

Buyouts under the threat of preemption

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Abstract

This paper analyses the effects of preemption fears on the buyout efficiency when firms combine non-synergistic operational activities and have asymmetric access to financing. Bidders with preemption fears are more likely to acquire target firms at an earlier development stage. However, if uncertainty is high, an acquirer may opt to wait and buy the target firm at a later stage as assets in place. The fear of preemption affects the efficient exercise of each offer differently. While the timing of a hostile takeover under threat of preemption converges to an efficient global optimiser threshold, negotiated mergers are exercised inefficiently too early. Premiums to the target firm are higher when the firm is acquired at an earlier stage, and when the bidder fears being preempted.

Keywords: Buyouts, Real Options, Fear of Preemption

JEL Classification: G34, G13, G32

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1. Introduction

Buyouts are a quite important form of ownership change in the mergers and acquisitions (M&A) market. Acquirers in this market are mostly financial intermediaries such as private equity funds. Many target firms rely on the funding provided by financial intermediaries. Relatively cheaper financing provided by these intermediaries may create financial synergies. For example, Mr Reynolds the CEO of Puget Energy and PSE explained a rationale behind the recent deal as “The merger will provide us with USD 5 billion over the next five years, insulating us from volatility in the public equity markets. Partnering with the Consortium, which is comprised of committed and experienced long-term infrastructure investors, will provide the best end result for our customers, our employees and the communities we serve in western Washington. This will be business as usual, only better.”¹

The buyout market is quite competitive and the M&A transaction is typically a complex decision. Firms must decide on the terms and timing of the acquisition under the fear of preemption. However, there is contradictory evidence on how competition affects the deal. For example, there are concerns among investors and policymakers that competition reducing behavior through forming consortiums, harms target shareholders, yet on the other hand it has been shown that reduced competition does not always harm target shareholders (Boone and Mulherin (2011)). Moreover, private equity firms are typically perceived as investors in mature markets, yet they often also buy growth capital (Phalippou (2014)).²

It remains an open question, then, how (i) the offer type, (ii) firm-life cycle, and (iii) competition among bidders interact to form both the terms and timing of acquisitions made by a financial intermediaries. Consider recent developments in the private equity market in the US where a raise in the number of private equity firms increases the competition among them for the potential set of target firms. Many offers are made as takeovers where the target typically gains bargaining power over the price. Yet, there are also firms that decide to negotiate the deals first.

This paper studies how competition affects deal efficiency (i.e. M&A surplus) in a dynamic

¹Zephyr, Deal No 588261

²“Titans turn attention to Silicon Valley”, Financial Times, 2015

environment, depending on the offer type, where the bidder has to decide on whether to acquire the target firm early as a growth option (i.e., prior to commercialization), or whether to wait and acquire it later, as assets generating profits. The buyout market provides an intuitive setting to study the effects of competition on the timing of a friendly merger or hostile offer and its efficiency. Friendly mergers occur when firms enter into agreement to acquire and the division of M&A surplus and timing are negotiated simultaneously, while during hostile takeovers the target dictates the terms and the acquirer subsequently decides on the timing.

I address a number of novel research questions in this study. First, I explore the characteristics that determine the choice between acquiring the target as a growth option or as assets in place. Second, I examine whether the synergies differ depending on the target firm's stage of development. Third, I analyse how the fear of preemption affects each type of offer, either friendly merger or hostile takeover. I find that firms tend to be acquired as growth options if uncertainty is low and the acquirer fears being preempted. Furthermore, the acquirer is more likely to buy the target as a growth option if corporate taxes are higher, the target is small, and if it has a high growth rate and low bankruptcy cost.

The core prediction of the model is that the fear of preemption has different implications depending on the negotiation process between the acquirer and the target firm. In the case of a merger agreement, the fear of preemption can erode option value and force the merger timing to converge to the break-even threshold. In the case of a hostile takeover, however, the fear of preemption erodes the acquirer's option, and the timing of the acquisition converges to the global optimizer first-best merger threshold. The intuition behind this prediction is that if the target firm acts as a Stackelberg leader and decides on the terms first, it can preserve the value of the option to wait and obtain an efficient share in synergies.

To address these research questions, I develop a model framed within the real options literature, where firms make investment and financing decisions. These techniques are key to my results because they allow me to model the dynamic development of a target firm that is initially financed by equity and has an investment option. The target firm's profits are subject to corporate taxes, which provides an incentive to finance the cost of investment

using debt due to tax shield benefits. However, debt issuance for the target firm is costly, and the firm must pay a proportional issuance cost. This in turn affects the optimal capital structure and investment.

The acquirer has an option to buy the target firm and both firms can obtain financial synergies when the acquirer facilitates access to financing for the target and changes its optimal capital structure. The acquirer can thus exercise its option to buy the target firm either before or after the investment exercise threshold. Note that, in my model, the acquirer is a financially unconstrained firm that can raise financing costlessly, as in McDonald and Siegel (1986).

The acquirer's decision is subject to the underlying diffusion process that is the cash flow risk. The target firm delays the investment exercise if issuing financing is costly. The acquirer can take over the target firm and provide cheap financing. The acquirer also faces a risk of preemption from other bidders, which is modelled as a jump process. The decision about whether to acquire the target firm as a growth option or as assets in place is an outcome of the financial constraints that bind the target, and of the competition among interested bidders.

I solve the model using continuous time techniques. First, I solve the investment and financing problem of the target firm. Second, I solve the optimization problem of the acquirer as: i) global optimum, ii) merger negotiation, or iii) hostile takeover. I find closed-form solutions for investment and acquisition thresholds, and determine when the bidder is likely to acquire growth opportunities or physical assets. If the target firm is financially constrained, the decision to invest is delayed, which strengthens the incentives of the acquirer to buy the target firm, and enhances the synergies by providing financing.

Most of the extant M&A literature has focused on operational or financial synergies when firms combine their assets in place (e.g., Lambrecht (2004); Leland (2007); and Malenko and Malenko (2015)). Yet, none of the previous papers analysed the acquirer decision as a sequential option under the threat of preemption. This paper proposes a model, where synergies arise due to asymmetric access to financing and aims to complement the existing literature by analysing the effects of acquiring growth options or assets in place in competitive

environment.

The model contributes to the previous literature in several ways. First, the model is related to the literature on merger and acquisition decisions within a real options framework as it studies the timing of buyout decision motivated by asymmetric access to financing when the acquirer can buy growth options or assets in place. The existing literature solves for the optimal timing only if firms acquire assets in place. For example, Lambrecht (2004), Lambrecht and Myers (2007), and Bernile, Lyandres, and Zhdanov (2011) study the terms and timing of mergers and acquisitions that are motivated by operational synergies and strategic reasons when two firms combine assets in place. Morellec and Zhdanov (2008) highlight the strategic role of debt in the bidding process. Hege and Hennessy (2010) present an analysis where the level of debt plays a strategic role in benefiting from a larger merger share.

Second, the paper contributes to the literature that analyses the effects of competition on investment decisions. Previous literature shows that firms do not take investment decisions in isolation and competition affects the terms and timing of corporate investment.³ For example, Morellec and Zhdanov (2005) show that the competition for the target firm speeds up the takeover process, and erodes the ownership stake of bidding shareholders. Calcagno and Falconieri (2014) study the impact of competition on the outcomes of takeovers. Also many empirical studies highlight the importance of competition among acquirers.⁴ Yet, none of the previous papers analyses how competition affects the timing of the different offer type and its efficiency. I contribute to the previous literature by analysing the effect of competition when the transaction is structured as friendly merger or hostile takeover.

Third, the model is related to the literature on financial synergies of mergers and acquisitions. Financial synergies arise when changes in the scope of the firm affect the optimal

³For example, Hackbarth and Miao (2012), Hackbarth, Mathews, and Robinson (2014), Bustamante (2015), Bustamante and Donangelo (2017)

⁴Ruback (1983) is an early example of empirical studies that examine the presence of competition in the acquisitions market by looking at returns. Boone and Mulherin (2007b), Boone and Mulherin (2007a) and Boone and Mulherin (2009) are among the first studies that provide comprehensive evidence of competition in the takeovers market. Aktas, de Bodt, and Roll (2010) show that the probability that rival bidders appearing affects the negotiation process and reduces the bid premium.

capital structure (Lewellen (1971); Stapleton (1982)). This paper shares some features with Leland (2007), who derives a model where only financial synergies motivate merger decisions. In contrast to previous literature, I contribute by analysing synergies that arise due to asymmetric financing.

Finally, the paper is also related to the literature on buyout transactions. Marquez, Nanda, and Yavuz (2014) discuss the matching between limited and general partners in private equity setting. Humphery-Jenner (2012) explains the size effects observed in private equity. Margsiri, Mello, and Ruckes (2008) show that acquisitions may be an important outside option as opposed to internal growth. Furthermore, Malenko and Malenko (2015) show that operational and financial sources of value creation in leveraged buyouts are complements. I contribute to the extant literature by showing that the contradictory prediction for the effects of competition on the deal efficiency might be explained by the effect of fear of preemption on different offer type.

The remainder of this paper is organized as follows. Section 2 presents an outline and my model's assumptions. Section 3 presents closed-form valuation formulas and the investment threshold when it is costly to issue financing. Section 4 presents a discussion of the financial synergies of buyout, and the optimal timing of the global optimizer. Section 5 analyses the effects of preemption fears on the decision terms and timing, while section 6 explores the decision to acquire either growth options or assets in place, and includes numerical examples. Section 7 discusses premiums. Section 8 concludes.

2. Model and assumptions

Acquirers i.e. financial intermediaries are defined as firms without any internal growth potential, but with the ability to finance projects at low cost. The acquirer's growth strategy is to buy unexercised production opportunities or assets in place of other firms. The acquirer acts as in McDonald and Siegel (1986) setting, and can raise funds costlessly. It is, however, subject to the fear of preemption. Competitors that have the same strategy to acquire lucrative investment opportunities can arrive randomly, with intensity δ (the fear of preemption

as in Hackbarth, Mathews, and Robinson (2014) and Morellec, Valta, and Zhdanov (2014)).

The target has a production opportunity that is associated with sunk cost κ . The target is subject to underinvestment because of the high cost of issuing financing to cover the capital outlay.⁵ It can either issue debt or equity to finance its project, and it must pay the proportional issuance cost (ι_d or ι_e). However, a high issuance cost may delay the investment exercise. In that case, the target firm can be acquired by another company that facilitates access to cheap financing. The acquirer can either propose a merger agreement or make a hostile offer to the target shareholders. The acquirer can buy the firm as a growth option when the optimal acquisition threshold is lower than the investment trigger of the financially constrained target firm. Otherwise, the bidder can buy the target firm after the production opportunity is commercialized.

Investors can borrow and lend at the risk-free interest rate (r). Managerial incentives are aligned with maximizing the wealth of equityholders. Investment irreversibility implies that, once exercised, the decision cannot be costlessly reversed. Assets in place and growth options are subject to the same source of uncertainty x_t , which follows a geometric Brownian motion:

$$dx_t = \mu x_t dt + \sigma x_t dW_t \tag{1}$$

where $\mu < r$ is a deterministic drift, $\sigma > 0$ is volatility, and dW_t is the standard Brownian motion process.

Note further that taxes can affect a firm's capital structure. The optimal coupon is chosen to balance the tax advantage of debt with expected bankruptcy costs. When the firm has debt in place, the default threshold is chosen endogenously by equityholders.

⁵The finance literature offers some explanations for why firms may forgo positive NPV investment opportunities and underinvest: financial constraints (Fazzari, Hubbard, and Petersen (1988) and Boyle and Guthrie (2003)) and debt overhang (a conflict between shareholders and debtholders as part of the project's NPV financed with equity is captured by debtholders when debt is risky), as in Myers (1977).

3. Investment when financing is costly

To determine the optimal investment threshold of the target firm, I solve the game backward, as follows. First, I solve for post-investment values when it is costly to issue debt or equity. Second, I derive closed-form solutions for the optimal investment threshold.

3.1 Value of the firm after investment

Before the firm exercises its production opportunity, its shareholders receive capital gains over each time interval.⁶ Throughout the paper, I denote the equity value of the innovative firm before investment as $V_{I,j}$, and the post-investment values of debt, equity, and firm value as $B_{I,j}^+$, $E_{I,j}^+$, and $V_{I,j}^+$, where j stands for the type of growth option financing, which is either equity (E) or debt (D).

When the growth option is exercised by issuing equity at a cost of ι_e , the firm starts to generate after-tax cash flows of $(1 - \tau)\pi x_t$ at each instant of time. The unlevered value of the firm after investment exercise is therefore:

$$V_{I,E}^+(x) = E_{I,E}^+(x) = \frac{(1 - \tau)\pi x}{r - \mu} \quad (2)$$

The value of the equity after the firm exercises the growth option at cost κ is the discounted present value of cash flows $(1 - \tau)\pi x_t$. We can interpret μ as the cash flow growth rate from the Gordon growth model. The issuance cost of equity (ι_e) does not affect the post-investment equity value, because it is a sunk cost paid at the time of investment.

The target firm can also issue risky debt to cover the investment cost (κ) and pay the proportional issuance cost of debt (ι_d). After the investment option is exercised, the cash flows and tax benefits accrue until default. But debt is risky, so equityholders are left with nothing at liquidation. However, bondholders are entitled to scrap value of the firm's assets left at default, which I represent as $(1 - \varphi)\phi x_{I,D}/(r - \mu)$, assuming $\phi < (1 - \tau)\pi$, where $\frac{\phi x_t}{r - \mu}$ is the first-best firm value when the firm is liquidated, φ is the decrease in firm assets

⁶I assume that the firm issued equity in order to expand its operations. It can thus finance the development of the production opportunity, which is not yet generating any cash flows.

at bankruptcy, and $\varphi \in (0, 1)$. When $\varphi = 0$, debtholders can recover the firm assets at bankruptcy. When $\varphi = 1$, the investment cannot be reversed costlessly.

Note that $\underline{x}_{I,D}$ is the default threshold selected by equityholders. The coupon $c_{I,D}(x, \iota_d)$ maximizes the firm value net of the issuance cost of debt after the investment exercise, which is shown by: $V_{I,D}^+(x, \iota_d) - \iota_d B_{I,D}^+(x, \iota_d)$. Using standard techniques, I calculate claims values and an optimal closure threshold. I present the results in the following lemma.

Lemma 1 *The optimal equityholders' closure threshold is:*

$$\underline{x}_{I,D} = \frac{\lambda}{(\lambda - 1)} \frac{(r - \mu)}{r} \frac{c_{I,D}(x, \iota_d)}{\pi} \quad (3)$$

where λ is a negative root of the quadratic equation $1/2\sigma^2 z(z - 1) + \mu z - r = 0$. The optimal coupon maximizing firm value is:

$$c_{I,D}(x, \iota_d) = x\pi\Omega^{1/\lambda} \frac{r}{r - \mu} \frac{\lambda - 1}{\lambda} \quad (4)$$

where , and given that $\tau > \iota_d$:

$$\Omega = 1 - \lambda \frac{(1 - \iota_d)(\pi - (1 - \varphi)\phi)}{\pi(\tau - \iota_d)} \quad (5)$$

Firm value when financing is costly ($\iota_d > 0$) is:

$$V_{I,D}^+(x, \iota_d) = x\Psi \quad (6)$$

where $\Psi = [\pi(1 - \tau + (\tau - \iota_d)\Omega^{1/\lambda})] / (r - \mu)$. Firm value when financing is costless ($\iota_d = 0$) is:

$$V_{I,D}^+(x, 0) = x\Phi \quad (7)$$

where $\Phi = \Psi(\iota_d = 0)$

Proof. See Appendix A. ■

The issuance cost of debt imposes financial frictions on the target firm. When a firm uses

debt to finance investment, the proportional issuance cost (ι_d) decreases the coupon that the firm can issue, which is lower than the first-best coupon $c_{I,D}(x, \iota_d) < c_{I,D}(x, 0)$. This in turn lowers the value of the firm after investment exercise, and $V_{I,D}^+(x, \iota_d) < V_{I,D}^+(x, 0)$. the higher the issuance cost of debt, the more severe the target firm's underinvestment problem. However, the presence of an external investor who can provide access to cheap financing can alleviate this problem.

3.2 Optimal investment exercise and financing terms

Before exercising an investment, the target firm decides on the timing and the financing strategy. When equity is issued, firm value is affected by the proportional sunk issuance cost at the time of investment. When debt is issued, the issuance cost affects the coupon as well as the post-investment firm value. Thus, the form of financing affects both the investment surplus and the optimal investment exercise.

Prior to the investment exercise, the shareholders of the target firm obtain capital gains $\mathbb{E}[dV_{I,j}(x)]$ over each time interval dt , because the firm is not yet generating cash flows. I solve this problem by using a standard ordinary differential equation (ODE) subject to boundary conditions. The solution is discussed in more detail in Appendix B and provides the following results:

Lemma 2 *The investment threshold of the target firm when the investment is financed with equity is:*

$$\bar{x}_I^c(\iota_e > 0) = \frac{\beta}{\beta - 1} \frac{(r - \mu)\kappa}{(1 - \iota_e)(1 - \tau)\pi} \quad (8)$$

The investment threshold of the target firm when the investment is financed with debt is:

$$\bar{x}_I^c(\iota_d > 0) = \frac{\beta}{\beta - 1} \frac{(r - \mu)\kappa}{(1 - \tau + (\tau - \iota_d)\Omega^{1/\lambda})\pi} \quad (9)$$

where β is a positive root of the quadratic equation $1/2\sigma^2z(z - 1) + \mu z - r = 0$. When the investment is financed with equity, the value of the target firm over the continuation interval

$x < \bar{x}_{I,j}$ is:

$$V_{I,E}(x, \iota_e) = x^\beta \frac{\kappa}{\beta - 1} \left[\frac{\beta - 1}{\beta} \frac{(1 - \tau)(1 - \iota_e)\pi}{(r - \mu)\kappa} \right]^\beta \quad (10)$$

When the investment is financed with debt, it is:

$$V_{I,D}(x, \iota_d) = x^\beta \frac{\kappa}{\beta - 1} \left[\frac{\beta - 1}{\beta} \frac{\Psi}{\kappa} \right]^\beta \quad (11)$$

For investments financed with debt, we can rewrite the above equations as the value of the growth option and the future tax shield: $V_{I,D}(x, \iota_d) = GO(x, \iota_d) + FTS(x, \iota_d)$, where the value of the growth option is:

$$GO(x, \iota_d) = \left[\frac{(1 - \tau)\pi x}{r - \mu} - \kappa \right] \left(\frac{x}{\bar{x}_{I,D}} \right)^\beta \quad (12)$$

and the value of the future tax shield is:

$$FTS(x, \iota_d) = \left[\frac{\pi x (\tau - \iota_d) (\Omega)^{1/\lambda}}{r - \mu} \right] \left(\frac{x}{\bar{x}_{I,D}} \right)^\beta \quad (13)$$

Proof. See Appendix B. ■

Lemma 2 provides a closed-form solution for the optimal investment exercise threshold when the cost of investment is financed by issuing equity or raising risky debt. Comparative statics illustrate the standard predictions of the real options literature. Note that the investment threshold is delayed when the cost of investment (κ) increases, or when the size of the growth option (π) decreases. Higher corporate taxes also delay investment. Although there is an increase in the tax shield when the corporate tax rate (τ) increases, this effect is offset by a decrease in the present value of after-tax cash flows. Uncertainty (σ) can further delay investment exercise due to the value of waiting.

Consider a case when the target firm chooses to finance investment costs with equity. It would thus not benefit from the tax shield related to debt. I show that, if an investment is financed with debt, the value of the firm is the sum of the value of the growth option and the discounted value of the tax shield that begins accruing after the investment option

is exercised. I also demonstrate how firm value can be destroyed by using a suboptimal financial structure, as in the following equation.

$$\frac{V_{I,E}(x, \iota_e)}{V_{I,D}(x, \iota_d)} = \left(\frac{(1 - \iota_e)(1 - \tau)}{1 - \tau + (\tau - \iota_d)\Omega^{1/\lambda}} \right)^\beta < 1 \quad (14)$$

If the investment is financed with debt, the value of the firm is comprised not only of the growth option, but also of the net present value of future tax benefits. Higher future cash flows speed up the investment threshold, therefore: $\bar{x}_{I,D} < \bar{x}_{I,E}$. This effect is consistent with the accelerated investment effect of Lyandres and Zhdanov (2010). They show that, when shareholders have no incentive to underinvest due to wealth transfers related to the presence of debt (the standard debt overhang problem of Myers (1977)), they will instead speed up investment.

4. Buyout investment and optimal timing

In this section I present an alternative form of financing which is provided to the target firm by an external investor who can raise funds costlessly. I assume that the external investor provides debt financing, because the cost of issuing debt is lower than the cost of issuing equity.

I define the external investor as a firm whose growth strategy is to acquire production opportunities or assets of other firms. Most of its acquisition deals are subsidiary mergers. The acquirer creates a shell subsidiary, whose stock is then used to acquire the stock of the target company. Gaughan (2011) The acquirer thus acts as a shell company and can finance the target firm as a separate project.

The investment problem of the acquiring firm is a two-stage project. The bidder has an option to acquire the target firm, which is worth $OM(x)$. In the first stage, the acquirer buys the target at an optimal merger threshold \bar{x}_M , and pays the sunk cost of K_M to cover restructuring costs. In addition, the target firm pays K_T , which is the sunk cost associated with the transaction processing. In the second stage, the growth option is exercised at an optimal first-best investment threshold $\bar{x}_I^o(\iota_d = 0)$ at a sunk cost κ , provided the acquisition

takes place before the investment exercise threshold of the financially constrained target firm $\bar{x}_I^c(\iota_d > 0)$.

The acquirer can buy the target firm as a growth option, and keep the investment 1) unexercised (if $\bar{x}_M < \bar{x}_I^o$), 2) as a growth option with immediate investment exercise (if $\bar{x}_I^o \leq \bar{x}_M < \bar{x}_I^c$), or 3) as assets in place (if $\bar{x}_I^c \leq \bar{x}_M$).

In each region, the synergies created depend on the target firm's phase of development. In the subsequent subsection, I decompose these synergies. I then determine the first-best merger threshold from which I can capture the dynamic aspects of the acquirer's decision.

4.1 Decomposition of synergies

An acquisition can change the value of the target firm by relaxing financial constraints. In this paper, I disregard synergies that result from revenue increases or cost efficiencies. If they exist, they will be supplementary to the synergies that I analyse. I focus solely on synergies created by facilitating the target firm's access to financing.

I define the option to invest $OI(x, 0)$ as a production opportunity when financing is raised costlessly, as in McDonald and Siegel (1986), and $OI(x, \iota_d)$ when it is costly. The total synergies that accrue to the acquirer, denoted as $\Delta(x, \iota_d)$, are the difference between the two options' values $OI(x, 0)$ and $OI(x, \iota_d)$. I can therefore define total synergies as follows:

$$\Delta(x, \iota_d) = OI(x, 0) - OI(x, \iota_d) \quad (15)$$

where:

$$OI(x, 0) = \begin{cases} V_{I,j}(x, 0) & x < \bar{x}_I^o \\ V_{I,j}^+(x, 0) & x \geq \bar{x}_I^o \end{cases} ; \quad OI(x, \iota_d) = \begin{cases} V_{I,j}(x, \iota_d) & x < \bar{x}_I^c \\ V_{I,j}^+(x, \iota_d) & x \geq \bar{x}_I^c \end{cases}$$

The acquirer compares the value of the target under each scenario. The characteristics of the total synergies depend on whether the acquirer buys the target firm as a growth option or as assets in place.

To isolate the effects of alterations in company ownership, I separate total synergies into three groups: the limited liability effect, the leverage effect, and the asymmetric financing effect. For the first two effects, I follow Leland (2007), and identify the synergies that arise due to the limited liability (LL) and leverage effect (LE). LL is associated with changes in the value of the option to abandon the firm if cash flows fall below the critical level. LE is associated with changes in the value of the tax shield (TS) and default costs (DC).

The asymmetric financing (AF) effect arises when the target firm is in an early stage of development and is subject to financial constraints. The acquirer provides access to cheaper financing, thus ensuring that the option to invest is exercised effectively. The acquirer does not have an option to refinance the debt of the target firm after the investment exercise. Total synergies can be decomposed as follows:

$$\Delta(x, \iota_d) = LL(x, \iota_d) + TS(x, \iota_d) + DC(x, \iota_d) + AF(x, \iota_d) \quad (16)$$

However, I show here only the incremental effects of synergies on the acquirer's value. I analyse total synergies over three regions when it is optimal to acquire the target firm depending on its development stage.

If $\bar{x}_M < \bar{x}_I^o$, the target firm is a form of a growth option. The acquirer compares the value of the target firm under both costless ($V_{I,D}(x, 0)$) and costly financing ($V_{I,D}(x, \iota_d)$). Gains in this region are associated with undervalued growth options and the future tax shield. Synergies depend on AF and LE. LL is not relevant here.

Total synergies are decomposed into:

$$\begin{aligned} \Delta(\bar{x}_M < \bar{x}_I^o) = & \left\{ \left[\frac{(1-\tau)\pi x}{r-\mu} - \kappa \right] \left(\frac{x}{\bar{x}_{I,D}(x, 0)} \right)^\beta - \left[\frac{(1-\tau)\pi x}{r-\mu} - \kappa \right] \left(\frac{x}{\bar{x}_{I,D}(x, \iota_d)} \right)^\beta \right\} \\ & + \left\{ \left[\frac{\pi x(\tau)(\Omega(0))^{1/\lambda}}{r-\mu} \right] \left(\frac{x}{\bar{x}_{I,D}(x, 0)} \right)^\beta - \left[\frac{\pi x(\tau - \iota_d)(\Omega(\iota_d))^{1/\lambda}}{r-\mu} \right] \left(\frac{x}{\bar{x}_{I,D}(x, \iota_d)} \right)^\beta \right\} \end{aligned}$$

The first term is related to AF. It shows the change in value of the growth option due to the facilitated access to financing provided by the acquirer. AF is positive as long as the

discrepancy in financing access prevails.

The second term, TS, shows the change in future tax benefits if the firm issues debt to finance the growth option. These synergies are always positive if there is a wedge between the cost of financing for the target and for the bidder.

If $\bar{x}_I^o \leq \bar{x}_M < \bar{x}_I^c$, the acquirer buys the target firm as a growth option, and immediately exercises the investment. However, this occurs later than the first-best investment trigger. The acquirer compares the target firm value that accrues at optimal investment exercise $V_{I,D}^+(x, 0)$ versus the when financing is costly $V_{I,D}(x, \iota_d)$. I decompose total synergies into:

$$\begin{aligned} \Delta(\bar{x}_I^o \leq \bar{x}_M < \bar{x}_I^c) = & \left\{ \frac{(1-\tau)\pi x}{r-\mu} - \kappa - \left[\frac{(1-\tau)\pi x}{r-\mu} - \kappa \right] \left(\frac{x}{\bar{x}_{I,D}^c(x, \iota_d)} \right)^\beta \right\} \\ & + \left\{ \frac{\tau c_{I,D}(0)}{r} - \left[\frac{\pi x (\tau - \iota_d) (\Omega(\iota_d))^{1/\lambda}}{r-\mu} \right] \left(\frac{x}{\bar{x}_{I,D}(\iota_d)} \right)^\beta \right\} \\ & + \left\{ \left(\frac{(1-\varphi)\phi \underline{x}_{I,D}(0)}{r-\mu} - \frac{c_{I,D}(0)}{r} \right) \left(\frac{x}{\underline{x}_{I,D}(0)} \right)^\lambda - 0 \right\} \\ & + \left\{ (1-\tau) \left[\frac{c_{I,D}}{r} - \frac{\pi \underline{x}_{I,D}(0)}{r-\mu} \right] \left(\frac{x}{\underline{x}_{I,D}(0)} \right)^\lambda - 0 \right\} \end{aligned}$$

The first term defines the synergies from AF. The acquirer compares the value of the optimally exercised option with the value of the option when managed by the financially constrained firm. It is positive because the probability of option exercise by the financially constrained firm is lower than one over this region, $(x/\bar{x}_{I,D}^c(x, \iota_d))^\beta < 1$. The next terms show LE, the positive effect of TS, and the negative effect of DC. The last effect is the positive contribution of the value of LL.

If $\bar{x}_I^c \leq \bar{x}_M$, the acquirer buys the target firm as assets in place. The acquirer compares the value of the target firm after investment exercise $V_{I,D}^+(x, 0)$ and the value of the financially constrained target firm $V_{I,D}^+(x, \iota_d)$. The ex-post investment option exercise synergies are related to two sources: LE (TS and DC), and LL. I can decompose total synergies into:

$$\begin{aligned}
\Delta(\bar{x}_I^c \leq \bar{x}_M) &= \left\{ \left(\frac{(1-\tau)\pi x}{r-\mu} - \frac{(1-\tau)\pi x}{r-\mu} \right) + \left(\frac{\tau c_{I,D}(0)}{r} - \frac{\tau c_{I,D}(\iota_d)}{r} \right) \right\} \\
&+ \left\{ \left[\frac{(1-\varphi)\phi \underline{x}_{I,D}(0)}{r-\mu} - \frac{c_{I,D}(0)}{r} \right] \left(\frac{x}{\underline{x}_{I,D}(0)} \right)^\lambda - \left[\frac{(1-\varphi)\phi \underline{x}_{I,D}(\iota_d)}{r-\mu} - \frac{c_{I,D}(\iota_d)}{r} \right] \left(\frac{x}{\underline{x}_{I,D}(\iota_d)} \right)^\lambda \right\} \\
&+ \left\{ (1-\tau) \left[\frac{c_{I,D}(0)}{r} - \frac{\pi \underline{x}_{I,D}(x,0)}{r-\mu} \right] \left(\frac{x}{\underline{x}_{I,D}(0)} \right)^\lambda - (1-\tau) \left[\frac{c_{I,D}(\iota_d)}{r} - \frac{\pi \underline{x}_{I,D}(\iota_d)}{r-\mu} \right] \left(\frac{x}{\underline{x}_{I,D}(\iota_d)} \right)^\lambda \right\}
\end{aligned}$$

The first term shows the change from the AF effect. When the assets in place are installed, the effect of the efficient investment exercise disappears. Positive synergies, when the target firm is under the management of the acquirer, may only be created when assets generate synergistic cash flows. The second term shows a change in synergies due to TS. I predict this effect to be positive as $c_{I,D}(0) > c_{I,D}(\iota_d)$. The third term is associated with DC. Consistent with Leland (2007), the incremental effect on synergies is negative. A higher coupon in the absence of operational synergies increases the probability of default and decreases the bankruptcy value. Note that I make no assumptions about any correlations between the assets of the acquirer and those of the target. However, as per Lewellen (1971), if the assets of two firms are imperfectly correlated, the portfolio combining them can actually reduce the risk of the merged firm. The last term is the incremental effect on the combined value of the firm due to LL on the synergies.

4.2 Merger surplus and globally optimal timing

The acquirer facilitates the access to financing for the target firm. Therefore, the value of the option to invest for the acquirer is $OI(x, 0)$, given financing is raised costlessly. If it raises costly financing, then the acquirer must pay the stand-alone value of the target firm $OI(x, \iota_d)$. The benefit of combining the two firms together equals the difference between the value of the target firm with the different cost of issuing the financing. If the cost of financing for the target firm is higher than that for the acquirer, the benefit is positive. Both firms must cover the costs of merging, which for the bidder is K_M , and for the target is K_T . If

we define the combined benefit from merging from a global optimizer perspective, we get: $\Delta(x, \iota_d) - K_M - K_T$, which is positive given $\iota_d > 0$. A merger is considered if the stochastic synergies are higher than the cost of merging. Note further that the benefit from merging appreciates if x increases. Therefore, in the option vernacular, the payoff resembles a call option characteristics, and is given as:

$$S(x, \iota_d) = \max_x[\Delta(x, \iota_d) - K_M - K_T, 0] \quad (17)$$

The firm can exercise the option to merge at an optimal threshold \bar{x}_M , and either receive the net synergies or leave the option unexercised. I denote the value of the option as OM and it is the solution to an ordinary differential equation (ODE). This equation can be solved subject to boundary conditions. The value-matching condition stipulates that, at the threshold, the synergies realized are equal to the option value. We thus have:

$$OM(\bar{x}_M, \bar{x}_M) = \Delta(\bar{x}_M, \iota_d) - K_M - K_T \quad (18)$$

The resulting value of the merger option over the continuation region (prior to exercise) is:

$$OM(x, \bar{x}_M) = (\Delta(\bar{x}_M, \iota_d) - K_M - K_T) \left(\frac{x}{\bar{x}_M} \right)^\beta \quad (19)$$

From a global optimizer viewpoint, the merger decision is made in isolation. However, the timing and terms of the decision depend on the investment and financing policy of the target firm. The goal is to facilitate the flow of financing and reduce underinvestment. It is therefore optimal to exercise the option to merge if the state variable x exceeds the merger threshold (\bar{x}_M). The merger threshold is the solution to the optimality (first-order) condition:

$$\frac{\partial OM(x, \bar{x}_M)}{\partial \bar{x}_M} = 0 \quad (20)$$

Optimizing the merger option with respect to \bar{x}_M results in the following proposition.

Proposition 1 *The first-best merger threshold of a global optimizer is defined as follows. If $\frac{K_M + K_T}{\kappa} < \frac{\Phi^\beta - \Psi^\beta}{\beta \Phi^\beta}$, the target firm is acquired as a growth option (i.e., $\bar{x}_M < \bar{x}_I^o < \bar{x}_I^c$), and*

the merger threshold is:

$$\bar{x}_M = \mathcal{H}_\beta \kappa \left[\frac{\beta(K_M + K_T)}{\kappa(\Phi^\beta - \Psi^\beta)} \right]^{\frac{1}{\beta}} \quad (21)$$

If $\frac{\Phi^\beta - \Psi^\beta}{\beta\Phi^\beta} \leq \frac{K_M + K_T}{\kappa} < \frac{\Phi - \Psi}{\Psi}$, the target firm is acquired as a growth option, which is immediately exercised (i.e., $\bar{x}_I^o < \bar{x}_M \leq \bar{x}_I^c$). The merger threshold is a solution to the following equation:

$$\bar{x}_M \Phi - \bar{x}_M^\beta \frac{\kappa}{\beta - 1} \left(\frac{\Psi}{\kappa \mathcal{H}_\beta} \right)^\beta - \mathcal{H}_\beta (K_M + K_T) = 0 \quad (22)$$

If $\frac{\Phi - \Psi}{\Psi} \leq \frac{K_M + K_T}{\kappa}$, the target firm is acquired as assets in place (i.e., $\bar{x}_I^o < \bar{x}_I^c \leq \bar{x}_M$), and the merger threshold is:

$$\bar{x}_M = \mathcal{H}_\beta \frac{K_M + K_T}{\Phi - \Psi} \quad (23)$$

where $\mathcal{H}_\beta = \beta/(\beta - 1)$, and $\beta > 1$ is the positive root of the quadratic equation $1/2\sigma^2 z(z - 1) + \mu z - r = 0$.

Proof. See Appendix C. ■

It is important to note that the merger option can be exercised before the investment option. This explanation is based on the following arguments. If $\bar{x}_M < \bar{x}_I^o$, the acquirer compares the value of two unexercised options. In contrast to a standard sequential investment model, the overall effect of the cost of investment (κ) on the merger threshold is $1 - \frac{1}{\beta}$. Thus, κ has two opposing effects on the merger threshold: i) the standard effect, which delays the exercise trigger, and ii) an acceleration of the merger exercise as it contributes to the synergies' benefits (a higher κ implies a larger magnitude of merger synergies). Therefore, if the investment cost is relatively high, and the following condition is satisfied $\frac{K_M + K_T}{\kappa} < \frac{\Phi^\beta - \Psi^\beta}{\beta\Phi^\beta}$, the merger can occur earlier than the investment threshold.

This proposition shows the importance of the form of the target firm's assets to the bidder's acquisition strategy. Depending on whether the acquirer is buying the target firm as a growth option or as assets in place, the optimal first-best merger is exercised at different triggers. Moreover, acquiring the target firm as a growth option, before the optimal investment exercise, is associated with high uncertainty over future synergies. This is reflected by additional factor β .

The higher the uncertainty the higher the realized synergies $(\Phi^\beta - \Psi^\beta(-1/\beta))$ are. Given the target is acquired as a growth option its value increases as the uncertainty of the underlying asset increases.

It is therefore optimal to acquire a firm at an earlier stage of development for a lower level of volatility. An increase in volatility limits the region over which the acquirer decides to buy the target firm as a growth option, because $(\Phi^\beta - \Psi^\beta)/\beta\Phi^\beta$ decreases if σ increases. All else equal, acquiring growth options becomes unlikely.

The merger threshold, conditional on acquiring the target firm as assets in place, has a standard form, which is well-known in the real options literature. It depends on the sunk transaction cost and the synergies that can be realized upon exercising. The merger threshold is delayed if uncertainty increases due to a hysteresis factor \mathcal{H}_β , which reflects the value of an option to wait.

5. The fear of preemption and acquisition terms and timing

Recent empirical literature suggests there is strong competition among bidders. Boone and Mulherin (2007a) and Boone and Mulherin (2007b) claim that half the takeover deals in their sample are subject to competition from other public or private bidders. Moreover, friendly mergers in a form of negotiation are not free from competition either. Aktas, de Bodt, and Roll (2010) provide evidence of latent competition (the likelihood that rival bidders could appear). This gives rise to the fear of preemption in the case of a merger agreement which can be explained by a fiduciary out clause included in the contract that gives the target the right to terminate the agreement if a better deal appears before the target board gives its full approval.

Therefore, based on this compelling evidence, I introduce competition into the model in the form of the fear of preemption. I assume the bidder that enters the negotiation process or makes a tender offer may be subject to preemption risk (δ) due to an arrival of a competing bidder. The fear of preemption is modelled as a jump in the value of the claim at the time the option to buy the target expires, with the probability of preemption per unit of time δdt .

This is reflected in an ODE by an additional term that changes firm value.

The form of an offer is an important element of my analysis, because it can fundamentally change the timing of a merger and how the synergies are shared between firms. Lambrecht (2003) shows that the negotiation game affects the terms and timing of mergers motivated by economies of scale. I follow his setting, and next compare friendly mergers and hostile takeovers.

Boone and Mulherin (2007b) unravel that there exists quite active market even before the firm is sold and the transaction is publicly announced. They show that many firms are sold in a negotiated process between the target firm and one or multiple bidders. One example of a friendly merger is Boone and Mulherin (2007b), p.849: "BankBoston provides an example of a negotiation. On April 1, 1998, the CEO of BankBoston met with the CEO of Fleet Financial to discuss a possible merger. During subsequent extended, private discussions, BankBoston did not contact any other potential bidders. The merger agreement was signed on March 14, 1999 and was publicly announced the following day. The merger was completed on October 1, 1999."

Therefore, I define friendly mergers as deals that can be initiated by either the bidder or the target firm and the terms and timing are negotiated simultaneously. In contrast, hostile takeovers are the deals that can only be initiated by the acquirer who publicly contacts target's shareholders.

More formally during the merger negotiation process, each firm possesses an option on the fraction of merger synergies. The acquirer obtains a share s_B of the new entity, and the target firm obtains a share s_T . I assume that, at the time of acquisition, the entire merger surplus is shared between two firms, thus, $s_B + s_T = 1$. And I define the benefit from exercising a merger option that accrues to the acquirer and the target as follows. The bidder's surplus is equal to a share s_B in the new entity, which can now raise the funds costlessly less the fixed acquisition costs, K_M , which are: $s_B OI(x, 0) - K_M$. The target exchanges its firm value when financing is costly into a share in the new entity when financing is costless, less the fixed acquisition costs K_T , and its benefit is: $s_T OI(x, 0) - OI(x, \iota_d) - K_T$. Each firm will exercise its option only if the stochastic benefit is higher than the merger cost. Otherwise, they leave

the option unexercised. This type of payoff structure has a call option characteristic that ensures the existence of an optimal exercise threshold for each firm, the bidder, and the target. Over the continuation region, the value of the option satisfies an ODE solved subject to boundary conditions.

The next subsections analyse how the terms and timing of the merger depend on the form of the acquisition. A friendly merger agreement refers to a negotiated deal; a hostile takeover, in a form of a tender offer, usually means that one firm makes an offer directly to shareholders to sell their shares at specified prices. Weston, Mitchell, and Mulherin (2004)

5.1 Friendly mergers

I analyse a friendly merger in the form of an agreement where firms negotiate how to divide the surplus. The payoff for both firms is uncertain, and is contingent on the future realization of merger synergies. Firms have an interest in maximizing these synergies, and in exercising their options at an optimal threshold. The bidder and the target negotiate the terms and the timing of the merger simultaneously.

At the optimal merger threshold, each firm compares the value of the merger option, $OM_B(x)$ for the bidder and $OM_T(x)$ for the target, with the payoff realized at the optimal exercise threshold. The value of the merger option for the bidder is:

$$OM_B(x, \bar{x}_M(s_B), \iota_d) = (s_B OI(\bar{x}_M(s_B), 0) - K_M) \left(\frac{x}{\bar{x}_M(s_B)} \right)^\xi \quad (24)$$

where $\bar{x}_M(s_B)$ is the reaction function of the bidder dependent on the share s_B . For the target, the value of the option is:

$$OM_T(x, \bar{x}_M(s_T), \iota_d) = (s_T OI(\bar{x}_M(s_T), 0) - OI(\bar{x}_M(s_T), \iota_d) - K_T) \left(\frac{x}{\bar{x}_M(s_T)} \right)^\beta \quad (25)$$

where $\bar{x}_M(s_T)$ is the reaction function of the target dependent on the share s_T .

Eqs. (24) and (25) show the discounted value of the synergies that accrue to each company. In the presence of competition, the discount factor of the bidder $(x/\bar{x}_M)^\xi$ is higher than the

discount factor of the target $(x/\bar{x}_M)^\beta$. The bidder, subject to preemption, becomes impatient and discounts its payoff at a higher hurdle rate.

Subsequently, from Eq. (24) and Eq. (25), I calculate the reaction function of the bidder $\bar{x}_M(s_B)$ and the target $\bar{x}_M(s_T)$. A friendly merger is executed when $\bar{x}_M(s_B) = \bar{x}_M(s_T)$, and surplus is divided according to the unique sharing rule (s_B, s_T) . I derive the optimal merger threshold for the regions discussed in Section 4. The results are summarized in the following proposition.

Proposition 2 *The exercise trigger of a merger agreement, modelled as a Cournot negotiation game, where the target and the acquirer decide on the terms and timing simultaneously, is defined as follows. If $\frac{(\mathcal{H}_\xi/\mathcal{H}_\beta)K_M+K_T}{\kappa} < \frac{\Phi^\beta-\Psi^\beta}{\beta\Phi^\beta}$, the target firm is acquired as a growth option (i.e., $\bar{x}_M < \bar{x}_I^o < \bar{x}_I^c$), and the merger threshold is:*

$$\bar{x}_M = \mathcal{H}_\beta \kappa \left[\frac{\beta \left(\frac{\mathcal{H}_\xi}{\mathcal{H}_\beta} K_M + K_T \right)}{\kappa (\Phi^\beta - \Psi^\beta)} \right]^{\frac{1}{\beta}} \quad (26)$$

If $\frac{\Phi^\beta-\Psi^\beta}{\beta\Phi^\beta} \leq \frac{(\mathcal{H}_\xi/\mathcal{H}_\beta)K_M+K_T}{\kappa} < \frac{\Phi-\Psi}{\Psi}$, the target firm is acquired as a growth option, which is exercised immediately (i.e., $\bar{x}_I^o < \bar{x}_M < \bar{x}_I^c$). The merger threshold is a solution to the following equation:

$$\bar{x}_M \Phi - \bar{x}_M^\beta \frac{\kappa}{\beta-1} \left(\frac{\Psi}{\kappa \mathcal{H}_\beta} \right)^\beta - \mathcal{H}_\beta \left(\frac{\mathcal{H}_\xi}{\mathcal{H}_\beta} K_M + K_T \right) = 0 \quad (27)$$

If $\frac{\Phi-\Psi}{\Psi} \leq \frac{(\mathcal{H}_\xi/\mathcal{H}_\beta)K_M+K_T}{\kappa}$, the target firm is acquired as assets in place (i.e., $\bar{x}_I^o < \bar{x}_I^c < \bar{x}_M$), and the merger threshold is:

$$\bar{x}_M = \mathcal{H}_\beta \frac{\frac{\mathcal{H}_\xi}{\mathcal{H}_\beta} K_M + K_T}{\Phi - \Psi} \quad (28)$$

where $\mathcal{H}_\xi = \xi/(\xi-1)$ and $\xi > 1$ is the positive root of the quadratic equation $1/2\sigma^2 z(z-1) + \mu z - r - \delta = 0$.

Proof. See Appendix D. ■

The fear of preemption speeds up the acquirer's exercise trigger. This is reflected by the additional factor $\mathcal{H}_\xi/\mathcal{H}_\beta$, which decreases the acquirer's costs K_M . It also suggests that the acquirer accepts lower or even negative NPV projects in order to preempt competition.

If there is no fear of preemption and $\delta = 0$, expressions from Proposition 2 coincide with the first-best merger threshold as defined in Proposition 1. It is then optimal to merge at the first-best threshold $\bar{x}_M(\delta = 0)$, and the target firm obtains a share in the new entity equal to $s_T(\delta = 0)$. However, if the fear of preemption increases, the bidder is willing to offer a higher share in the new entity to the target firm: $s_T(\delta > 0) > s_T(\delta = 0)$. Firms merge at a different threshold $\bar{x}_M(\delta > 0)$, which is lower than the first-best merger threshold. The fear of preemption changes both the terms and the timing of the acquisition. These are summarized in the following proposition.

Proposition 3 *If the bidder is subject to the fear of preemption, an acquisition that is an outcome of a merger agreement occurs earlier than the first-best merger threshold, and the target firm obtains a higher ownership share.*

5.2 Hostile takeover

In contrast to friendly mergers, where terms and timing are negotiated simultaneously, during the hostile takeover the target dictates the terms and the acquirer subsequently decides on the timing. I model the hostile takeover as a Stackelberg game, where the target firm determines the share (s_T), and the acquirer decides subsequently on the optimal merger exercise (\bar{x}_M).

The bidder firm and the target firm both have takeover options, denoted by $OT_B(x)$ and $OT_T(x)$, respectively. I show that the value of the option for the bidder is:

$$OT_B(x, \bar{x}_M(s_B)) = (s_B OI(\bar{x}_M(s_B), 0) - K_M) \left(\frac{x}{\bar{x}_M(s_B)} \right)^\xi \quad (29)$$

while for the target it is:

$$OT_T(x, s_T(\bar{x}_M), s_T) = (s_T(\bar{x}_M) OI(\bar{x}_M, 0) - OI(\bar{x}_M, \iota_d) - K_T) \left(\frac{x}{\bar{x}_M} \right)^\beta \quad (30)$$

The fear of preemption faced by the bidder is reflected in the discounting factor $(x/\bar{x}_M(s_B))^\xi$. I solve the game by backward induction. First, the acquirer chooses the timing of the acquisition, \bar{x}_M , given share s_B , by maximizing its option:

$$\max_{\bar{x}} OT_B(x, \bar{x}_M, s_B) \quad (31)$$

Second, the target firm maximizes its option:

$$\max_{s_T} OT_T(x, \bar{x}_M(s_T), s_T) \quad (32)$$

The optimal takeover threshold is derived for the regions discussed in Section 4.. The results are summarized in the following proposition.

Proposition 4 *I define the exercise trigger of a hostile takeover, modelled as a Stackelberg game, where the target firm decides on the terms and the acquirer subsequently decides on the timing, as follows. If $\frac{\mathcal{H}_\xi K_M + K_T}{\kappa} < \frac{\Phi^\beta - \Psi^\beta}{\beta \Phi^\beta}$, the target firm is acquired as a growth option (i.e., $\bar{x}_M < \bar{x}_I^o < \bar{x}_I^c$), and the merger threshold is:*

$$\bar{x}_M = \mathcal{H}_\beta \kappa \left[\frac{\beta(\mathcal{H}_\xi K_M + K_T)}{\kappa(\Phi^\beta - \Psi^\beta)} \right]^{\frac{1}{\beta}} \quad (33)$$

If $\frac{\Phi^\beta - \Psi^\beta}{\beta \Phi^\beta} \leq \frac{\mathcal{H}_\xi K_M + K_T}{\kappa} < \frac{\Phi - \Psi}{\Psi}$, the target firm is acquired as a growth option, which is exercised immediately (i.e., $\bar{x}_I^o < \bar{x}_M < \bar{x}_I^c$). The merger threshold is a solution to the following equation:

$$\bar{x}_M \Phi - \bar{x}_M^\beta \frac{\kappa}{\beta - 1} \left[\frac{\Psi}{\mathcal{H}_\beta \kappa} \right]^\beta - \mathcal{H}_\beta (\mathcal{H}_\xi K_M + K_T) = 0 \quad (34)$$

If $\frac{\Phi - \Psi}{\Psi} \leq \frac{\mathcal{H}_\xi K_M + K_T}{\kappa}$, the target firm is acquired as assets in place (i.e., $\bar{x}_I^o < \bar{x}_I^c < \bar{x}_M$), and the merger threshold is:

$$\bar{x}_M = \mathcal{H}_\beta \frac{\mathcal{H}_\xi K_M + K_T}{\Phi - \Psi} \quad (35)$$

In contrast to friendly mergers, hostile takeovers are associated with a delay due to increased costs. This is reflected by a premium, paid by the acquirer, in the form of an

additional hysteresis factor (\mathcal{H}_ξ). Thus, the acquisition costs of the acquirer are increased. In the absence of a fear of preemption, when $\delta = 0$, implying that $\mathcal{H}_\xi = \mathcal{H}_\beta$, hostile takeovers are exercised later than the first-best threshold and later than friendly mergers. This result is consistent with Lambrecht (2004), where pre-commitment delays the timing of the takeover. I contribute to this strand of the literature by showing that, when a bidder is subject to preemption fears, i.e., if $\delta > 0$, implying that $\mathcal{H}_\xi < \mathcal{H}_\beta$, the hostile takeover threshold is exercised earlier. If $\delta \rightarrow \infty$, implying that $\mathcal{H}_\xi \rightarrow 1$, the takeover is exercised at the optimal global optimizer merger threshold as defined in Proposition 1. The following proposition follows.

Proposition 5 *When the bidder is subject to preemption fear, mergers are exercised too early, while takeovers converge to the global optimizer first-best merger threshold.*

Proof. See Appendix E. ■

It is quite intuitive to predict that competition erodes the option value and speeds up the merger threshold. For example, Morellec and Zhdanov (2005), in their model of takeovers, demonstrate that competition speeds up timing and increases the target firm's share. The analysis suggests that it is important, however, to distinguish how the competition affects each type of acquisition offer. I show that, with no competition, a friendly merger offer is the optimal choice that gives the first-best outcome. However, in the presence of an infinite fear of preemption, the hostile takeover threshold tends to the first-best merger threshold.

I obtain a novel result: The implications of the effect of competition depend on the negotiation process between the acquirer and the target firm. In the case of a merger agreement, competition erodes the option value, and forces a merger's timing to converge to the break-even threshold. However, in the case of a hostile takeover, the timing of an acquisition converges to the first-best merger threshold (the global optimizer merger threshold). The intuition here is that, if the target firm acts as a Stackelberg leader, it preserves the option value and obtains an efficient share. Subsequently, the acquirer, fearing preemption decides on the timing of the acquisition, which converges to the global optimizer first-best merger threshold.

6. Model predictions

To better illustrate the results of my study and understand the model's dynamics, I next present several numerical examples. Parameter values for each figure are based on estimates from the corporate finance literature. Volatility is assumed to be at the level of $\sigma = 20\%$, which is roughly consistent with volatility estimates from Schaefer and Strebulaev (2008). I set the growth rate of cash flows to $\mu = 5\%$, the risk-free rate to $r = 6\%$, and the corporate tax rate is $\tau = 25\%$. The default cost is based on recent estimates of Glover (2016) and $\varphi = 45\%$, which imply that approximately 65% of the revenue stream is recovered in the case of an alternative use of the firm's assets. The size of the growth option is $\pi = 10$ and the costs of investment and acquisition exercise are as follows: $\kappa = 140$, $K_M = 10$, and $K_T = 5$. The arrival rate of competitors is set as $\delta = 1$.

6.1 Risk analysis

In this subsection, I present the implications of the parameters that define risk in the model, uncertainty over future cash flows (σ), and preemption risk (δ). Figure 1 illustrates when it is optimal to acquire the target firm as a growth option or as assets in place.

I present the solution in the form of a region plot, where ι_d is a critical level of switching between regimes. I define three regions, where it is optimal for the acquirer to buy the target firm: (i) as assets in place (white region), (ii) as a growth option and immediate exercise (light shaded region), or (iii) as a growth option and wait to exercise at the optimal investment threshold (dark shaded region).

Panels A and D define the conditions for the global optimizer merger threshold as defined in Proposition 1, Panels B and E define the conditions for the friendly merger as defined in Proposition 2, and Panels C and F define the conditions for the hostile takeover as defined in Proposition 4.

Panel A shows the global optimizer solution. The first-best solution of the global optimizer is not affected by the fear of preemption. The critical level of ι_d is monotonically increasing in σ , which means that, at lower levels of volatility, the acquirer is more likely to buy the

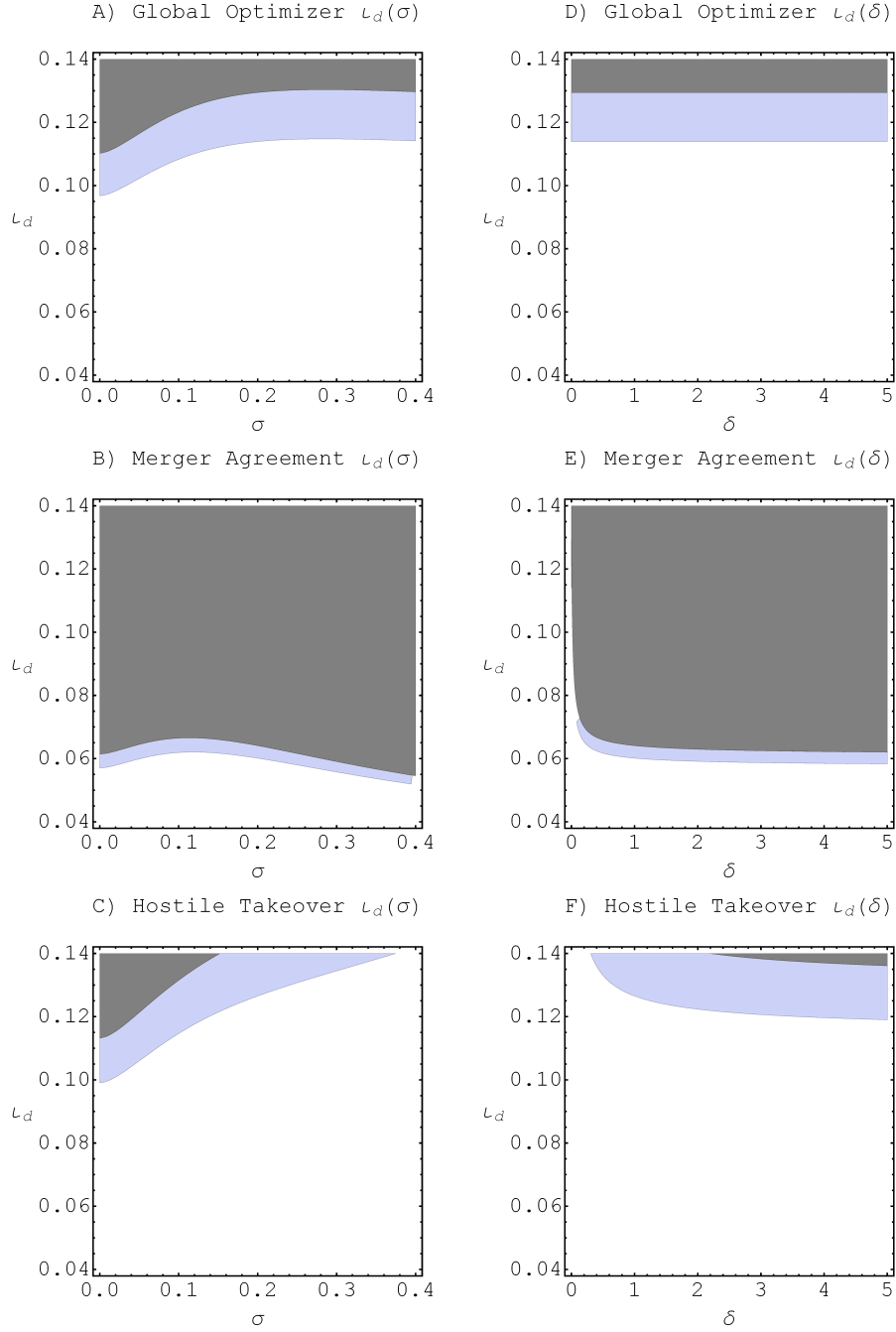


Figure 1: Optimal merger decision and risk analysis (region plot). The dark shaded area depicts when the bidder acquires the target firm as the growth option, and waits to exercise the investment option at the optimal investment threshold. The light shaded area depicts when the bidder acquires the target firm as the growth option and immediately exercises the investment option. The white area depicts when the bidder acquires the target firm as assets in place. I vary cash flow risk (σ), preemption risk (δ), and the issuance cost of financing (ι_d). Panels A and D define the conditions for the global optimizer merger threshold as defined in Proposition 1. Panels B and E define the conditions for the friendly merger as defined in Proposition 2. Panels C and F define the conditions for the hostile takeover as defined in Proposition 4.

target firm as a growth option. The decision is thus not only affected by the uncertainty surrounding the acquisition, but also by any subsequent uncertainty associated with the investment option exercise and the synergies that will materialize at that time.

Financial synergies in the case of buying the target firm as a growth option are associated with greater uncertainty. This is reflected by β in the expression defining synergies from acquisition $\Phi^\beta - \Psi^\beta$. Note that the latter decreases as σ increases. Therefore, for higher levels of uncertainty, the acquirer is more likely to buy assets in place that are already generating profits.

In Panel B, in the case of a solution for the friendly merger offer subject to the fear of preemption the effect of σ is non-monotonic. To understand this further, I first consider the optimal policy of the acquirer and the target. As uncertainty increases, it delays merger and investment exercise because the hysteresis factor \mathcal{H}_β increases. However, in the case of a friendly merger threshold, as defined in Proposition 2, the cost of the acquisition is associated with an additional factor, which is a multiple of K_M . It depends on hysteresis factors $\mathcal{H}_\xi/\mathcal{H}_\beta$, and decreases in σ . In the presence of significant competition, the fear of preemption can erode the value of waiting. The acquirer is then forced to buy the target firm at the break-even threshold.

In Panel C, in the case of a solution for the hostile takeover offer, the effect of σ on the critical level of ι_d is monotonically increasing. This represents a delay compared to the friendly merger offer. The delay comes from an additional hysteresis factor \mathcal{H}_ξ imposed on the merger cost K_M , which increases in σ . This premium may be associated with a higher entry cost for hostile bidders, because they tend to face more uncertainty than in the case of a negotiated bid.

The first-best solution of the global optimizer is not affected by preemption. And, in Panel D, the relationship is constant. However, I show it for comparison with the friendly merger and hostile takeover offers.

In Panel E, I show that the acquirer is more likely to buy the target firm as a growth option when the fear of preemption increases. This effect is associated with the erosion of the option value due to competition.

In Panel F, I illustrate the effect of the fear of preemption on the hostile takeover offer. The competition accelerates the optimal exercise. The takeover threshold converges to the first-best threshold of the global optimizer.

6.2 Capital structure

I next analyse the parameters of primary importance for the capital structure choice of the target firm in the model: the tax rate (τ), and the bankruptcy cost (φ). In Figure 2, I depict region plots of the decision to acquire the target firm as a growth option or as assets in place.

In Panels A to C, the critical level ι_d decreases in τ . This means that the acquirer is more likely to buy the target firm as a growth option when corporate taxes are higher. In the model, taxes affect financial synergies. The corporate tax increases the importance of the future tax shield in the case of acquiring growth options. Thus, higher taxes increase financial synergies and speed up the exercise decision of the acquirer. Furthermore, when taxes are high, the reduction in after-tax profit delays the investment decision, which makes the underinvestment problem of the constrained target firm even more severe. Countries with high tax rates may want to consider that acquiring a firm as a growth option could be a solution to relaxing the capital constraints these firms face.

In Panels D to F, the critical level ι_d increases with the bankruptcy cost φ . Acquiring the target firm as a growth option is more likely when the target firm has a lower haircut on its assets. In other words, in the case of default, its assets can be sold or converted into an alternative use at a relatively low price. The high bankruptcy cost delays the investment threshold of the constrained target firm. The bankruptcy cost also has an effect on the acquisition threshold, in the form of increasing the probability of default of the target firm. This decreases the financial synergies, and delays the exercise trigger of the acquirer.

6.3 Profitability of target firm

I also show how the parameters related to the target firm's profitability affect the choice between acquiring the target firm as a growth option or as assets in place. In Figure 3, I

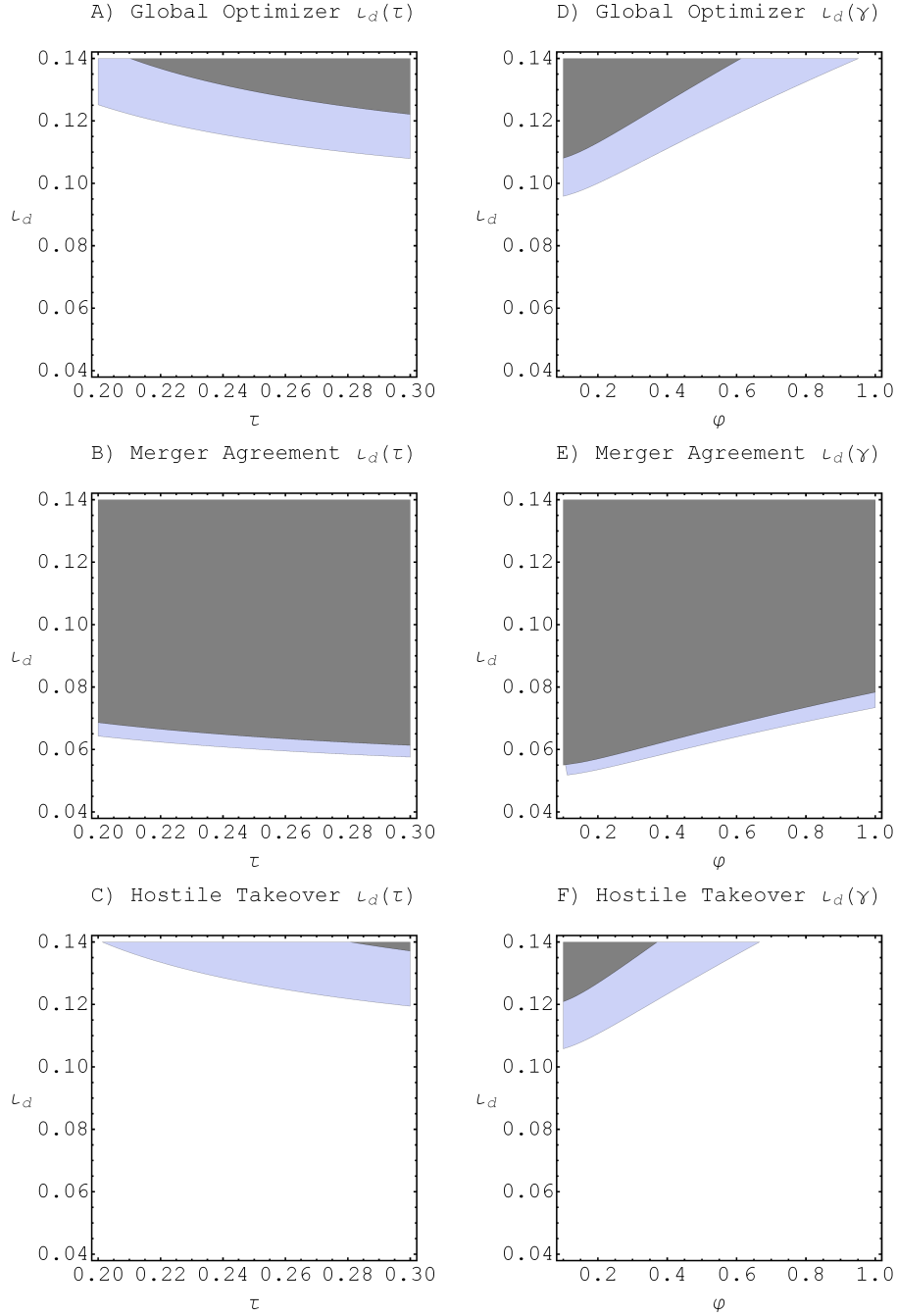


Figure 2: Optimal merger decision and capital structure (region plot). The dark shaded area depicts when the bidder acquires the target firm as a growth option, and waits to exercise the investment option at the optimal investment threshold. The light shaded area depicts when the bidder acquires the target firm as the growth option and immediately exercises the investment option. The white area depicts when the bidder acquires the target firm as assets in place. I vary the tax rate (τ), the bankruptcy cost (φ), and the issuance cost of financing (ι_d). Panels A and D define the conditions for the global optimizer merger threshold as defined in Proposition 1. Panels B and E define the conditions for the friendly merger as defined in Proposition 2. Panels C and F define the conditions for the hostile takeover as defined in Proposition 4. The parameters are set as in the previous figure.

depict how the growth rate of cash flows (μ) and the size of the growth option (π) impact the acquisition decision.

In Panels A to C the critical level ι_d decreases in the growth rate of cash flows (μ). A higher μ increases the value of future cash flows by accelerating the investment decision of the constrained firm. However, for the acquiring firm, μ increases the financial synergies of acquiring a growth option, and erodes the effect of uncertainty surrounding the option exercise in $\Phi^\beta - \Psi^\beta$.

In the case of the first-best and hostile takeover solution (Panels A and C), note that the increase in financial synergies speeds up the acquisition more when the acquirer buys growth options and waits to exercise the investment. These two effects are of the same magnitude when the acquirer buys a growth option with an immediate exercise trigger.

In the case of a friendly merger, μ has an additional effect on cost K_M . As μ increases, it affects the factor $\mathcal{H}_\xi/\mathcal{H}_\beta$, and erodes the effect of uncertainty associated with the acquisition. This makes acquiring growth options more likely.

In Panels D to F, the critical level ι_d increases with the size of the growth option (π), which speeds up the investment exercise given that sunk cost κ is fixed. The underinvestment problem of the target firm is therefore less severe, which in turn lowers the financial synergies of acquiring growth options. It suggests that smaller firms are more likely to be acquired as growth options, and larger firms are more likely to be acquired as assets in place.

7. Target premium and acquirer return in friendly mergers and hostile takeovers

7.1 Target premium

The existing literature offers no agreement about how takeover premiums are affected by competition and by the type of offer. For example, Boone and Mulherin (2007b) suggest that wealth effects for target shareholders do not differ depending on the form of acquisition. Mandatory disclosure rules that increase expected competition among bidders may raise offer premiums. However, Eckbo (2008) shows there are "no conclusions as to whether offer premiums are higher, the same, or lower in tender offers than in merger bids." I thus present

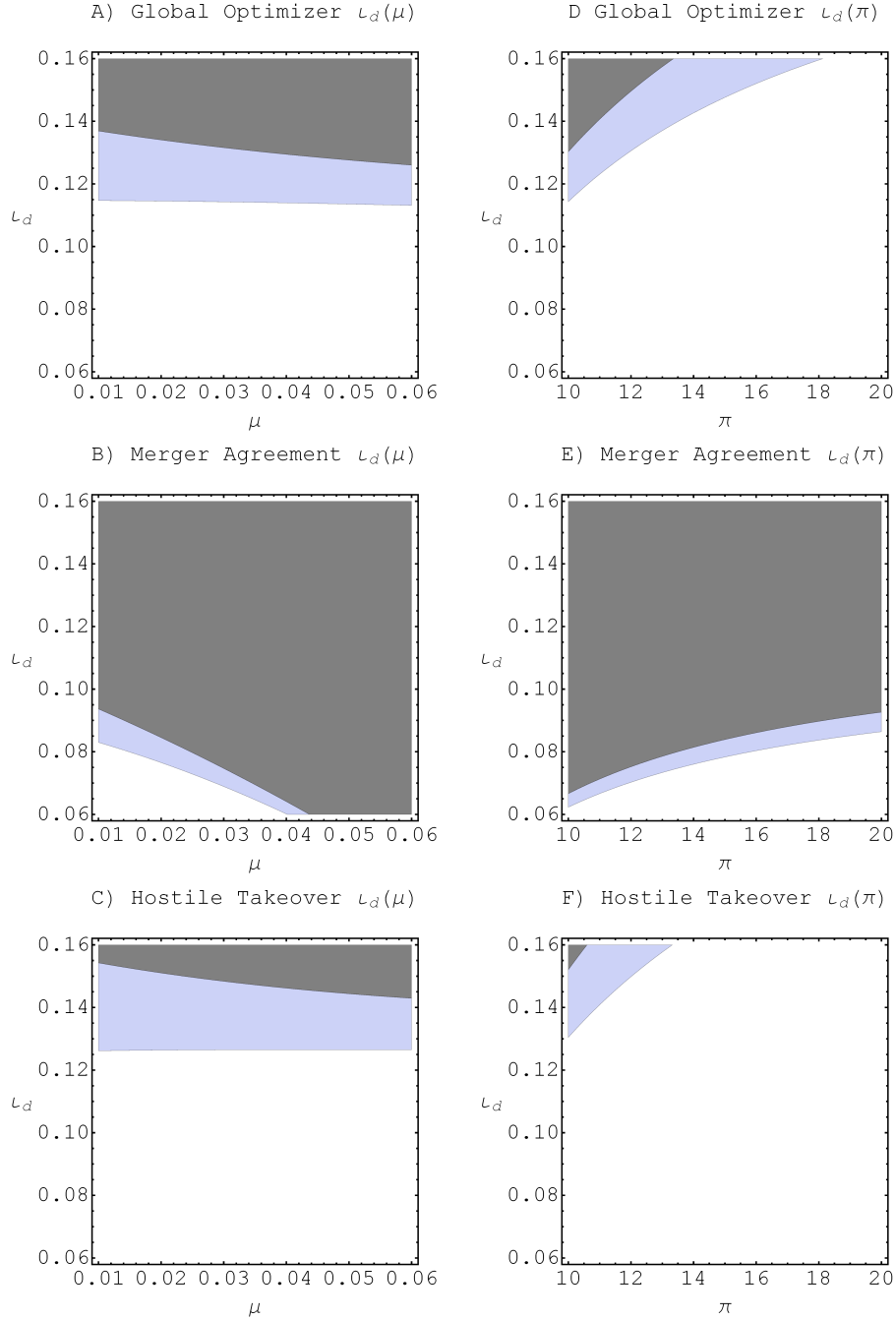


Figure 3: Optimal merger decision and profitability (region plot). The dark shaded area depicts when the bidder acquires the target firm as the growth option and waits to exercise the investment option at the optimal investment threshold. The light shaded area depicts when the bidder acquires the target firm as the growth option and immediately exercises the investment option. The white area depicts when the bidder acquires the target firm as assets in place. I vary the growth rate of cash flows (μ), the size of the growth option (π), and the issuance cost of financing (ι_d). Panels A and D define the conditions for the global optimizer merger threshold as defined in Proposition 1. Panels B and E define the conditions for the friendly merger as defined in Proposition 2. Panels C and F define the conditions for the hostile takeover as defined in Proposition 4. The parameters are set as in the previous figure.

some insights into how competition and the type of offer impact the target's premiums.

Many empirical studies approximate the takeover premium by using a measure based on cumulative takeover return.⁷ I define the cumulative return as a change in stand-alone value due to the merger option. I therefore express the takeover premium as the cumulative return that results from a merger option, as a fraction of stand-alone value:

$$TP = \frac{OM(x, \bar{x}_M, \iota_d)}{OI(x, \iota_d)} \quad (36)$$

The stand-alone value of the target firm ($OI(x, \iota_d)$) depends on its phase of development. When it is acquired as a growth option, $OI(x, \iota_d) = V_{I,D}(x, \iota_d)$. When it is acquired as assets in place, $OI(x, \iota_d) = V_{I,D}^+(x, \iota_d)$.

Figure 4 shows the sensitivity of an acquisition premium to volatility (σ). I compare the premium to the target firm from the merger agreement and hostile takeover when the acquirer makes an offer in isolation ($\delta = 0$), or when it is subject to the fear of preemption ($\delta > 0$).

In contrast to previous studies that predict a positive effect of volatility on the cumulative return, when a merger is exercised in isolation (e.g., Lambrecht (2004)), or in the presence of competition (e.g., Hackbarth and Miao (2012)), the uncertainty decreases the cumulative return. Previous studies examined the synergies obtained from combining two firms in a setting where they were independent of uncertainty (e.g. "size effect" in Lambrecht (2004)). Then, the main driver of the positive effect of volatility on the cumulative return is the hysteresis factor. I show here that if the synergies generated depend on uncertainty, then the increase in volatility can lower the cumulative return. This effect is driven primarily by the fact that synergies depend on capital structure. Optimal leverage decreases with uncertainty, and thus the synergies related to a firm's financial structure decrease.

The target firm's premium depends on its development phase. The premium is higher when it is acquired as a growth option (dotted line). Note that an acquirer only decides to buy the target firm as a growth option when the level of uncertainty is relatively low.

⁷Eckbo (2008)

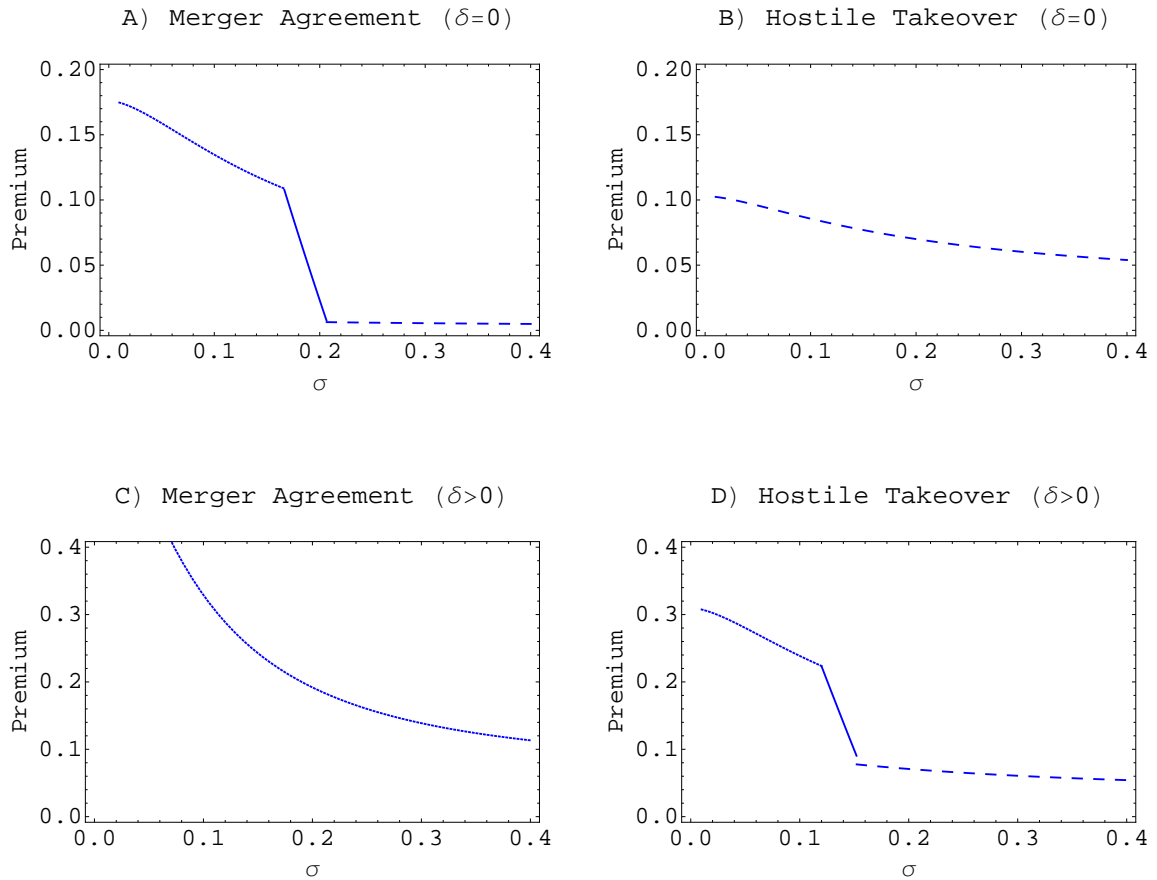


Figure 4: Acquisition premium to the target firm as a function of volatility. The panels depict when the acquirer buys the target firm as 1) a growth option, and waits to exercise the investment option at the optimal investment threshold (dotted line), 2) a growth option, and immediately exercises the investment option (solid line), or 3) assets in place (dashed line).

I also show the importance of the dynamics embedded into the acquisition decision of the acquirer. The premium to the target firm is higher in the case of the merger agreement offer if the target firm is acquired earlier and in the form of a growth option. If the target firm is acquired as assets in place, then the premium from the takeover offer is higher. The fear of preemption increases premiums in the case of a merger agreement. In the case of a takeover offer, the premium increases because of the bidder's preemption fears, and acquirers target firm as a growth option. This is consistent with evidence in Aktas, de Bodt, and Roll (2010), who show that competition increases the bid premium.

In Figure 7, I report the sensitivity of the acquisition premium to issuance cost (ι_d). The

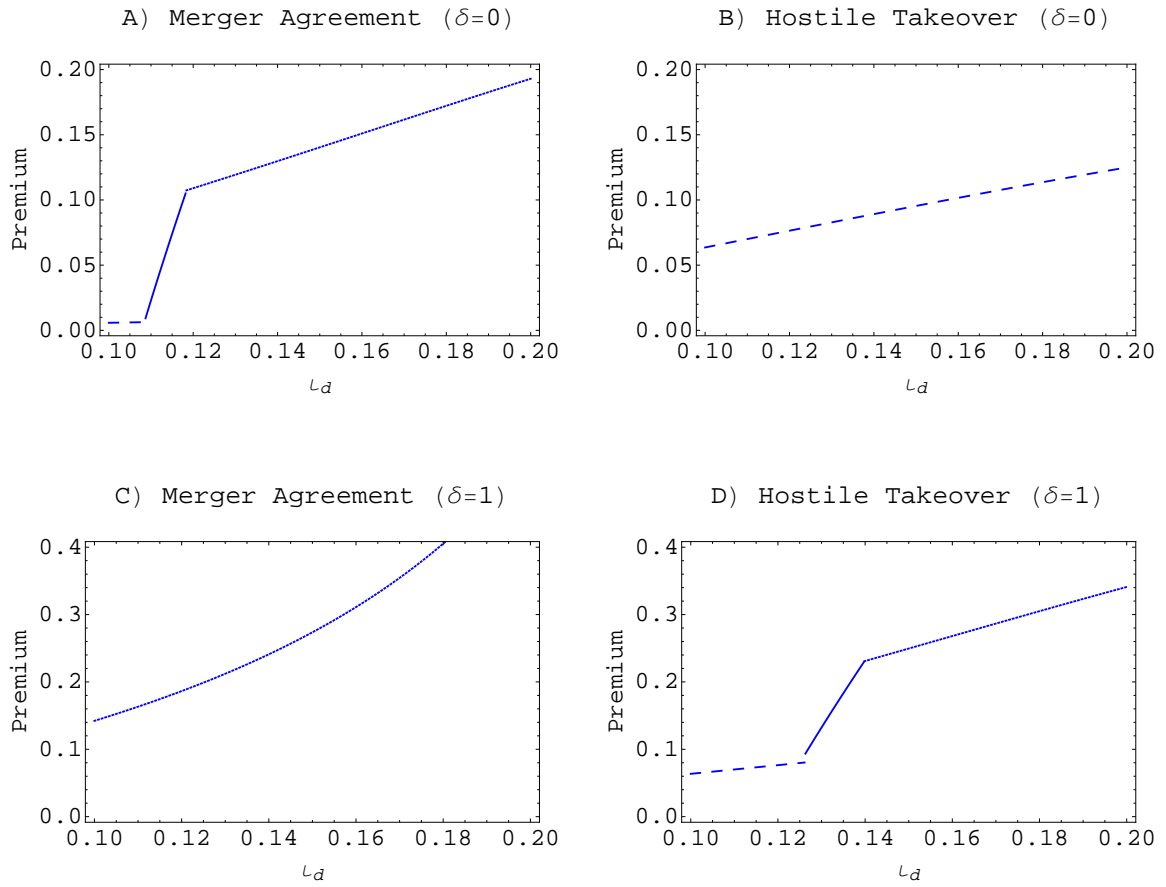


Figure 5: Acquisition premium to the target firm as a function of the issuance cost. The panels depict when the acquirer buys the target firm as 1) a growth option, and waits to exercise the investment option at the optimal investment threshold (dotted line), 2) a growth option, and immediately exercises the investment option (solid line), or 3) assets in place (dashed line).

increase in the issuance cost of financing also increases the takeover premium to the target firm, because higher issuance cost increases the synergies. Thus, there is also a larger pie to share, and the target firm obtains more as a fraction of its stand-alone value. Competition between bidders increases takeover premiums.

Figure 8 depicts the sensitivity of the acquisition premium to the bankruptcy cost (φ). If φ is low, then debtholders can recover the assets of the firm at bankruptcy. In other words, firms tend to have more tangible assets on their balance sheet. If φ is high, then debtholders cannot costlessly recover the assets of the firm at bankruptcy. In this case, firm has more intangible assets on their balance sheet. The model thus predicts that the takeover premiums

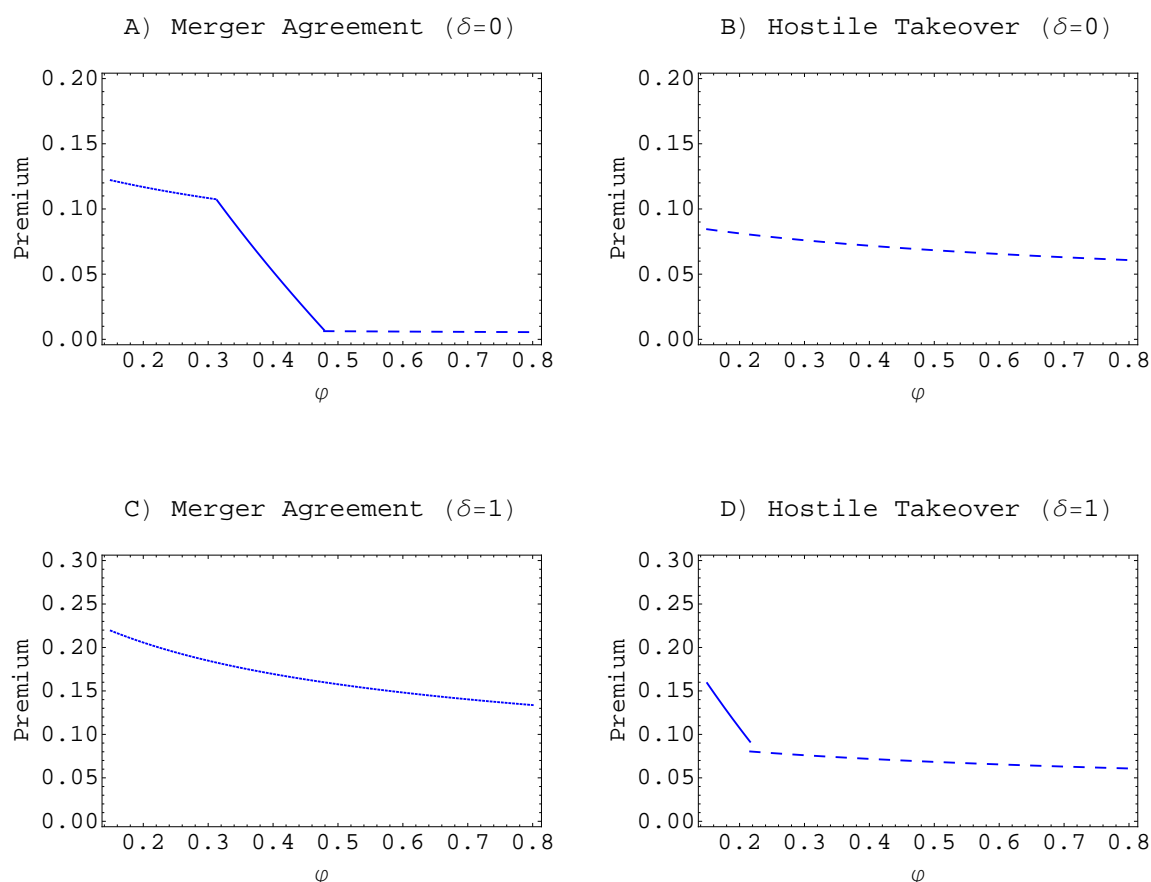


Figure 6: Acquisition premium to the target firm as a function of the bankruptcy cost. The panels depict when the acquirer buys the target firm as 1) a growth option, and waits to exercise the investment option at the optimal investment threshold (dotted line), 2) a growth option, and immediately exercises the investment option (solid line), or 3) assets in place (dashed line).

are higher for firms with more tangible assets. I do not report other comparative statics with respect to the growth rate of cash flow (μ) or the interest rate (r) because they share the same predictions about takeover premiums with other models (e.g., Hackbarth and Miao (2012)).

7.2 Acquirer return

From the acquirer's perspective its expected gains are defined as a change in stand-alone value due to the merger option. I therefore express the acquirer return as the cumulative return that results from a merger option, as a fraction of stand-alone value:

$$AR = \frac{OM(x, \bar{x}_M, \iota_d)}{OI(x, 0)} \quad (37)$$

The stand-alone value of the target firm is worth for the acquirer - $OI(x, 0)$ and depends on its phase of development. When it is acquired as a growth option, $OI(x, 0) = V_{I,D}(x, 0)$. When it is acquired as assets in place, $OI(x, 0) = V_{I,D}^+(x, 0)$.

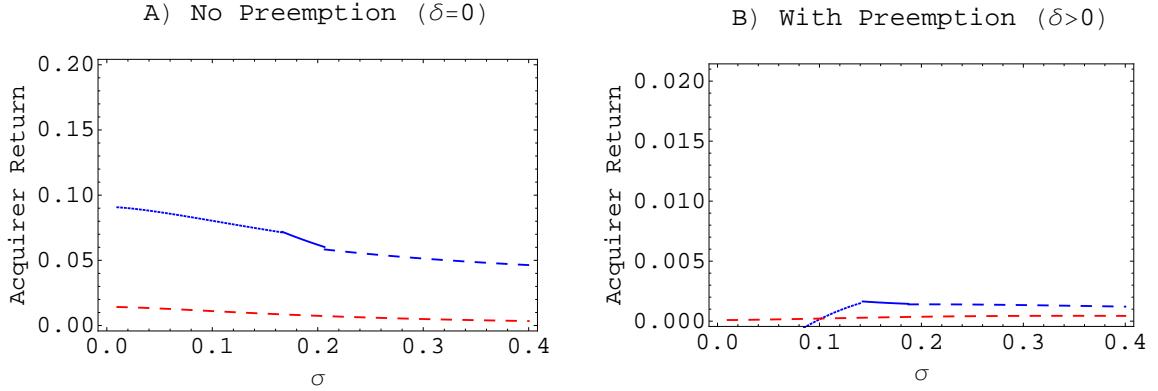


Figure 7: Acquirer return as a function of volatility. The panels depict when the acquirer buys the target firm as 1) a growth option, and waits to exercise the investment option at the optimal investment threshold (dotted line), 2) a growth option, and immediately exercises the investment option (solid line), or 3) assets in place (dashed line) in the form of the merger agreement (blue) or hostile takeover (red line).

Figure 7 shows the sensitivity of an acquirer return to volatility (σ) from the merger agreement (blue) and hostile takeover (red line) when the acquirer makes an offer in isolation ($\delta = 0$), or when it is subject to the fear of preemption ($\delta > 0$). Similarly to the target's premium the acquirer return decreases in uncertainty when there is no fear of preemption and the acquirer expected gains are higher when under the merger agreement offer. Otherwise in the case of the hostile takeover its return is close to zero.

The acquirer return in the presence of the competition is lower almost equal to zero. If the target firm is acquired as a growth option, the acquirer's return initially increases in uncertainty. This is consistent with previous studies suggesting that the hysteresis factor dominates. However, there is a kink when the target's growth option can be immediately exercised and since then acquirer's return decreases in uncertainty. The hostile takeover is preferred than the merger agreement only for lower levels of uncertainty.

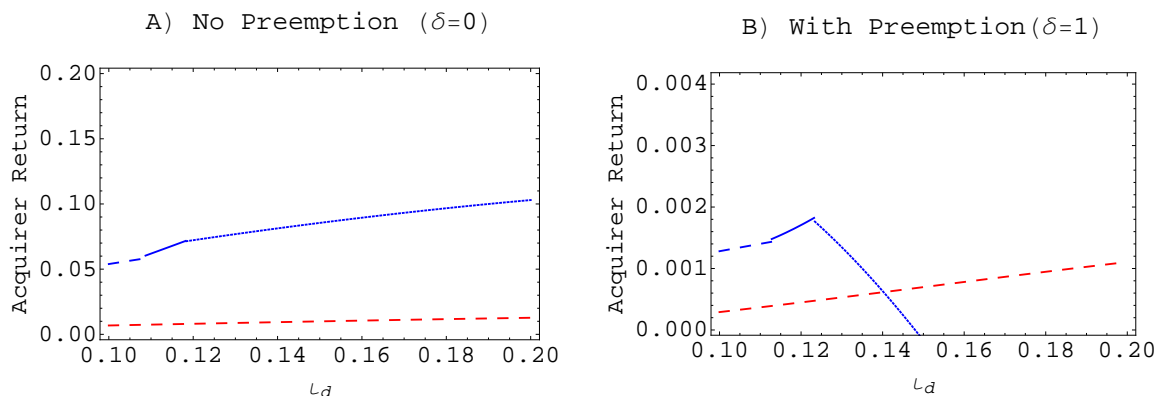


Figure 8: Acquirer return as a function of the issuance cost. The panels depict when the acquirer buys the target firm as 1) a growth option, and waits to exercise the investment option at the optimal investment threshold (dotted line), 2) a growth option, and immediately exercises the investment option (solid line), or 3) assets in place (dashed line) in the form of the merger agreement (blue line) or hostile takeover (red line).

Figure 8 shows the sensitivity of an acquirer return to the issuance cost (σ) from the merger agreement (blue) and hostile takeover (red) when the acquirer makes an offer in isolation ($\delta = 0$), or when it is subject to the fear of preemption ($\delta > 0$). When the offer is exercised in isolation the acquirer return increases when the issuance cost increases due to the positive effect of the issuance cost increase on synergies. Also, when there is no fear of preemption the merger offer is preferred than the hostile takeover as it generates higher return for the acquirer.

In the presence of competition the acquirer return is close to zero. The acquirer return from hostile takeover offer is higher than the one from merger offer when the issuance cost is high.

Figure 9 shows the sensitivity of an acquirer return to the bankruptcy cost (σ) from the merger agreement (blue) and hostile takeover (red) when the acquirer makes an offer in isolation ($\delta = 0$), or when it is subject to the fear of preemption ($\delta > 0$). The acquirer return decreases in bankruptcy cost when the offer is exercised in isolation and the merger offer is preferred than the hostile takeover as it generates higher return for the acquirer. Acquirer return is higher when buying a target with more tangible assets.

In the presence of competition the acquirer return is close to zero yet the merger offer

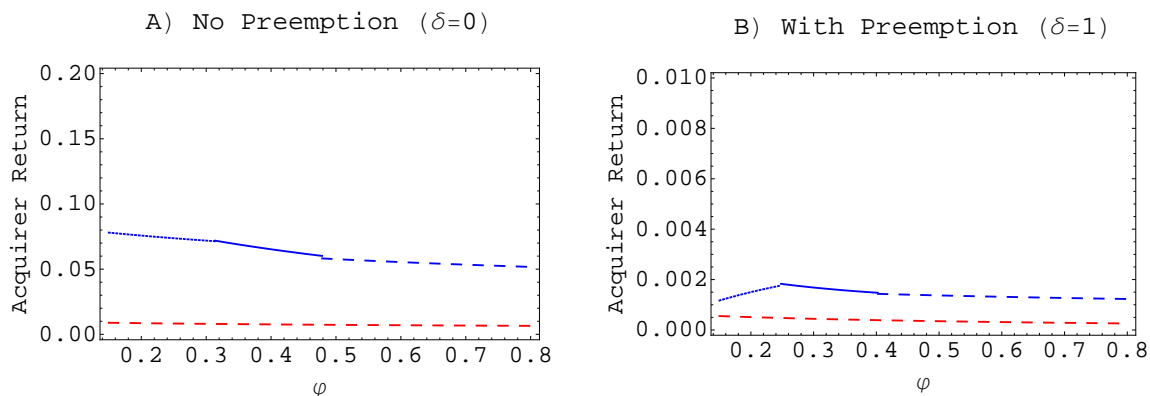


Figure 9: Acquirer return as a function of the bankruptcy cost. The panels depict when the acquirer buys the target firm as 1) a growth option, and waits to exercise the investment option at the optimal investment threshold (dotted line), 2) a growth option, and immediately exercises the investment option (solid line), or 3) assets in place (dashed line) in the form of the merger agreement (blue line) or hostile takeover (red line).

still generates a higher return for the acquirer than hostile takeover.

8. Conclusion

This paper presents a dynamic model of buyouts, where the bidder's decision is a sequential option under the threat of preemption. The bidder can acquire the target firm as a growth option or as assets in place. The synergies arise due to asymmetric access to financing. The acquirer's optimal choice depends on the magnitude of financial synergies, the level of preemption fear, and the offer type. The target firm's development phase affects the optimal merger threshold, the division of synergies, and the takeover premium.

The model shows that the synergies created by providing cheap financing to the target firm can be decomposed into three effects: limited liability, leverage, and asymmetric financing. The magnitude and importance of these synergies depend on whether the target firm is acquired as a growth option or as physical assets. If the target firm is acquired at an early stage of development, the synergies, the acquirer can realize are related to the asymmetric financing and leverage effects. However, once the target firm has commercialized its growth options, and its assets in place generate profits, the synergies are related to the leverage effect and the limited liability effect.

When the bidder faces competition, in the form of preemption fears, it is more likely to acquire the target firm at an earlier stage of development when the growth option remains unexercised. Furthermore, my framework predicts that the fear of preemption speeds up the timing of a merger agreement, while the timing of a hostile takeover converges to the global optimizer merger threshold. My analysis reveals additional insights into the role of competition in the bidding process. When the bidder has preemption fears, friendly mergers tend to be exercised too early. When the fear of preemption is high, hostile takeovers converge to the first-best merger threshold. Takeover premiums to the target firm are higher when the firm is acquired at an earlier stage of development, and when the bidder is subject to the fear of preemption. In contrast, acquirer return is lower when subject to the fear of preemption.

The main empirical predictions of the model are as follows. First, this study implies a positive correlation between the number of bidders for a target firm and the likelihood it will be acquired as a growth option (or a production opportunity). Therefore, firms with higher levels of R&D on their balance sheets are acquired earlier than firms with more physical assets. Second, there is also a positive correlation between the issuance cost of financing for the target firm, and the likelihood that mergers are motivated by financial synergies. The model predicts more merger activity of financial bidders during economic booms when there is a high spread in the cost of financing between the acquirer and the target.

Appendix A. Proof of Lemma 1

To work out the optimal investment threshold of the innovating firm I have to solve the problem backwards. First, I solve for the post-investment values when the innovating target firm can rely on capital markets financing. Second, I derive the ex ante-investment values and then closed form solutions for the optimal investment threshold.

When the innovative firm financed the cost of investment with risky debt, its assets in place generate the after tax cash-flow $(1 - \tau)\pi$ less the fixed coupon $c_{I,D}$ paid to bondholders.

Assuming that r is a risk free rate and agents are risk-neutral, the firm's equity $E_{I,D}^+$ and debt $B_{I,D}^+$ must satisfy:

$$rE_{I,D}^+ = (1 - \tau)\pi x - (1 - \tau)c_{I,D} + \frac{d}{d\Delta} \mathbb{E}[E_{I,D,t+\Delta}^+] \Big|_{\Delta=0} \quad (\text{A.1.})$$

$$rB_{I,D}^+ = c_{I,D} + \frac{d}{d\Delta} \mathbb{E}[B_{I,D,t+\Delta}^+] \Big|_{\Delta=0} \quad (\text{A.2.})$$

Assuming $E_{I,D}^+$ and $B_{I,D}^+$ are twice-continuously differentiable functions of the state variable x_t , then by applying Ito's lemma I obtain:

$$rE_{I,D}^+(x) = (1 - \tau)\pi x - (1 - \tau)c_{I,D} + \frac{\partial E_{I,D}^+(x)}{\partial x} x\mu + \frac{\partial^2 E_{I,D}^+(x)}{\partial^2 x} x^2 \frac{\sigma^2}{2} \quad (\text{A.3.})$$

$$rB_{I,D}^+(x) = c_{I,D} + \frac{\partial B_{I,D}^+(x)}{\partial x} x\mu + \frac{\partial^2 B_{I,D}^+(x)}{\partial^2 x} x^2 \frac{\sigma^2}{2} \quad (\text{A.4.})$$

The ordinary differential equations have solutions as follows:

$$E_{I,D}^+(x) = \frac{(1 - \tau)\pi x}{r - \mu} - (1 - \tau)c_{I,D} + A_1 x^\beta + A_2 x^\lambda \quad (\text{A.5.})$$

$$B_{I,D}^+(x) = \frac{c_{I,D}}{r} + A_3 x^\beta + A_4 x^\lambda \quad (\text{A.6.})$$

where $\beta > 1$ and $\lambda < 0$ are the positive and negative root of the equation: $1/2\sigma^2 z(z - 1) + \mu z - r = 0$.

The constants A_1 and A_2 are determined by the following conditions for equityholders.

The first condition stipulates that at the default threshold, $\underline{x}_{I,D}$, the equityholders are left with nothing and their claims are equal to: $E_{I,D}^+(\underline{x}_{I,D}) = 0$. Second, by a no-bubble condition states that when the state variable goes to infinity the equityholders claims approach the unlimited liability value: $\lim_{x_t \rightarrow \infty} E_{I,D}^+(x_t) = (1 - \tau)\pi x / (r - \mu) - (1 - \tau)c_{I,D}/r$.

The constants A_3 and A_4 are determined by the following conditions for bondholders. First, at the default threshold, $\underline{x}_{I,D}$, the bondholders are left with the liquidation value, $B_{I,D}^+(\underline{x}_{I,D}) = (1 - \varphi)\phi \underline{x}_{I,D} / (r - \mu)$. Second, when the state variable goes to infinity the bondholders claims approach the unlimited liability value: $\lim_{x_t \rightarrow \infty} B_{I,D}^+(x_t) = c_{I,D}/r$. These necessary conditions yield the solutions for equity and debt when $x \geq \bar{x}_{I,D}$:

$$E_{I,D}^+(x, 0) = (1 - \tau) \left[\frac{\pi x}{r - \mu} - \frac{c_{I,D}}{r} \right] - \left[\frac{(1 - \tau)\pi \underline{x}_{I,D}}{r - \mu} - \frac{(1 - \tau)c_{I,D}}{r} \right] \left(\frac{x}{\underline{x}_{I,D}} \right)^\lambda \quad (\text{A.7.})$$

$$B_{I,D}^+(x, 0) = \frac{c_{I,D}}{r} - \left(\frac{c_{I,D}}{r} - \frac{(1 - \varphi)\phi \underline{x}_{I,D}}{r - \mu} \right) \left(\frac{x}{\underline{x}_{I,D}} \right)^\lambda \quad (\text{A.8.})$$

The firm value is the sum of equity and debt given in Eq. (7) in Lemma 1. Equityholders choose the default threshold when the equity value is maximized w.r.t. x which is evaluated at $x = \underline{x}_{I,D}$ ⁸:

$$\left. \frac{\partial E_{I,D}^+(x)}{\partial x} \right|_{x=\underline{x}_{I,D}} = 0 \quad (\text{A.9.})$$

which gives the solution for the closure threshold in Lemma 1. Next, I substitute for $\underline{x}_{I,D}$ in $V_{I,D}^+(x)$. I determine the closed-form solution for the optimal coupon $c_{I,D}(x)$ by maximizing the firm value (the root of the first order condition):

$$\frac{\partial [V_{I,D}^+(x, 0) - \iota_d B_{I,D}^+(x, 0)]}{\partial c_{I,D}(x)} = 0 \quad (\text{A.10.})$$

Inserting values for $c_{I,D}$ and $\underline{x}_{I,D}$ the post-investment equity and debt are:

$$E_{I,D}^+(x, \iota_d) = \frac{\pi x (1 - \tau) (1 - \lambda + \lambda \Omega^{-1/\lambda} - \Omega^{-1}) \Omega^{1/\lambda}}{\lambda (r - \mu)} \quad (\text{A.11.})$$

⁸Equityholders can cover operating losses by injecting more capital.

$$B_{I,D}^+(x, \iota_d) = \frac{x\Omega^{\frac{1-\lambda}{\lambda}} (\pi(1-\iota_d)(1-\lambda) + (1 - (1-\iota_d)\lambda - \tau)\phi(-1+\varphi))}{(r-\mu)(\tau-\iota_d)} \quad (\text{A.12.})$$

where $1/\lambda [1 - \lambda + \lambda\Omega^{-1/\lambda} - \Omega^{-1}] > 0$ is always satisfied. The post-investment firm value net of issuance cost is:

$$V_{I,D}^+(x, \iota_d) = V_{I,D}^+(x, 0) - \iota_d B_{I,D}^+(x, 0) = x\Psi \quad (\text{A.13.})$$

where $\Psi = [\pi x (1 - \tau + (\tau - \iota_d)(\Omega)^{1/\lambda})] / (r - \mu)$. Lemma 1 follows.

Appendix B. Proof of Lemma 2

In the continuation region, before the investment exercise, the innovative firm is a growth option and does not generate any cash flows. The equityholders only obtain capital gains. The firm value has to satisfy the following Bellman equation:

$$rV_{I,j} = \frac{d}{d\Delta} \mathbb{E}[V_{I,j,t+\Delta}] \Big|_{\Delta=0} \quad \text{for } j = E, D. \quad (\text{B.1.})$$

Using Ito's lemma one can show that the firm value before investment satisfies:

$$rV_{I,j}(x_t) = \frac{\partial V_{I,D}(x)}{\partial x} x\mu + \frac{\partial V_{I,D}(x)}{\partial x} x^2 \frac{\sigma^2}{2} \quad (\text{B.2.})$$

The ordinary differential equation has the solution as follows:

$$V_{I,j}(x_t) = A_5 x^\beta + A_6 x^\lambda \quad (\text{B.3.})$$

where $\beta > 1$ and $\lambda < 0$ are the positive and negative root of the equation: $1/2\sigma^2 z(z - 1) + \mu z - r = 0$. The constants are derived as the solutions to no-bubble condition, limiting $A_6 = 0$, and the value matching condition that at the time of investment the value of equity has to be equal the payoff from investment. When the capital outlay is financed with equity the following expression has to be satisfied:

$$V_{I,E}(\bar{x}_{I,E}) = (1 - \iota_e) V_{I,E}^+(\bar{x}_{I,E}) - \kappa \quad (\text{B.4.})$$

and when the investment cost is financed by raising debt:

$$V_{I,D}(\bar{x}_{I,D}) = V_{I,D}^+(\bar{x}_{I,D}, \iota_d) - \iota_d B_{I,D}^+(\bar{x}_{I,D}, \iota_d) - \kappa = \Psi \bar{x}_{I,D} - \kappa \quad (\text{B.5.})$$

Then, the smooth-pasting conditions to ensure that the investment occurs along the optimal path for investment financed with equity and debt respectively are:

$$\partial V_{I,E}(x)/\partial x \Big|_{x=\bar{x}_{I,E}} = \partial(1 - \iota_e)V_{I,E}^+(x)/\partial x \Big|_{x=\bar{x}_{I,E}} \quad (\text{B.6.})$$

$$\partial V_{I,D}(x)/\partial x \Big|_{x=\bar{x}_{I,D}} = \partial(1 - \iota_d)V_{I,E}^+(x, \iota_d)/\partial x \Big|_{x=\bar{x}_{I,D}} = \Psi \quad (\text{B.7.})$$

Lemma 2 follows.

Appendix C. Proof of Proposition 1

Over the continuation interval investors having an option to merge obtain capital gains and the following condition has to be satisfied:

$$rOM = \frac{d}{d\Delta} \mathbb{E}[OMt + \Delta] \Big|_{\Delta=0} \quad (\text{C.1.})$$

Assuming OM is a twice-continuously differentiable function of the state variable x_t , then by applying Ito's lemma I obtain a second-order ODE equation:

$$rOM(x) = \mu X \frac{\partial OM(x)}{\partial X} + \frac{1}{2} \sigma^2 X^2 \frac{\partial^2 OM(x)}{\partial^2 X} \quad (\text{C.2.})$$

The ordinary differential equation has a solution as follows:

$$OM(x) = A_7 x^\beta + A_8 x^\lambda \quad (\text{C.3.})$$

This equation can be solved subject to boundary conditions. The value matching condition stipulates that at the optimal merger threshold the value of the merger option equals to the realized net synergies: $OM(\bar{x}_M, \bar{x}_M, \iota_d) = \Delta(\bar{x}_M, \iota_d) - K_M - K_T$. A no-bubble condition implies that: $\lim_{x_t \rightarrow 0} OM(x_t) = 0$. The resulting value of the merger option conditional on the merger trigger satisfies the following equation:

$$OM(x, \bar{x}_M, \iota_d) = (OI(\bar{x}_M, 0) - OI(\bar{x}_M, \iota_d) - K_M - K_T) \left(\frac{x}{\bar{x}_M} \right)^\beta \quad (\text{C.4.})$$

The first-order condition ensures that the merger occurs along optimal path, and $\partial OM(\bar{x}_M, \iota_d) / \partial \bar{x}_M = 0$. The optimal threshold \bar{x}_M satisfies the following condition:

$$-\beta (OI(\bar{x}_M, 0) - OI(\bar{x}_M, \iota_d) - K_M - K_T) + \bar{x}_M \frac{\partial (OI(\bar{x}_M, 0) - OI(\bar{x}_M, \iota_d))}{\partial \bar{x}_M} = 0 \quad (\text{C.5.})$$

I solve the above equation for the following cases when (the logic is similar to Chapter 10 on sequential investment of Dixit and Pindyck (1994)):

$$1) \bar{x}_M < \bar{x}_I^o < \bar{x}_I^c$$

If the acquirer buys the target firm as a growth option and waits to exercise the investment at the optimal trigger, the merger threshold is the solution to the following F.O.C.:

$$\bar{x}_M^\beta \frac{\kappa}{\beta - 1} \left[\frac{1}{\mathcal{H}_{\beta\kappa}} \right]^\beta (\Phi^\beta - \Psi^\beta) - \mathcal{H}_\beta K_M - \mathcal{H}_\beta K_T = 0 \quad (\text{C.6.})$$

where $\Phi = \Psi(\iota_d = 0)$. The optimal threshold when the acquirer buys the target firm as a growth option is:

$$\bar{x}_M = \mathcal{H}_{\beta\kappa} \left[\frac{\beta(K_M + K_T)}{\kappa(\Phi^\beta - \Psi^\beta)} \right]^{\frac{1}{\beta}} \quad (\text{C.7.})$$

And is satisfied only when:

$$\bar{x}_M < \bar{x}_I^o \iff \frac{K_M + K_T}{\kappa} < \frac{\Phi^\beta - \Psi^\beta}{\beta\Phi^\beta} \quad (\text{C.8.})$$

$$2) \bar{x}_I^o \leq \bar{x}_M < \bar{x}_I^c$$

If the acquirer buys the target firm as a growth option and exercises the investment option immediately, the merger threshold is the solution to the following F.O.C.:

$$\bar{x}_M \Phi - \kappa - \bar{x}_M^\beta \frac{\kappa}{\beta - 1} \left[\frac{\Psi}{\mathcal{H}_{\beta\kappa}} \right]^\beta - \mathcal{H}_\beta K_M - \mathcal{H}_\beta K_T = 0 \quad (\text{C.9.})$$

The above equation requires a numerical solution for \bar{x}_M . And is satisfied only when:

$$\bar{x}_I^o \leq \bar{x}_M < \bar{x}_I^c \iff \frac{\Phi^\beta - \Psi^\beta}{\beta\Phi^\beta} \leq \frac{K_M + K_T}{\kappa} < \frac{\Phi - \Psi}{\Psi} \quad (\text{C.10.})$$

$$3) \bar{x}_I^o < \bar{x}_I^c \leq \bar{x}_M$$

If the acquirer buys the target firm as assets in place, the merger threshold is the solution to the following F.O.C.:

$$\bar{x}_M(\Phi - \Psi) - \mathcal{H}_\beta K_M - \mathcal{H}_\beta K_T = 0 \quad (\text{C.11.})$$

The optimal threshold when the acquirer buys the target firm as assets in place is:

$$\bar{x}_M = \frac{\mathcal{H}_\beta K_M + \mathcal{H}_\beta K_T}{\Phi - \Psi} \quad (\text{C.12.})$$

And is satisfied only when:

$$\bar{x}_I^c \leq \bar{x}_M \iff \frac{\Phi - \Psi}{\Psi} \leq \frac{K_M + K_T}{\kappa} \quad (\text{C.13.})$$

To prove that \bar{x}_M is defined over all possible regions and no discontinuities are present one can check that: when $\bar{x}_I^o = \bar{x}_M$ then $\frac{K_M + K_T}{\kappa} = \frac{\Phi^\beta - \Psi^\beta}{\beta \Phi^\beta}$, and when $\bar{x}_I^c = \bar{x}_M$ then $\frac{\Phi - \Psi}{\Psi} = \frac{K_M + K_T}{\kappa}$. Proposition 1 follows.

Appendix D. Proof of Proposition 2 and 3

The probability of one jump in the Poisson process is:

$$Pr(C = 1) = \delta t e^{-\delta t} \quad (\text{D.1.})$$

Therefore, the expected time before competitor's arrival is:

$$\mathbb{E}[\mathcal{T}_C] = \frac{1}{\delta} \quad (\text{D.2.})$$

The option to merge with the target can be only exercised before the competitor arrives at time (\mathcal{T}_C). Therefore, if $t < \mathcal{T}_C$ bidder can still exercise the option to merge. Otherwise, if $t > \mathcal{T}_C$ the competing bidder takes over the target firm. Bidder maximizes the value of the option to merge, at time \mathcal{T}_M , which is now:

$$OM_B(x) = \max_{\mathcal{T}_M} \mathbb{E}[\mathbb{1}_{\mathcal{T}_M < \mathcal{T}_C} e^{-r\mathcal{T}_M} (s_B OI(\bar{x}_M, 0) - K_M)] \quad (\text{D.3.})$$

$\mathbb{1}_a$ is the indicator function of an event a . $\mathbb{1}_a = 1$ if $t < \mathcal{T}_C$ and $\mathbb{1}_a = 0$ otherwise. The Bellman equation over the continuation region is:

$$rOM_B(x)dt = \mathbb{E}[dOM_B(x)] \quad (\text{D.4.})$$

Using Ito's lemma one can show that the value of the option to acquire before exercise and project expiry has to satisfy (where the jump is of a fixed size):

$$rOM_B(x) = \mu X \frac{\partial OM_B(x)}{\partial X} + \frac{1}{2} \sigma^2 X^2 \frac{\partial^2 OM_B(x)}{\partial^2 X} + \delta(OM_B^J(x) - OM_B(x)) \quad (\text{D.5.})$$

As $OM_B^J(x) = 0$ equation can be written as:

$$rOM_B(x) = \mu X \frac{\partial OM_B(x)}{\partial X} + \frac{1}{2} \sigma^2 X^2 \frac{\partial^2 OM_B(x)}{\partial^2 X} - \delta OM_B(x) \quad (\text{D.6.})$$

The left hand side of the equation represents the required rate of return of investing in the option to acquire. The right hand side shows the capital gains that investors get per unit of time and the last term reflects the effect of preemption. The ordinary differential equation has solution as follows:

$$OM_B(x_t) = A_9 x_t^\xi + A_{10} x_t^v \quad (\text{D.7.})$$

where $\xi > 1$ and $v < 0$ are the solutions of the equation: $1/2\sigma^2 z(z-1) + \mu z - r - \delta = 0$. This equation can be solved subject to boundary conditions. The value matching condition stipulates that at the optimal merger threshold the value of the option equals the merger payoff,

$$OM_B(\bar{x}_M) = s_B OI(\bar{x}_M, 0) - K_M \quad (\text{D.8.})$$

and no-bubble condition eliminates constant A_{10} :

$$\lim_{x \rightarrow 0} OM_B(x) = 0 \quad (\text{D.9.})$$

The value of the merger option conditional on the merger trigger satisfies the following equation for the bidder:

$$OM_B(x, \bar{x}_M(s_B), \iota_d) = (s_B OI(\bar{x}_M(s_B), 0) - K_M) \left(\frac{x}{\bar{x}_M(s_B)} \right)^\xi \quad (\text{D.10.})$$

where $\bar{x}_M(s_B)$ is the reaction function of the bidder dependent on the share s_B . Following similar arguments, where now $\delta = 0$, the merger option for the target firm satisfies the following ODE:

$$rOM_T(x) = \mu X \frac{\partial OM_T(x)}{\partial X} + \frac{1}{2} \sigma^2 X^2 \frac{\partial^2 OM_T(x)}{\partial^2 X} \quad (\text{D.11.})$$

The left hand side of the equation represents the required rate of return of investing in the option to acquire. The right hand side shows the capital gains that investors get per unit of time. The option value for the target firm is:

$$OM_T(x, \bar{x}_M(s_T), \iota_d) = (s_T OI(\bar{x}_M(s_T), 0) - OI(\bar{x}_M(s_T), \iota_d) - K_T) \left(\frac{x}{\bar{x}_M(s_T)} \right)^\beta \quad (\text{D.12.})$$

where $\bar{x}_M(s_T)$ is the reaction function of the bidder dependent on the share s_T . To determine the optimal merger threshold I calculate reaction functions for the bidder and the target dependent on the share in the new entity. The F.O.C. for the bidder is as follows:

$$-\xi(s_B OI(\bar{x}_M(s_B), 0) - K_M) + \bar{x}_M(s_B) \frac{\partial (s_B OI(\bar{x}_M(s_B), 0))}{\partial \bar{x}_M(s_B)} = 0 \quad (\text{D.13.})$$

and for the target:

$$\begin{aligned} & -\beta(s_T OI(\bar{x}_M(s_T), 0) - OI(\bar{x}_M(s_T), \iota_d) - K_T) + \\ & + \bar{x}_M(s_T) \frac{\partial (s_T OI(\bar{x}_M(s_T), 0) - OI(\bar{x}_M(s_T), \iota_d))}{\partial \bar{x}_M(s_T)} = 0 \end{aligned} \quad (\text{D.14.})$$

The optimal threshold \bar{x}_M is the solution to the following condition: $\bar{x}_M(s_B) = \bar{x}_M(s_T)$. I solve the above optimization problem for the following cases discussed in Section 4.

$$1) \bar{x}_M < \bar{x}_I^o < \bar{x}_I^c$$

If the bidder buys the target firm as a growth option and waits to exercise the investment at the optimal trigger, the merger threshold is the solution to the following F.O.C.s, for the bidder:

$$\bar{x}_M^\beta \frac{\kappa}{\beta - 1} \left[\frac{1}{\mathcal{H}_\beta \kappa} \right]^\beta s_B \Phi^\beta - \mathcal{H}_\xi K_M = 0 \quad (\text{D.15.})$$

and for the target:

$$\bar{x}_M^\beta \frac{\kappa}{\beta - 1} \left[\frac{1}{\mathcal{H}_\beta \kappa} \right]^\beta (s_T \Phi^\beta - \Psi^\beta) - \mathcal{H}_\beta K_T = 0 \quad (\text{D.16.})$$

The reaction function of the bidder is:

$$\bar{x}_M(s_B) = \frac{\mathcal{H}_\beta \kappa}{\Phi} \left[\frac{(\beta - 1) \mathcal{H}_\xi K_M}{\kappa s_B} \right]^{\frac{1}{\beta}} \quad (\text{D.17.})$$

and the reaction function of the target:

$$\bar{x}_M(s_T) = \frac{\mathcal{H}_\beta \kappa}{\Phi} \left[\frac{(\beta - 1) \mathcal{H}_\beta K_T}{\kappa (s_T - (\Psi/\Phi)^\beta)} \right]^{\frac{1}{\beta}} \quad (\text{D.18.})$$

The optimal ownership is calculated as the solution to: $\bar{x}_M(s_B) = \bar{x}_M(s_T)$ and $s_T = 1 - s_B$.

$$s_B = \frac{\mathcal{H}_\xi K_M (\Phi^\beta - \Psi^\beta)}{\Phi^\beta (\mathcal{H}_\xi K_M + \mathcal{H}_\beta K_T)} \quad (\text{D.19.})$$

After substituting I obtain the merger threshold when the bidder is subject to competition as:

$$\bar{x}_M = \mathcal{H}_\beta \kappa \left[\frac{\beta (K_M + K_T)}{\kappa (\Phi^\beta - \Psi^\beta)} \right]^{\frac{1}{\beta}} \quad (\text{D.20.})$$

And is satisfied only when:

$$\bar{x}_M < \bar{x}_I^o \iff \frac{\frac{\mathcal{H}_\xi}{\mathcal{H}_\beta} K_M + K_T}{\kappa} < \frac{\Phi^\beta - \Psi^\beta}{\beta \Phi^\beta} \quad (\text{D.21.})$$

$$2) \bar{x}_I^o < \bar{x}_M < \bar{x}_I^c$$

If the acquirer buys the target firm as a growth option and exercises the investment option immediately, the merger threshold is the solution to the following F.O.C.:

$$s_B \bar{x}_M \Phi - \mathcal{H}_\xi K_M = 0 \quad (\text{D.22.})$$

The reaction function when the bidder buys the target firm as a growth option and immediately exercises is:

$$\bar{x}_M(s_B) = \mathcal{H}_\xi \frac{K_M}{s_B \Phi} \quad (\text{D.23.})$$

The F.O.C. for the target firm is:

$$s_T \bar{x}_M \Phi - \bar{x}_M^\beta \frac{\kappa}{\beta - 1} \left[\frac{\Psi}{\mathcal{H}_\beta \kappa} \right]^\beta - \mathcal{H}_\beta K_T = 0 \quad (\text{D.24.})$$

The reaction function for the target $\bar{x}_M(s_T)$ requires a numerical solution. Then the ownership share can be derived as the solution to: $\bar{x}_M(s_B) = \bar{x}_M(s_T)$. And is satisfied only when:

$$\bar{x}_I^o \leq \bar{x}_M < \bar{x}_I^c \iff \frac{\Phi^\beta - \Psi^\beta}{\beta \Phi^\beta} \leq \frac{\frac{\mathcal{H}_\xi}{\mathcal{H}_\beta} K_M + K_T}{\kappa} < \frac{\Phi - \Psi}{\Psi} \quad (\text{D.25.})$$

$$3) \bar{x}_I^o < \bar{x}_I^c < \bar{x}_M$$

If the acquirer buys the target firm as assets in place, the merger threshold is the solution to the following F.O.C.:

$$s_B \bar{x}_A \Phi - \mathcal{H}_\xi K_M = 0 \quad (\text{D.26.})$$

The F.O.C. for the target firm is:

$$s_B \bar{x}_M \Phi - \bar{x}_M \Psi - \mathcal{H}_\beta K_T = 0 \quad (\text{D.27.})$$

The reaction function when the bidder buys assets in place is:

$$\bar{x}_M(s_B) = \mathcal{H}_\xi \frac{K_M}{s_B \Phi} \quad (\text{D.28.})$$

and for the target:

$$\bar{x}_M(s_T) = \mathcal{H}_\beta \frac{K_T}{s_T \Phi - \Psi} \quad (\text{D.29.})$$

The share is calculated as the solution of $\bar{x}_M(s_T) = \bar{x}_M(s_B)$:

$$s_B = \frac{\mathcal{H}_\xi K_M (\Phi - \Psi)}{(\mathcal{H}_\xi K_M + \mathcal{H}_\beta K_T) \Phi} \quad (\text{D.30.})$$

The after substituting I obtain the merger threshold when the bidder is subject to competition:

$$\bar{x}_M(\delta > 0) = \frac{\mathcal{H}_\xi K_M + \mathcal{H}_\beta K_T}{\Phi - \Psi} < \bar{x}_M(\delta = 0) \quad (\text{D.31.})$$

And is satisfied only when:

$$\bar{x}_I^c < \bar{x}_M(\delta > 0) \iff \frac{\Phi - \Psi}{\Psi} \leq \frac{\frac{\mathcal{H}_\xi}{\mathcal{H}_\beta} K_M + K_T}{\kappa} \quad (\text{D.32.})$$

Proposition 2 and 3 follow.

Appendix E. Proof of Proposition 4

Following similar arguments as in in previous appendix for Proposition 2 I can show that a takeover option, denoted as $OT(x)$, satisfies the following equation, which is for the bidder:

$$OT_B(x, \bar{x}_M(s_B)) = (s_B OI(\bar{x}_M(s_B), 0) - K_M) \left(\frac{x}{\bar{x}_M(s_B)} \right)^\xi \quad (\text{E.1.})$$

and for the target:

$$OT_T(x, s_T(\bar{x}_M), s_T) = (s_T(\bar{x}_M) OI(\bar{x}_M, 0) - OI(\bar{x}_M, \iota_d) - K_T) \left(\frac{x}{\bar{x}_M} \right)^\beta \quad (\text{E.2.})$$

In contrast to merger agreement the takeover is solved as a Stackelberg game, where the target decides on the ownership share (s_T) and then the bidder decides on the timing of the takeover conditional on the share that the target firm obtains. The smooth-pasting condition ensures that the takeover occurs along optimal path, and $\partial OT_B(\bar{x}_M)/\partial \bar{x}_M = 0$. The bidder's takeover reaction function $\bar{x}_M(s_B)$ satisfies the following condition:

$$-\xi (s_B OI(\bar{x}_M, 0) - K_M) + \bar{x}_M \frac{\partial s_B OI(\bar{x}_M, 0)}{\partial \bar{x}_M} = 0 \quad (\text{E.3.})$$

The target firm then decides on the share. Its optimization problem can be formulated as $\max_{s_T} OT_T(x, s_T(\bar{x}_M), s_T)$ or when I substitute for $s_T(\bar{x}_M)$ the value derived from Eq. (E.3.) it can be written as $\max_{\bar{x}_M} OT_T(x, \bar{x}_M, s_T(\bar{x}_M))$. Solving the latter optimization problem the takeover threshold is the solution to the following equation:

$$-\beta (s_T OI(\bar{x}_M, 0) - OI(\bar{x}_M, \iota_d) - K_T) + \bar{x}_M \frac{\partial (s_T OI(\bar{x}_M, 0) - OI(\bar{x}_M, \iota_d))}{\partial \bar{x}_M} = 0 \quad (\text{E.4.})$$

I solve the above optimization problem for the following cases:

$$1) \bar{x}_M < \bar{x}_I^o < \bar{x}_I^c$$

If the acquirer buys the target firm as a growth option and waits to exercise the investment

at the optimal trigger, the takeover threshold is the solution to the following F.O.C.:

$$s_B \bar{x}_M^\beta \frac{\kappa}{\beta - 1} \left[\frac{1}{\mathcal{H}_\beta \kappa} \right]^\beta \Phi^\beta - \mathcal{H}_\xi K_M = 0 \quad (\text{E.5.})$$

The reaction function when the bidder buys the target firm as a growth option is:

$$\bar{x}_M(s_B) = \frac{\mathcal{H}_\beta \kappa}{\Phi} \left[\frac{(\beta - 1) \mathcal{H}_\xi K_M}{\kappa s_B} \right]^{\frac{1}{\beta}} \quad (\text{E.6.})$$

or rewriting:

$$s_B(\bar{x}_M) = \frac{\mathcal{H}_\xi K_M}{(\bar{x}_M \frac{1}{\mathcal{H}_\beta \kappa} \Phi)^\beta} \frac{\beta - 1}{\kappa} \quad (\text{E.7.})$$

Now substituting for s_B into the F.O.C. for the target firm:

$$\bar{x}_M^\beta \frac{\kappa}{\beta - 1} \left[\frac{1}{\mathcal{H}_\beta \kappa} \right]^\beta (\Phi^\beta - \Psi^\beta) - \mathcal{H}_\beta \mathcal{H}_\xi K_M - \mathcal{H}_\beta K_T = 0 \quad (\text{E.8.})$$

The optimal takeover threshold when the acquirer buys the target firms as a growth option is:

$$\bar{x}_M = \mathcal{H}_\beta \kappa \left[\frac{(\beta - 1)(\mathcal{H}_\beta \mathcal{H}_\xi K_M + \mathcal{H}_\beta K_T)}{\kappa(\Phi^\beta - \Psi^\beta)} \right]^{\frac{1}{\beta}} \quad (\text{E.9.})$$

The optimal share s_B is:

$$s_B = \frac{\mathcal{H}_\xi K_M (\Phi^\beta - \Psi^\beta)}{\Phi^\beta (\mathcal{H}_\beta \mathcal{H}_\xi K_M + \mathcal{H}_\beta K_T)} \quad (\text{E.10.})$$

And the above is satisfied only when:

$$\bar{x}_M < \bar{x}_I^o \iff \frac{\mathcal{H}_\xi K_M + K_T}{\kappa} < \frac{\Phi^\beta - \Psi^\beta}{\beta \Phi^\beta} \quad (\text{E.11.})$$

$$2) \bar{x}_I^o < \bar{x}_M < \bar{x}_I^c$$

If the acquirer buys the target firm as a growth option and exercises the investment option immediately, the takeover threshold is the solution to the following F.O.C.:

$$\bar{x}_M s_B \Phi - \mathcal{H}_\xi K_M = 0 \quad (\text{E.12.})$$

The reaction function when the bidder buys the target firm as a growth option followed by immediate exercise is:

$$\bar{x}_M(s_B) = \frac{\mathcal{H}_\xi K_M}{s_B \Phi} \quad (\text{E.13.})$$

or rewriting:

$$s_B(\bar{x}_M) = \frac{\mathcal{H}_\xi K_M}{\Phi \bar{x}_M} \quad (\text{E.14.})$$

Now substituting for s_B into the F.O.C. for the target firm:

$$\bar{x}_M \Phi - \bar{x}_M^\beta \frac{\kappa}{\beta - 1} \left[\frac{\Psi}{\mathcal{H}_\beta \kappa} \right]^\beta - \mathcal{H}_\beta \mathcal{H}_\xi K_M - \mathcal{H}_\beta K_T = 0 \quad (\text{E.15.})$$

The above equation requires a numerical solution for the optimal merger threshold \bar{x}_M . And is satisfied only when:

$$\bar{x}_I^o \leq \bar{x}_M < \bar{x}_I^c \iff \frac{\Phi^\beta - \Psi^\beta}{\beta \Phi^\beta} \leq \frac{\mathcal{H}_\xi K_M + K_T}{\kappa} < \frac{\Phi - \Psi}{\Psi} \quad (\text{E.16.})$$

$$3) \bar{x}_I^o < \bar{x}_I^c < \bar{x}_M$$

If the acquirer buys the target firm as assets in place, the takeover threshold is the solution to the following F.O.C.:

$$-\xi (s_B \bar{x}_M \Phi - K_M) + s_B \bar{x}_M \Phi = 0 \quad (\text{E.17.})$$

The reaction function when bidder buys assets in place is:

$$\bar{x}_M(s_B) = \frac{\mathcal{H}_\xi K_M}{s_B \Phi} \quad (\text{E.18.})$$

or rewriting:

$$s_B(\bar{x}_M) = \frac{\mathcal{H}_\xi K_M}{\Phi \bar{x}_M} \quad (\text{E.19.})$$

Substituting into F.O.C. for the target firm gives:

$$\bar{x}_M(\Phi - \Psi) - \mathcal{H}_\beta \mathcal{H}_\xi K_M - \mathcal{H}_\beta K_T = 0 \quad (\text{E.20.})$$

The optimal takeover threshold is:

$$\bar{x}_M = \frac{\mathcal{H}_\xi \mathcal{H}_\beta K_M + \mathcal{H}_\beta K_T}{\Phi - \Psi} \quad (\text{E.21.})$$

The ownership is shared according to the following rule $s_T = 1 - s_B$, where:

$$s_B = \frac{\mathcal{H}_\xi K_M (\Phi - \Psi)}{\Phi \mathcal{H}_\beta (\mathcal{H}_\beta \mathcal{H}_\xi K_M + \mathcal{H}_\beta K_T)} \quad (\text{E.22.})$$

Above is satisfied only when:

$$\bar{x}_I^c < \bar{x}_M \iff \frac{\Phi - \Psi}{\Psi} \leq \frac{\mathcal{H}_\xi K_M + K_T}{\kappa} \quad (\text{E.23.})$$

Proposition 4 follows.

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