sure of the success of his innovation, he can raise money in an easier way.

This paper opens a new perspective in the field of real options. It shows how to optimally structure investment decisions in function of the investor and the entrepreneur preference. We show that, independently of all the other factors, that staging investment provides superior value for the investor. The fact that the value can be the same in different investment conditions enables the entrepreneur to optimally negotiate with the investor about the shares of the company he will sell him.

The use of this model enables on the one hand to reduce the model risk within the start-up valuation model and on the other hand it shows the positive leverage effect gained by the use of options in the approach. Theoretically, there is no problem to buy options and the delta of the underlying and thus to span assets on the market. However, in practice start-up markets are extremely illiquid (i.e. inefficient) and thus, adopting a replication strategy is very complex and probably impossible. The non-possibility for the investor to span assets on the market may invalidate some results of the model. See Schwarz (1995) for an interesting discussion on the validity of real options when assets cannot be spanned. However we show that, when the spanning of assets holds, the investor can choose different strategies in function of his risk preferences that all provide the same value to him. In particular, if the start-up is a catastrophe, the investor looses less as he invested less. If the start-up is a success, the investor gets a better return as he invested less and he can exercise its option to further invest in a good start-up. In summary, the investor improves its risk/return ratio with the investment model proposed for three reasons that are not included in traditional valuation methodologies. First, the volatility that the investor faces at time $t=t_0$ does enable to conduct a serious risk/return analysis. The model helps to manage the model risk on the estimation of the volatility. Second, the cost for liquidity in such transactions is high and the staging of

investment proposed enables to reduce this cost. Third, entrepreneurs are not really affected by the structure of such a staged investment if they are successful while investors can loose the whole amount invested. It is also important to mention an additional limitation of such an analysis, which is the organizational structure of the market. Indeed, the more intense the competition between investors, the more complex the fixing of the objectives and vice-versa.

Finally, it is worth to mention that the use of the option to wait is not new and is generally used under the terminology of « Milestone planning ». This technique is already old but allows to modular the investment structure in function of the information available at each critical development stage. The value assed of real options adds value to the analysis by pricing the value of investment decisions (go/ no go) at each development stage. This value is just an option on a project and its value will not be a function of a price at maturity (objective very difficult to fix at the beginning for investors in biotechnology or natural resource developments), but function of a degree of information at each development stage. The degree of information can be the result of researches but more than everything will be the opinion of all agents on the future evolution of the underlying market.

« there is nothing genuine, the opinion of all makes the opinion of each one »

Democritus, Greek philosopher (460 b.c. - 370 b.c.)

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PO Box, 1211 Geneva 4
Switzerland
Tel (++4122) 312 09 61
Fax (++4122) 312 10 26
http: //www.fame.ch
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