Acquiring or partnering with a small technology firm under competition

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Abstract

We develop a real options framework for the acquisition of small firms by larger ones interested in their technology. We show that, in the presence of uncertainties related to the efficiency of the technology of the target firm and the pressure of the competition, the large firm has incentives to partner with the small one, allowing for a hedging against the competition. This modeling leads to the assessment of the value of this partnership as the difference between the value of the proprietary option and that of the option under competition.

Keywords: Dynamic programming; Capital budgeting; Technology acquisition; real options *JEL Classification*: G31,G34, O32

1 Introduction

It is often considered that small firms have large comparative advantages at early stages of innovation process, while large firms have advantages at later stages (Granstrand and Söjlander, 1990). In this context, the acquisition of small firms by larger established ones is a common practice that allows the latter to acquire interesting technological innovations. Ahuja and Katila (2001) found that large companies should focus their merger and acquisition activity on small targets if they would like to increase their innovative performance. This tendency has been recently confirmed in (Andersson and Xiao, 2016) using a data set from Sweden.

It is important to notice that, in these operations, the interest is usually reciprocal between both firms involved in the acquisition. From the perspective of the small firm, the acquisition is often considered as a more favorable outcome than an independent development. As a matter of fact, it has been observed that small businesses tend to over-invest in R&D before a potential acquisition to report their skills and attract interested buyers, leading to a positive correlation between R&D activity and the acquisition probability (Phillips & Zhdanov, 2011). On the other hand, from the buyer perspective, the acquisition of innovative firms is considered as a complement to the internal innovations generated by in-house R&D innovations (Granstrand and Sjölander, 1990; Desyllas and Hughes, 2008).

In this paper, we focus on the acquisition of innovative firms from the perspective of the acquirer. We make use of a real options method and incorporate in the proposed framework many of the most important characteristics of real-world technology markets. For instance, we consider that the revenue of the firm depends on the technology-efficiency level and that the cost for acquiring a firm increases when its technology approaches maturity. Our approach is well established in the literature since the empirical work of Folta (1998) that noticed that R&D activities are characterized by the presence of uncertainty and can be analyzed using the real options lens and that uncertainty increases the value of the option to defer. Folta and Miller (2002) extended this framework to the study of the trade-off between growth and deferral if risks of preemption and erosion are dominant. The real options method is an adaptation of the theory of financial options taking into account the constraints of the real economy. More recently, the modeling of these options started another trend that allowed it to reflect a shift from the sphere of finance to the sphere of strategic management (Bowman & Hurry, 1993). Since then, real options has been identified by Li et al. (2007) as a conceptual framework that could become dominant in strategy.

A critical and innovative aspect that is considered in this article is the competition between "large" companies over small ones. It has been observed that acquisition may take place only to prevent a competitor from buying (Granstrand and Sjölander, 1990).We incorporate the pressure of the competition in the model and show that competition accelerates the acquisition decision while reducing the option value. However, there exist different modes of partnership between firms other than immediate acquisition that can be considered as an option to cover against the actions of the competitors. These include a wide range of modes from licensing via R&D consortia to minority investments, as detailed by Duysters and Hagedoorn (2000b).

We extend the developed option to a more general one where an initial partnership allows hedging against the actions of the competitors, leading to a two-stage decision. This allows the valuation of the partnership as the difference between the value of the proprietary option and that of the option under competition. The remainder of this paper is organized as follows. In section 2, we develop our real options framework for acquisition of small innovative firms and propose a dynamic programming algorithm that allows deriving the optimal investment timing and the value of the option. Section 3 incorporates the impact of the competition in the model and shows how the pressure of competitors accelerates the decision, increasing the risk of useless acquisitions. Section 4 introduces a two-stage option that incorporates the tight cooperation as an option to cover against competitors. Section 5 concludes the paper.

2 Real options method

The success of mathematical methods; Black and Scholes, (1973) in continuous time framework and the binomial model also known as Cox_Ross_Rubinstien model in discrete time and the large development and using of financial options in financial markets have also replicates on capital budgeting "or investment decisions" revolutionize by the emerging of Real options Theory (RO). In 1977, Myers was the first one who named the real options by seeing the future opportunity to invest in uncertain environment as real options [Myers, 1977]. Since, scholars have conducted a large number of studies investigating the concept and the method of real options and multiplied studies have applied RO method in many fields of life. The real options theory is a research field that spreads across different disciplines; the early applications have been in the natural resource investments as in [Brennan et al.,1985] where the authors valued a gold mine as an option. [Kolbe, Morris, and Teisberg, 1991] studied the options elements embedded in R&D projects. In IT infrastructure investment, Balasubramanian, Kulatilaka and Storck, (2000) based on RO theory, developed of a formal and practical methodology to evaluate information technology infrastructure investments.

The authors in [Mcdonald & Siegel, 1986] have studied investment timing in irreversible project where both cost and benefit from the project follow GBM process; as a result the authors obtained a closed formula for the value of the option to invest. They found a closed formula of threshold of the ratio of benefit over cost where the optimal criteria consist to invest when this ratio exceed the optimal threshold.

For interested reader in this method, the book of Dixit and Pindyck, (1994) consist a good base for a deeper comprehension of this theory.

The classical decision method based on cost-benefit (Discount Cash Flow DCF) analysis is not suitable for the following reasons:

- There are two sources of uncertainty: The cost of the acquisition increase stochastically over time, and the the profit. DCF ignores the possibility of waiting for a better situation, and leads to values that do not exploit the option "invest now or later", whereas the real options method deals with the uncertainty about the future returns in a flexible way.
- As detailed in McDonald and Siegel (1986), the uncertainty increases the firm's opportunity costs of investment and raises the threshold rate of return required to induce the firm to forgo its option to defer investment. the classical decision criteria based on cost-benefit (Discount Cash Flow DCF) analysis are not suitable. In fact, DCF ignores the possibility of waiting for a better situation, and leads to values that do not exploit the option "invest now or later". The Real options method, however, takes into account the important effect of the uncertainty about the future returns of the project. Furthermore, the authors in [**?**] found that uncertainty increases the firm's opportunity costs of investment and raises the threshold rate of return required to induce the firm to forgo its option to defer investment. In this work we have the same negative relationship between investment decision date and uncertainty.

In the next section, we focus on the specific problem of the acquisition of small innovative companies by large firms using the real options lens. The empirical findings of the study indicate that the market on which STBFs are traded is typically a seller's market often characterized by monopoly.

3 A real options framework for the acquisition decision

3.1 Problem statement

We consider that a large firm **G** has currently a mature technology with a known, established, efficiency. From his side, a small firm **S** is developing a promising technology that is not yet as efficient as the technology of firm **G**, but **G** believes that this technology could become complementary to its own internal resources and increase its techno-efficiency. However, as the technology of firm **S** is not yet mature, the general problem facing firm **G** is to choose, at each instant t, whether it is better to acquire firm **S** and integrate his technology, or to wait for future developments. The dilemma facing firm **G** is the following:

- if it decides to acquire too early, the technology of firm **S** may not evolve as expected and it would loose the acquisition cost,
- if it postpones the decision, the technology of firm **S** may develop faster than expected. In this case, the cost that the firm **G** will have to pay for the acquisition will increase accordingly.

However, the above analysis neglects the presence of competitors that could forestall the firm **G** and propose an acquisition. Indeed, the acquisition option considered above is shared by others in the industry who may be interested in the technology in question. The strategic decision of firm **G** has thus to integrate the risk linked to the actions of competitors.

Our objective is to develop a decision making framework that determines whether it is worth acquiring the innovative firm, and when to perform this acquisition. To manage this flexibility in the presence of the uncertainty; we suggest to make use of the real options approach.

3.2 Notation

In the remainder of this paper, we will use the following notations:

- The efficiency of the technology of firm **G** is denoted by θ^g. We assume that, as this technology is mature, its efficiency is not expected to change. However, our modeling can easily be extended to a time-changing θ^g.
- The technology of firm **S** at time t is denoted by θ_t^s and evolves in time following a stochastic process. We suppose that, if acquisition occurs, this complementarity will be translated by a new technology efficiency function $\theta_t(\theta_t^s, \theta^g)$, that is also stochastic. In the numerical applications (section **??**), we consider a jump process $d\theta_t = \beta\theta_t dq$, where $dq = 1$ with probability $1-\lambda$ and $dq = 0$ with probability λ. β is a positive constant[1].

[1] A similar formulation has been proposed originally by Farzin et al. (1998), where the arrivals of new technology components increase the techno-efficiency of the firm; however, the arrival times of these components is not known in

- Maturity date: At a given date T, we suppose that the technology-efficiency of **S** attains its maturity and remains constant. Hence at T, **G** can acquire the target firm or abandon definitively the acquisition.
- The revenue π per unit of time of the firm **G** depends on the technology-efficiency ($\pi(\theta)$ is an increasing function of θ). This formulation is based on a model introduced by (Huisman and Kort, 2003). For the numerical applications, we consider a linear profit function $\pi(\theta) = \pi_0 + a(\theta - \theta^g)$, where π_0 is a constant representing the profit of firm **G** before the acquisition (i.e. when $\theta = \theta^g$).
- We model the impact of competitors by an exogenous stochastic process σ_t, representing the evolution of their interests in this technology. We consider in section **??** a jump process for σ_t, where it increases by a proportion γ with probability $1 - \alpha$ and remains constant with probability α.
- The cost C of acquisition of the firm **S** is more important when its technology-efficiency level is higher: C is an increasing function of θ. We consider in section **??** a linear cost function $C(\theta) = C_0 + c(\theta - \theta_g)$, where c and C_0 are constants. However, the presence of the competitors has a direct impact on the cost of acquisition[2]. The acquisition cost depends hence on the couple (θ, σ). We consider in section **??** that C depends on σ also linearly.

3.3 Dynamic programming

To evaluate the value of the investment opportunity we will use the dynamic programming approach. This method breaks merely a whole sequence of decisions into two components: the immediate decision, and a valuation function that encapsulates the consequence of all subsequent decisions (the continuation value). The firm **G** has the opportunity to acquire the firm **S** immediately and increase its technology efficiency with a cost depends also on the technology efficiency acquired or waiting one period of time and then deciding whether to invest or to wait another period before making the same decision. This process will depend on the level of the technology efficiency at each period of time.

If, at the instant $t < T$ and for an arbitrary value of technology efficiency $\overline{\theta}_t$ the firm **G** buys **S**, its profit increases due to the acquisition by:

$$\begin{aligned} P_t(\overline{\theta}_t) &= E_{\overline{\theta}_t}\left(\int_t^{\infty} \pi(\theta_s) e^{-\mu(s-t)} ds\right) - \int_t^{\infty} \pi(\theta^g) e^{-\mu(s-t)}) ds \qquad (1) \\ &= E_{\overline{\theta}_t}\left(\int_t^{\infty} \pi(\theta_s) e^{-\mu(s-t)} ds\right) - C(\overline{\theta}_t) - \pi(\theta^g)\frac{e^{-\mu t}}{\mu} \end{aligned}$$

where $\overline{\theta}_t$ is the value of the technology efficiency of firm G at instant t (after the acquisition), $E_{\overline{\theta}_t}(\int_t^{\infty} \pi(\theta_s) e^{-\mu(s-t)} ds)$ the profit if purchase occurs at t (the profit after the acquisition) and $\pi(\theta^g)\frac{e^{-\mu t}}{\mu}$ the profit if the acquisition never takes place. μ is the appropriate discount rate.

advance.

[2] it has been noticed in (Morellec and Zhdanov, 2005) that targeted firms usually take advantage from the competition and the acquisition takes place at higher price.

If **G** decides to wait one period of time Δt before deciding, it gets the expected return of holding the "option to wait" actualized at discount free-rate r.

Let us write the dynamic programming problem of firm **G**, considering a discrete time where decision can occur only at instants separated by an interval Δt. If the **G** acquires at time t and for a combined techno-efficiency equal to $\overline{\theta}_t$, it gets the immediate return $P_t(\overline{\theta}_t) - C(\overline{\theta}_t)$, where $C(\overline{\theta}_t)$ the cost of the acquisition. If it decides to invest later, it gets the expected return of holding the option actualized at discount rate r. One can then write the following Hamilton-Jacobi-Bellman (HJB) equations:

$$O(\overline{\theta}_t) = \max\{P_t(\overline{\theta}_t) - C(\overline{\theta}_t), \frac{1}{(1+r\Delta t)} E[O(\theta_{t+1}, t+\Delta t)|\theta_t]\} \quad (2)$$

where $O(\theta_t, t)$ be the value of the firm's option to acquire **S** at time t (the value of the opportunity of acquisition).

Our approach consists then of comparing the value resulting from immediate investment and from waiting. The value of waiting is the value of the option (the opportunity next period). The basic idea of dynamic programing is simple. It is based on dividing a complex optimization problem into sub-problems where each sub-problem is linked to another one through the HJB equations. We start by solving the problem at the latest day and process of reasoning backwards in time.

3.4 Problem resolution

We now solve the above defined dynamic programming problem for specific techno-efficiency, profit and cost functions defined below.

3.4.1 Profit and cost functions

We consider the following functions for the profit and the cost:

- a linear profit function w.r.t θ (the technology-efficiency of firm **G**):

  $$\pi(\theta) = \pi_0 + a(\theta - \theta^g) \quad (3)$$

  where θ^g is the initial techno-efficiency of the firm **G** and π_0 is a constant representing the profit of firm **G** before the acquisition takes place (i.e. when $\theta = \theta^g$).

- a linear cost function w.r.t θ: when the combined technology-efficiency is equal to θ, the acquisition cost is expressed as

  $$C(\theta) = C_0 + c(\theta - \theta_g) \quad (4)$$

  c and C_0 are constants.

This modeling means that, as long as the technology of firm **S** does not bring an addition to that of firm **G** (the combined techno-efficiency θ if the acquisition occurs is equal to the initial techno-efficiency θ^g), the profit of **G** does not change (even if the acquisition occurs) and the acquisition cost is constant and equal to C_0. If **S** starts bringing gains to the techno-efficiency (i.e. $\theta > \theta^G$), the profit of **G** if the acquisition occurs become larger than its original profit, while the acquisition cost, if it did not yet occur, increases. Note that C is paid once upon acquisition, even if the technology further increases leading to larger profits.

3.4.2 Stochastic process for θ

Although the model developed in this paper is general, we consider that the technological change of the techno-efficiency of the firm **G** by the acquisition of the technology developed by **S** is an exogenous process modeled by the following jump process:

$$d\theta_t = \beta\theta_t dq$$

where $dq = 1$ with probability $1-\lambda$ and $dq = 0$ with probability λ. β is a positive constant.

For all $t > 0$, θ_t, the techno-efficiency at time t verifies: $\theta_t \leq \theta_{max} = (1+\beta)^M\theta_0$. $M = T/\Delta t$ is the maximum number of upward states (the maximum times that the efficiency could go upward). This is illustrated in Figure **??**.

3.4.3 Computation of the acquisition payoffs

We start by computing the net profit of the acquisition at each time and for each value of the efficiency. At the maturity date $t_M = T$, beyond which the technology-efficiency remains constant, where the technology-efficiency equals $\theta_j \in [\theta_0, \theta_0(1+\beta)^M] = \Theta_M$. The interval $[0, M]$ is then divided to M sub-intervals each with length Δt and where $\Theta_n = [\theta_0, \theta_0(1+\beta)^n]$; $1 \leq n \leq M$

To define the net profit of the acquisition we start at the last day "maturity day" and then we determine the evolution of the net profit by backward.

$$P_N(\theta_j) = (\pi(\theta_j, \theta^g) - \pi(\theta_g))\frac{e^{-\mu N}}{\mu} \tag{5}$$

at $t_n < T$, the profit is calculated by the following:

$$P_n(\theta_j) = (\pi(\theta_j, \theta^g) - \pi(\theta_g))\Delta t + [(1-\lambda)P_{n+1}(\theta_{j+1}) + \lambda P_{n+1}(\theta_j)]e^{-\mu\Delta t} \tag{6}$$

A simple backward algorithm can be used to compute the termination values P_n as follows:

1. Start at T and compute, for all $\theta_j \in \Theta_N$, the value $P_N(\theta_j)$ as in equation (5).
2. Move backwards for one step and compute $P_{N-1}(\theta_j)$ using equation (6) for all $\theta_j \in \Theta_{N-1}$.
3. Continue moving backwards until computing $P_0(\theta_0)$, where θ_0 is the value of the technology efficiency of the firm **G** at time t_0.

3.4.4 Dynamic programming algorithm

Let $O_T(\theta_j) = \max[P(T, j) - C(\theta_j), 0]$ be the option value at time T if the technology efficiency is θ_j. At time T, the Firm **G** has two alternatives choices: Invest and get $P(T, j) - C(\theta_j)$ or never invest and get 0. By moving back one period, it gets:

$$O(T-1, j) = \max[P(T-1, j) - C(\theta_j), \frac{\lambda O_T^j + (1-\lambda)O_T^{j+1}}{1+r}]$$

At a time $t < T$, the firm has also two alternatives choices: Invest now and get $P(t, j)$ or wait one period and then decide. At the next period, the efficiency will increase with $1-\lambda$ or remain the same with probability λ. We should then take the expected value of the option to wait actualized at time t.

More precisely, we can write the following algorithm:

- Start at the maturity date T at which a now or never decision should be undertaken.
- at $t = T$ the option is calculated as $O_T(j) = \max[P(T,j) - C(\theta_j), 0]$ for all $0 < j \leq M$
- Move back one period to $T-2$ and calculate O_{T-2} and so on.

$$O(T-1,j) = \max[P(T-1,j) - C(\theta_j), \frac{\lambda O_T^j + (1-\lambda)O_T^{j+1}}{1+r}]$$

Let note $O(t,\theta_j) = O_t^j$ if the technology efficiency does not change, otherwise $O(t,\theta_{j+1}) = O_t^{j+1}$

- The first time t such that $P(t,j) - C(\theta_j) > \frac{\lambda O_{t+1}^j + (1-\lambda)O_{t+1}^{j+1}}{1+r}$ is then the optimal time to acquire with θ_j. This happens when the value of the immediate investment is higher than the expected value of option to wait for this value of the investment cost and this level of technology efficiency.

4 Impact of the competition

The above model neglects the presence of competitors that could forestall the firm **G** and propose an acquisition. Indeed, the repurchase option considered above is shared by others in the industry who may be interested in the technology in question. The strategic decision of firm **G** has thus to take into account the risk linked to the action of a competitor: "And if a competitor decides to acquire the firm before me and deny me access to this technology? " Targeted firms usually take advantage from this competition and the acquisition takes place at higher price (Morellec & Zhdanov, 2005).

4.1 Real options analysis for the acquisition under competition

We model the impact of competitors by an exogenous stochastic process σ_t, representing the evolution of the interest of competitors in this technology. The presence of the competitors has a direct impact on the cost of acquisition of **S**. Hence , the cost of acquisition depends on the couple (θ, σ)[3]. The erosion being considered as exogenous, this allows representing the acquisition problem as a maximization problem that incorporates the erosive impact of competition but ignores any reciprocal effect from the competitors.

The state of the world is then described by the couple (θ, σ). The additional profit of the firm **G**, after its acquisition of the firm **S** at time t is still computed as in equation(1) (it only depends on the techno-efficiency and not on the competitors). However, the acquisition cost depends on both variables: $C(\overline{\theta}_t, \overline{\sigma}_t)$.

At each date t, let $\Theta(t)$ and $\Sigma(t)$ be the state spaces representing all the possible realizations for θ_t and σ_t, respectively. A dynamic programming algorithm, similar to the one presented in the previous

[3]While the techno-efficiency θ can be estimated by the technical experts of firm **G**, e.g. by analyzing the patents produced by firm **S**, the pressure of the competition is less tangible and has to be evaluated using market intelligence techniques.

section, can be applied, taking in consideration the development of the intensity of competition σ in addition to the techno-efficiency θ:

$$\acute{O}_n(\theta_j, \sigma_l) = max[P_n(\theta_j) - C(\theta_j, \sigma_l); \sum_{(\theta_k, \sigma_l) \in \Theta_n \times \Sigma_n} p_j^n(k) q_l^n(i) \acute{O}_{n+1}(\theta_k, \sigma_i) e^{-r\Delta t}] \quad (7)$$

with $q_l^n(i)$ the probability of the transition concerning the intensity of competitors, from the value $\sigma_l \in \Sigma_n$ at the instant n to the the value $\sigma_i \in \Sigma_{n+1}$.

4.2 Hedging against competition by a tight cooperation

The problem formulated in the previous section illustrates the negative impact of the competition on the firm's decision: it increases that risk that the acquisition cost increases, leading generally to a premature investment. We now consider the common case where the large firm hedges against competition by an exclusive partnership with the small firm. This may consist of different modes of tight cooperation as analyzed in [Duysters & Hagedoorn, (2000)], among then we cite the following:

- One-directional technology flow, Second-sourcing, licensing
- Customer-supplier relations, R&D contract, Co-production, Co-makership
- Minority investment, minority and cross-holding
- Joint R&D, such as research pacts and joint development agreements.

We consider in this paper, for modeling simplicity, these forms of partnership between large and small firms as forms of partial acquisition that help hedging against the intervention of the competitors; the firm **G** guaranteeing a sort of exclusivity over firm **S** during some time.

At $t = 0$, the company **G** is thus facing a strategic decision to apply one of the following:

- partial acquisition,
- total acquisition,
- waiting for future developments.

It is clear that these actions are not exclusive, in the sense that a partial acquisition can be seen as a first step before a total acquisition. However, a partial acquisition allows to hedge against the risk of competitors.

A careful look to this three actions option shows that it can be decomposed into two classical real options at $t = 0$:

- If the firm **G** pays a "premium" at $t = 0$ allowing her to have the exclusivity on **S** until a maturity date T, the option reduces to a proprietary real option identical to that described in section 3.3.
- Otherwise, this is a real option with competition identical to that described in section 4.1.

The dynamic programming algorithms described in sections 4.1 and 3.3 can then be used to evaluate this new option. These algorithms give the values of the two options with and without competition at $t = 0$: $\acute{O}$ and O, respectively.

The firm **G** , at $t = 0$ is thus ready to pay up to $V = O - \acute{O}$ for the partnership with **S** at time 0. We call this value V the premium of the partnership option.

5 Numerical results

We illustrate in Figures 1-5 below the real options framework developed in this paper for both cases (with and without competition).

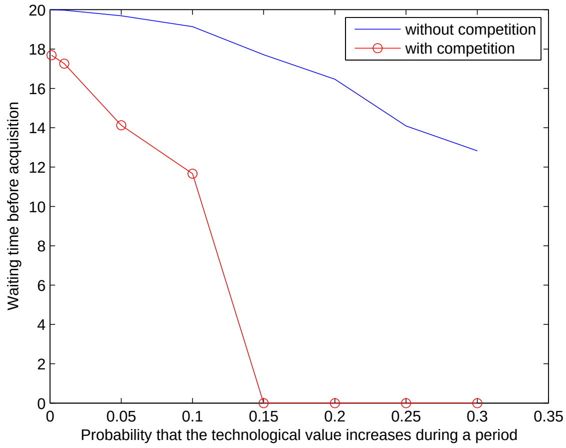

Figure 1: Impact of the technological potential of firm **S**. (Ã enlever courbe rouge)

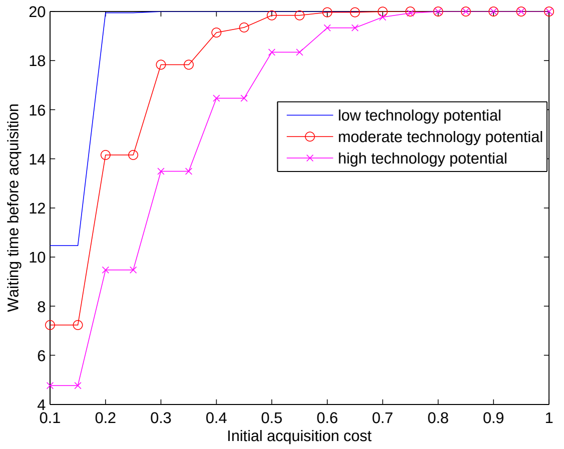

Figure 2: Impact of the initial acquisition cost.)

5.1 Acquisition decision with no competition

We first focus on the case of the proprietary option when there is no competition pressure. We illustrate the waiting time, i.e. the average time before the large firm decides to acquire the small one. We study the impact of two system parameters: the technological potential of firm **S** (Figure 1) and the initial acquisition cost (Figure 2).

Figure 1 shows the probability of acquisition of the firm **S** function of the probability that the techno-efficiency increases at each time step $(1-\lambda)$. It can be observed that the larger the technological potential of the firm **S** (a smaller λ), the more likely the acquisition will occur.

Figure 2 plots the expected time before acquisition as a function of C_0, the initial cost of acquisition for different values of λ. This figure shows that a high level of techno-efficiency accelerates the decision of acquisition while a high initial acquisition cost favors waiting. It is worth noting that the initial acquisition cost depends on many factors like the initial investment paid by firm **S**.

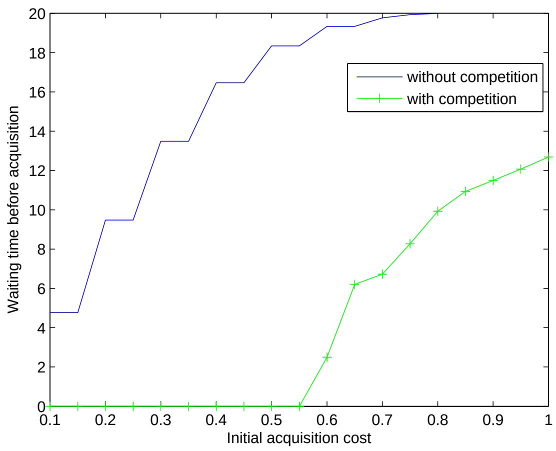

Figure 3: Waiting time in presence of competition)

5.2 Impact of competition

We first illustrate the impact of the competition on the decision to acquire. Figure 3 shows that the presence of competitors accelerates substantially the decision to acquire, i.e. for the same initial cost C_0, firm **G** tends to invest earlier. Indeed, the presence of competitors puts pressure on the firm **G** by increasing the risk that the cost will be higher in the future. This pressure encourages the firm **G** to invest prematurely in order to hedge against this risk. This result is corroborated by the literature that indicates that "competition speeds up acquisition process" (Morellec and Zhdanov, 2005).

We now illustrate in Figure 4 another indicative parameter that is the probability that the acquisition occurs, function of the technological potential of firm **S**. For large technological potential, this probability tends to 1 as it is almost always beneficial for firm **G** to invest in **S**. This probability increases also when competition occurs for the same reasons explained above.

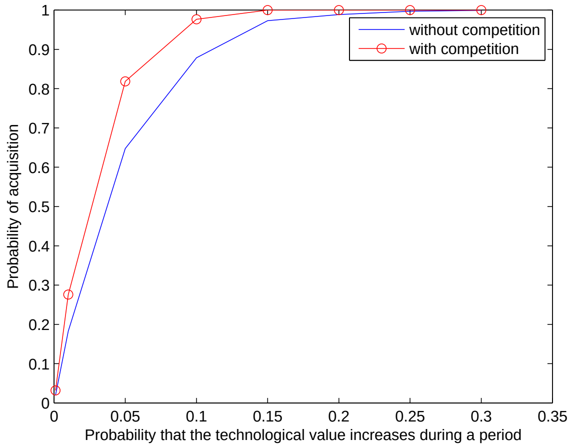

Figure 4: Probability that acquisition occurs.

Figure 5 illustrates the case of risk hedging by a partnership. It plots the value of the premium, i.e. the amount of money firm **G** would accept to invest in a partnership with **S** guaranteeing exclusivity on it until its technology reaches maturity. First, this value is (always) positive, as the competition encourages the firm to acquire earlier, reducing the value of the waiting option. The value of this acquisition also increases with the initial cost of acquisition: when the C_0 is high, the risk of loss in case of acquisition is greater and the firm **G** has the means to wait for the resolution of the uncertainty without being jostled by the competition.

"Acquisitions of target firms are frequently preceded by equity investments in the targets (Mikkelson and Ruback, 1985; Choi, 1991)."

6 Conclusion and future research perspectives

In this paper, we developed a real options framework for decision making in technology acquisition through the purchase of innovative firms. We started by the simple monopolistic case where a large firm is interested in a small innovative one and presented a dynamic programming algorithm that evaluates the acquisition opportunity and estimated the waiting time before the purchase. We then generalized the algorithm to the case when competition is also interested in the technology of the target firm and showed that the pressure of the competition accelerates the purchase decision. This analysis led us to the evaluation of the opportunity of partial acquisition as a risk hedging against competition. We then showed how to derive the value of this risk hedging option.

When evaluating the acquisition decision, we modeled the impact of the competitors by an exogenous process that represents the interest of competitors in the target technology. This approach is similar to the classical real options literature that, inspired by financial options, modeled competition as an option with dividends (Trigeorgis (1991), Smit & Trigeorgis (2007, 2012)). For instance, Smit & Ankum (1993) considered that a deferred project in monopoly situations is similar to a call option

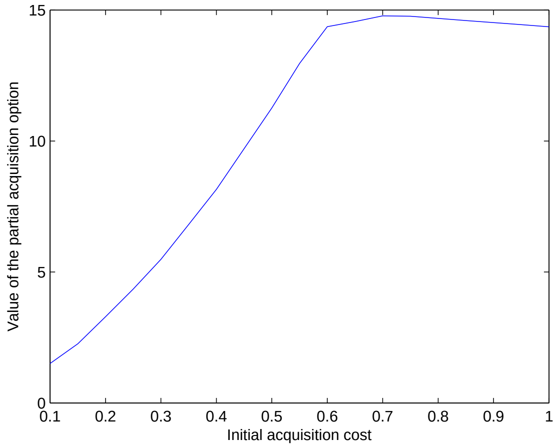

Figure 5: Value of the partnership for firm **G**.

on a stock characterized by a constant dividend payout ratio, while a perfect competition situation corresponds to a variable dividend rate. In the latter case, the influence of each individual company on the others is negligible, eliminating direct interaction between actors. Erosion is then considered as exogenous allowing to continue representing the investment problem as a maximization problem that incorporates the erosive impact of competition but ignores any reciprocal effect from the competitors. However, the real investment opportunities are in general open to a limited number of competing firms in the same industry, subject of course to the core competencies of each firm. Direct interaction between these competitors is then inevitable, with considerable impact of the action of a firm on the investment opportunities of the others, and the possibility of a response action on the part of the latter. One speaks in this case of a "shared real options" that is "jointly held by a number of competing firms, or even by an entire industry, and can be exercised by any one of the collective owners" (Smit and Trigeorgis, 2012), in contradiction with the "proprietary real options", open to a single firm. This presence of competitors leads thus to strategic interactions between the holders of the option that can be considered in the dynamic programming algorithm. This will be the subject of a future work.

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