On the optimality of funding and hiring/firing according to stochastic demand: The role of growth and shutdown options

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1. Introduction

The literature on investment theory and cost of capital has been initiated by the seminal paper of Modigliani and Miller (1958). Further extensions have examined its robustness with respect to various market frictions including for example transaction costs. Real frictions, taking account of imperfections, can explain why Modigliani and Miller assumptions can be violated. For instance, there exists an uncertainty about the level of future cash-flows. Additionally, investment is often partially irreversible.\(^1\)

As proved by Pindyck (1988), the investor can benefit from the option to wait before investing. Usually, the option to invest is exercised as soon as the expected discounted cash-flows are higher than the sunk investment expenditures. McDonald and Siegel (1986) have illustrated this case when the value of the investment project evolves as a geometric Brownian motion and only one output is produced. In that case, the optimal investment strategy is a trigger one: the option to invest is exercised at the first time the value of the investment project exceeds a critical threshold (see Dixit and Pyndick, 1994).

As mentioned by Décamps et al. (2006), research on investment under uncertainty has also emphasized the key role of entry and exit decisions (Dixit, 1989), the flexibility of incremental capacity choice (Kandel and Pearson, 2002; Pindyck, 1988), the shutdown options (McDonald and Siegel, 1986), the costly reversibility (Abel and Eberly, 1994, 1996; Laughton and Jacoby, 1993), and finally, the sequential nature of investment decision (Bar-Ilan and Strange, 1998; Majd and Pindyck, 1987). Therefore, both financing and investing decisions must be analyzed according to such real options, as illustrated by Quigg (1993, 1995), Schwartz (1988, 1997), Trigeorgis (1996) and Abel and Eberly (1994, 1999). Extending previous results by Abel and Eberly (1996), Tserlukevich (2008) introduces a model that can potentially explain some empirical financing patterns. Investment irreversibility can be either complete or partial, with or without fixed investment costs. One single or multiple growth options can be available. When the market demand follows a geometric Brownian motion, the leverage ratio can be constant or can be time-varying according to the presence of the growth option. Following Capozza and Li (1994) and Bar-Ilan and Strange (1999) but introducing an abandonment option, Wong (2010) examines how changes in irreversibility of investment affect the timing and intensity of lumpy investment.

In this paper, contrary to Abel and Eberly (1996) and Tserlukevich (2008), we introduce another important factor namely the employment level. As illustrated by Faria et al. (2010), there exists a strong relation between entrepreneurship and employment level.\(^2\) More generally, the employment level of a given firm and its potential flexibility\(^3\) have a big impact on its performances that we illustrate on the global firm...
Finally, we consider both previous cases. Depending on demand level, whether or not the demand level reaches given thresholds. The residual value of the equity \( E_t(S_t, K_0, L_0) \) is the sum of the net present value at time \( t \) corresponding to initial capital \( K_0 \) and employment level \( L_0) \) net of debt, that is

\[
max(1-\tau)E_t \left[ \int_t^{T_1^+} e^{-r(t-T_1^+)} K_0^\alpha L_0^\beta S_0^d s ds \right] - D_t
\]

and a part of the growth option value equal to:

\[
max(1-\tau)E_t \left[ \int_{T_1^+}^{\tau} e^{-r(t-T_1^+)} K_1^\alpha L_1^\beta S_0^d s ds \right] - \tau e^{-r(T_1^+)} C(K_0, K_1^+, L_0^+, L_1^+) \]

We consider the cost associated with the additional investment and labor levels. For the investing/hiring case, both costs are proportional to respectively \((K_1^+ - K_0)\) and \((L_1^+ - L_0)\) with proportion coefficients respectively equal to \(\rho_t > 1\) and \(q_t > 1\):

\[
C(K_0, K_1^+, L_0^+, L_1^+) = \rho_t (K_1^+ - K_0) + q_t (L_1^+ - L_0).
\]

The optimal time \( T_1^+ \) corresponds to the first time at which the demand \( S \) reaches the barrier \( S_{\text{max}} \).
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