Innovation, Learning, and Killer Acquisitions*

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Abstract

We study dynamic market competition between a monopoly incumbent and an entrant experimenting with disruptive innovation. The monopolist can only pursue the uncertain innovation if it buys the disruptor, who is more efficient and privately knows its ability. Mergers generate synergies. We characterize perfect Bayesian equilibria in Markov strategies on bargaining and R&D. The equilibrium path is determined by market belief on the unobservable state and the distribution of private information. Mergers may happen too early or too late, depending on whether the merger reveals private information and the size of private returns to R&D. Buyout effects may worsen over-experimentation.

Keywords: Merger, killer acquisition, entry deterrence, innovation, R&D, experimentation

JEL codes: D83, L12, L41, O30

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1 Introduction

Much of the recent scrutiny on anti-competitive behavior of "big tech" and other dominant firms has centered around a practice now widely known as "killer acquisition". Large incumbent firms buy out innovating startups only to shut down the target firms' R&D activities. While standard economic theory explains mergers on the ground of efficiency gain due to synergies, a new strand of studies (e.g. Cabral, 2021; Cunningham, Ederer, and Ma, 2021; Motta and Peitz, 2021) emphasizes another motive. Killer acquisitions are driven by preempting future competition, posing an antitrust threat from the innovation and dynamic welfare standpoint.[1]

Despite serious practical interests in killer acquisitions, understanding of the market and social incentives behind these activities is only just beginning to emerge. In particular, there is still no satisfactory answer to the following question. If the target firm is an innovating startup that has yet to launch a rival product, how should an antitrust authority evaluate the welfare consequences of a proposed merger? Current merger policies based on market share and firm size are not equipped to deal with big techs buying up a fleet of fledgling startups only with ideas or immature products.

To approach this on-going issue, we focus on the dynamic and uncertain nature of innovation. The likelihood of success is unknown and the evolution of the "belief" depends on the innovator's actions. Intuitively, if the innovator agrees to sell its operation, which is then killed off, it may be because the prospect of success has turned out to be poor. Such a merger is likely to be motivated by synergies. If the innovator is highly optimistic, on the other hand, it should be less inclined to sell, despite the incumbent's eagerness for preemptive buyout to protect the status quo. With enough optimism, the incumbent may also wish to continue R&D itself after the acquisition. It is *a priori* unclear how the dynamic incentives of R&D interact with those of bargaining as well as when market failure would arise.

We examine dynamic market competition between an incumbent monopolist and a potential entrant/startup experimenting with disruptive innovation, or a "disruptor". The un-

[1] Killer acquisitions differ from the classic entry deterrence via supply-side commitments. In Gilbert and Newbery (1982), the incumbent preempts competition by committing to R&D investment itself and then killing off the *outcome* of R&D in the form of "sleeping patent". A number of authors, including Henderson and Clark (1990) and Christensen (1997), have argued that large established firms are often incapable of such maneuvers against small, nimble competitors.

observable state of nature is either good or bad, with the players holding common belief (on the good state). The innovation can be successful only in the good state, where the arrival of success follows an exponential distribution in continuous time as long as the disruptor chooses to invest in R&D at a flow cost. The belief jumps to 1 after the arrival of success; otherwise, the belief drifts down and the market becomes more pessimistic.

Successful innovation gives rise to a new product that cannibalizes the status quo product. The disruptor possesses private information on its ability to appropriate the rents from innovation (e.g. Teece, 1986), which is either high or low with a commonly known prior. The monopolist cannot pursue the innovation on its own and must acquire the disruptor to do so (e.g. Henderson and Clark, 1990; Christensen, 1997). The replacement surplus is however greater with the entrant than with the incumbent. One-off bargaining opportunity arrives with an exponential distribution and the monopolist makes a take-it-or-leave-it offer to the disruptor. If the offer is accepted, and a merger takes place, from then on the monopolist decides whether or not to invest in R&D and experiment. A merger also generates a positive, and immediate, synergy effect, which leads to a welfare trade-off in the spirit of Williamson (1968) against the cost of future entry deterrence.

We consider Markov perfect Bayesian equilibria of this game of endogenous learning and mergers. The essentially unique equilibrium outcome is characterized by a series of threshold beliefs on the unobservable state. As the belief drifts down, the monopolist first buys out the low ability disruptor and then switches the offer to a level that is acceptable also to the high ability disruptor. The timing of the switch of offers is sensitive to the prior on private information. If the likelihood of the high type is large, the monopolist raises the offer early knowing that both types remain in the game. If the likelihood is small, it waits until the low type drops out. A merger may or may not be a killer acquisition. Even if the monopolist chooses to continue R&D after the merger, there will still be less innovation as it stops R&D earlier than would the disruptor, consistent with the replacement effect of Arrow (1962).

We then evaluate welfare properties of the equilibrium outcome in terms of both expected surplus *ex post* and R&D incentives *ex ante*. The nature of ex post market failure and optimal policy response depend critically on whether private information is revealed in equilibrium. Another key factor is the size of private returns to R&D, which depend on externalities that the innovation creates for the society as a whole.

First, there exists a unique threshold belief below (above) which merger yields a higher (lower) welfare than non-merger. When the producer extracts full returns on its R&D investment, this social merger threshold is equal to the laissez faire merger threshold with complete information, but with incomplete information, the social threshold exceeds the market threshold.[2] This implies the following when private returns to R&D are less than full but large.

When a proposed merger reveals the disruptor's private information in equilibrium, via its price, it may be happening *too early*. At intermediate beliefs, the disruptor lacking short-run cash flow agrees to sell but the society prefers it to continue the R&D. Inefficient mergers may not be killer acquisitions; neither is a killer acquisition always inefficient. When a merger fails to reveal private information, on the other hand, it happens *too late*. The monopolist must pay more than the value of the low ability disruptor to induce agreement, and this information rent makes the monopolist wait for the belief on the unobservable state and the disruptor's reservation price to fall when the society wants a merger. Nonetheless, there is no efficiency loss, or a need for antitrust intervention, when the merger actually happens. Note that in our dynamic model, both these cases emerge along the same equilibrium path.

Turning to ex ante R&D incentives, the prospect of buyout has no effect with symmetric information since the monopolist must always pay the full value of the innovation. With asymmetric information, the offer may exceed the value of certain disruptor types, which in turn leads the low ability disruptor to invest more than it would in an environment that prohibits takeovers. This so-called "buyout effect" does not necessarily imply welfare improvement. The reason is that the startup could be *over*-experimenting without the merger possibility, in which case the buyout effect only worsens the inefficiency. The buyout effect can improve efficiency only when the startup *under*-experiments without mergers. This happens when private returns to R&D are small.[3] Thus, uncertainty reinforces the rationale for ex post merger restrictions in environments with large private returns to R&D.

Our main contribution to the growing literature on killer acquisitions is the explicit treatment of dynamics and uncertainty. The existing static models on the topic, including Cunningham, Ederer, and Ma (2021), Letina, Schmutzler, and Seibel (2021), Motta and Peitz (2021), and Banerjee, Teh, and Wang (2022), assume that the probability of success is known and fixed.[4] In a monopoly entry deterrence context, we endogenize not only the path of R&D

[2]With full surplus extraction, and with complete information, the loss from reduced innovation is compensated exactly by the gain from synergies, consistent with the Coasian principles.

[3]In this case, it is also possible that the disruptor switches from under- to over-experimentation.

[4]In these papers, as well as ours, the entrant faces no financing constraint, and hence, inefficient mergers are not a consequence of lack of funding. The financing aspect is considered by Fumagalli, Motta, and

but also the path of when a merger would, and should, occur. Our results suggest that the antitrust authority must pay careful attention to the informational contents of the proposed merger.

The ex ante effects of mergers on innovation have been examined by a number of papers with mixed policy implications, dating back to Rasmusen (1988). A noteworthy recent thread in this body of research considers innovating startups facing multiple project choices. For instance, Letina, Schmutzler, and Seibel (2021) show that banning killer acquisition could reduce product variety, while Callander and Matouschek (2022) favor a strict merger policy to encourage radical innovation. Meanwhile, a model of repeated competition between incumbents and innovating entrants is studied by Denicolò and Polo (2021), who show that positive buyout effects may last only in the short run. We do not model multiple or repeated R&D projects. Instead, the buyout effect arises due to asymmetric information, and more importantly, we show in a single setup that the extra R&D may imply negative as well as positive welfare consequences, depending on the size of private returns to R&D.

Last but not least, we add to the growing body of papers that address the effects of learning on the formation of market structure. Bergemann and Välimäki (1997, 2000, 2002) consider how incentives for experimentation affect firms' decision to launch and price new products in various competitive settings, while monopoly pricing is analyzed by Bergemann and Välimäki (2006) and Bonatti (2011). Murto and Välimäki (2011) and Chen, Ishida, and Mukherjee (2021) study entry and exit decisions. Few papers also identify market failure and derive policy suggestions, as we do. Guéron and Lee (2022), for instance, find the possibility of over- and under-experimentation by an innovating monopolist facing the threat of technology leakage and discuss the role of "two-tier" patent policy.

The rest of the paper is organized as follows. Section 2 describes our model of innovation, learning, and mergers. Section 3 characterizes the equilibrium and its properties. Section 4 introduces the concept of welfare and identifies market failure. Section 5 draws policy implications and discusses how to implement our suggestions. Concluding remarks are offered in Section 6. Appendix contains formal proofs left out of the main text for expositional reasons.

Tarantino (2020). Bergemann and Hege (1998, 2005) endogenize the financing constraint for a startup in an experimentation setting similar to ours (but without mergers). Investors stop financing, and the startup exits, when belief falls too low due to the opportunity cost of funding.

2 Model

We consider a model of dynamic market competition between a monopoly incumbent and a potential entrant/startup experimenting with disruptive innovation. The incumbent will sometimes be referred to as "monopolist", or simply M, and the entrant as "disruptor", or simply D. The following model combines features of experimentation and bargaining in a single framework.

Time is continuous, $t \in [0, \infty)$, with common real discount rate $r > 0$. At every t, the disruptor chooses whether or not to perform R&D, which incurs a flow cost $c > 0$. Whether the R&D can succeed depends on the state of nature, which is unobservable to both players. There are two possible states, "good" and "bad". In the bad state, R&D can never succeed. In the good state, R&D succeeds randomly according to an exponential distribution with parameter $\lambda > 0$. Success generates a product that replaces the incumbent monopolist. Let $p(t)$ denote the common belief on the good state at time t, which will sometimes be referred to as the "state belief".

The disruptor's ability to appropriate the rents from innovation is private information. This reflects the fact that an innovating firm's success often hinges on how it navigates through alternative methods of commercializing its ideas (e.g. Teece, 1986). Let i index the disruptor type, which can be either "high" (H) or "low" (L), and $q \in [0, 1]$ denote the belief on type H, which we also call the "type belief" to distinguish it from the belief on the unobservable state p. The commonly known prior is denoted by $q_0 \in (0, 1)$.

The incumbent cannot perform R&D on its own and must buy out the entrant to do so. There may be a variety of organizational and other obstacles that make it difficult for large established firms to invest in innovations that will challenge the "status quo" that they themselves manage (e.g. Henderson and Clark, 1990; Christensen, 1997). We consider a simple bargaining structure to endogenize mergers. Specifically, we assume that M randomly receives a one-off opportunity to make a take-it-or-leave-it (TIOLI) offer to D according to an exponential distribution with parameter $\beta > 0$. This process is independent of the state. If D accepts the offer, a merger takes place, and from then on, M chooses whether or not to spend c to experiment at every t. If D rejects the offer, it continues with the innovation process. D does not have the means to acquire M.

The total flow surplus depends on who invests in R&D as well as its success. Before R&D succeeds, the total flow surplus is $W_M^0 > 0$ if M serves the market, i.e. in the "non-merger" situation, and is $W^0_{MA} > 0$ if M both serves the market and invests in R&D, i.e. in the "merger" situation. D's share of the surplus is normalized to 0, which captures the entrant's short-run liquidity constraint relative to the incumbent. After R&D succeeds, and hence with a new disruptive product, the surplus is W^1_i if the disruptor of type i made the breakthrough and is W^1_{MA} if M had bought out D and continued R&D until the success. If D succeeds in innovation, M's payoff falls to zero, which is another normalization.

Both W^0_{MA} and W^1_{MA}, the post-merger surpluses, are independent of the disruptor type. The ability to commercialize innovation may be embedded in human, organizational, and other forms of capital which are not transferred in a merger that primarily targets R&D operations.

The producer's share of the surplus, denoted by $\alpha \in (0, 1]$, is fixed and constant across all players before and after the success of R&D. We can interpret α as a measure of private returns to R&D if the surplus accrues to the society beyond the specific market that we analyze. With no spillover externalities, and with perfect consumer screening, the monopoly producer extracts full surplus and $\alpha = 1$. A low value of α may arise from multiple sources. While large externalities offer one such source, the demand and supply conditions of the market may also dictate a large consumer surplus.

Let us make the following assumptions on these surplus values.

Assumption 1. $W^0_M < W^0_{MA} < W^1_{MA} < W^1_L < W^1_H$.

This assumption implies that (i) there is immediate synergy effect from merger (i.e. $W^0_M < W^0_{MA}$), (ii) the new product is superior to the status quo product (i.e. Schumpeterian creative destruction), and (iii) innovation is more valuable when introduced to market by D (i.e. $W^1_{MA} < W^1_i$ for all $i \in \{L, H\}$). The last part is necessary to impose a social cost of merger and also delivers the replacement effect discussed by Arrow (1962). Note that while the synergy occurs immediately upon merger, the replacement benefit is realized only after the innovation is successful.[5] The "Williamson trade-off" (Williamson, 1968) therefore lies in balancing the short-run productivity improvements from a merger with the long-run losses from missed disruptive entry, which are uncertain.

Assumption 2. $rc < \alpha\lambda(W^1_{MA} - W^0_{MA})$.

[5]In Cunningham, Ederer, and Ma (2021), synergies improve the probability of success, which is known and fixed.

This assumption, coupled with Assumption 1, guarantees that both M and D want to pursue R&D if sufficiently optimistic. See Corollary 1.

A Markov strategy of M is a state-belief-dependent offer in the space $\mathbb{R}_+$, conditional on the arrival of the one-off bargaining opportunity. A Markov strategy of each $i \in \{L, H\}$ is a state-belief-dependent pair of binary response (acceptance or rejection) to each possible offer, conditional on the arrival of the one-off bargaining opportunity, and binary R&D decision, conditional on non-arrival of the bargaining opportunity.

We look for perfect Bayesian equilibrium in Markov strategies, or Markov perfect Bayesian equilibrium (MPBE), which consists of mutually optimal strategies together with a Bayes-rational system of type beliefs. Also, in what follows, a "winning (losing) offer" refers to an offer that is accepted (rejected) in equilibrium. We say that a merger is a "killer acquisition" if M immediately stops R&D after acquiring D.

Remark 1. Note that we do not specify the players' post-bargaining R&D behavior in the definition of strategies. This is for simplicity. Whether a merger takes place or not, the strategic play ends with a takeover bid and the continuation play proceeds as in the single-player context, which is analyzed in Section 3.1.

Remark 2. The simple bargaining protocol assumed in the above model is sufficient to crystalize market failure due to our assumptions. Our analysis and results also extend to an alternative setup in which the monopolist can choose when to make the one-off TIOLI offer to the disruptor. A more sophisticated protocol, with multiple bargaining opportunities, could itself be a source of frictions.

Remark 3. Since α is constant, Assumption 1 implies the same order for the corresponding producer surpluses. Constant α is however not necessary for this. For example, the incumbent may be better able to monetize the innovation (i.e. higher α), but the total and producer surpluses can still be greater when the entrant sells it. The latter may reflect a social preference on Schumpeterian dynamics, which diverts public resources to innovative small enterprises. One potential reason is the declining "reallocation" effect (e.g. Decker, Haltiwanger, Jarmin, and Miranda, 2016, 2017), whereby growth of small, productive firms boosts aggregate productivity by squeezing out less productive ones.

3 Market Incentives for Mergers

3.1 Optimal Innovation Policy

Let us begin by considering the single-player incentives for R&D and innovation in absence of bargaining and mergers. The analysis below offers not only a useful benchmark for solving the game but also the players' optimal behavior after the one-off bargaining takes place. Note that the strategic play ends with the arrival of the bargaining opportunity.

If the state is good, the probability that R&D is unsuccessful during a time interval of dt is given by $e^{-\lambda dt}$. If the state is bad, the probability is 1. Therefore, given that R&D is not yet successful, the belief evolves according to

$$p(t+dt) = \frac{p(t)e^{-\lambda dt}}{p(t)e^{-\lambda dt} + 1 - p(t)},$$

which gives the familiar law of motion

$$dp(t) = -\lambda p(t)(1-p(t))dt. \tag{1}$$

If R&D is successful, the belief jumps to 1.

Throughout the paper, we denote the odds ratio at belief p by $\Omega(p) := (1-p)/p$. Fix $i \in \{L, H, MA\}$ where, with some abuse of notation, $i = MA$ refers to the monopolist who has already acquired the disruptor. Let Π_i^0 denote the flow payoff accruing to player i while performing R&D, or experimenting, and let Π_i^1 denote the corresponding post-success payoff. That is, if M acquires D and pursues the innovation, we have $(\Pi_{MA}^0, \Pi_{MA}^1) = (\alpha W_{MA}^0, \alpha W_{MA}^1)$, while $(\Pi_L^0, \Pi_L^1) = (0, \alpha W_L^1)$ and $(\Pi_H^0, \Pi_H^1) = (0, \alpha W_H^1)$. Finally, let $U_i(p)$ denote the value of player i from experimentation. The optimal policy is in threshold.

Lemma 1. *For $i \in \{L, H, MA\}$, there exists a unique threshold belief, or the "innovation threshold", ρ_i such that i chooses to invest in R&D if $p > \rho_i$ and stop if $p < \rho_i$. The threshold ρ_i is given by*

$$\rho_i = \frac{rc}{\lambda\left(\Pi_i^1 - \Pi_i^0\right)}.$$

The corresponding value function is given by

$$U_i(p) = \frac{1}{r}\left\{-c + \Pi_i^0 + \frac{\lambda}{\lambda+r}(\Pi_i^1 - \Pi_i^0 + c)p \right.$$
$$\left. + \left[c - \frac{\lambda}{\lambda+r}(\Pi_i^1 - \Pi_i^0 + c)\rho_i\right]\frac{1-p}{1-\rho_i}\left[\frac{\Omega(p)}{\Omega(\rho_i)}\right]^{r/\lambda}\right\},$$

if $p > \rho_i$, and $U_i(p) = \Pi_i^0/r$ otherwise.

Proof. See Appendix A.1. □

The affine term in U_i corresponds to the value from committing to investment in R&D, while the non-linear term corresponds to the option value of being able to stop. To find the value function U_i, we consider a small interval of time dt.

First, with probability $p\lambda dt$, R&D is completed and the value jumps to $U_i(1) = \Pi_i^1/r$. With the complementary probability, nothing happens, the belief drifts down to $p + dp$ according to the law of motion (1), and the value becomes $U_i(p + dp) \sim U_i(p) + U_i'(p)dp = U_i(p) - U_i'(p)\lambda p(1-p)dt$. This allows us to find the following ODE for $U_i(p)$:

$$\lambda p(1-p)U_i'(p) + (r + \lambda p)U_i(p) = -c + \Pi_i^0 + p\lambda\frac{\Pi_i^1}{r}.$$

Solving this ODE involves finding the threshold ρ_i, which is obtained from the value matching and smooth pasting conditions. Value matching says that at the threshold ρ_i, the value from investing in R&D must match the value from stopping; smooth pasting requires that the slopes are also the same.[6]

It is immediate from Assumption 1 that $0 < \rho_H < \rho_L < \rho_{MA} < 1$. The disruptor pursues R&D "longer" than the monopolist, in the sense that $\rho_i < \rho_{MA}$ for all $i \in \{L, H\}$. This is Arrow's replacement effect, which occurs because the gain from innovation is greater for D than for M. Assumption 2 guarantees that $\rho_{MA} < 1$ and hence both firms would want to pursue R&D if sufficiently optimistic about the state being good. It is also straightforward to obtain comparative statics on the threshold.

Corollary 1. *We have the following:*

1. $0 < \rho_H < \rho_L < \rho_{MA} < 1$.
2. $\frac{\partial \rho_i}{\partial c} > 0$, $\frac{\partial \rho_i}{\partial \lambda} < 0$, $\frac{\partial \rho_i}{\partial \Pi_i^0} > 0$, *and* $\frac{\partial \rho_i}{\partial \Pi_i^1} < 0$.

[6] See, for example, the description of the cooperative problem in Keller, Rady, and Cripps (2005).

3.2 Merger and Innovation Dynamics

3.2.1 Symmetric Information Benchmark

In this section, we solve the game with symmetric information. The equilibrium notion is subgame perfect equilibrium with Markov strategies, or Markov perfect equilibrium (MPE). The first step is to find the value of M's outside option, or its "status quo" value. Suppose that M has no chance of buyout (i.e. $\beta = 0$) but still faces the threat of replacement by D of type $i \in \{L, H\}$. From Lemma 1, we know that type i pursues R&D at $p > \rho_i$ and stops at $p < \rho_i$. If D pursues R&D and is successful, M is replaced and its value falls to zero. If D stops R&D, M retains its monopoly position with the flow playoff αW_M^0.

Lemma 2. *Suppose that the disruptor type is known to be $i \in \{L, H\}$. With the possibility of entry but no acquisition, the status quo value of the monopolist is given by*

$$m_i(p) = \frac{\alpha W_M^0}{r} \left\{ \left(1 - \frac{\lambda}{\lambda + r} p\right) + \frac{\lambda}{\lambda + r} p \left[\frac{\Omega(p)}{\Omega(\rho_i)}\right]^{\frac{r}{\lambda}+1} \right\}.$$

if $p > \rho_i$, and $m_i(p) = \alpha W_M^0 / r$ otherwise.

Proof. See Appendix A.2. □

Figure 1 illustrates the value of having access to R&D for both the disruptor and the monopolist, together with the monopolist's status quo value, which is decreasing in p.

Next, we characterize the winning offers with symmetric information.

Lemma 3. *Suppose that the disruptor type is known to be $i \in \{L, H\}$. Fix any MPE and any belief p. A winning offer must be $U_i(p)$. Moreover, a winning offer is made if and only if $U_{MA}(p) - m_i(p) \geq U_i(p)$.*

Proof. Suppose that the bargaining opportunity arrives. Clearly, type $i \in \{L, H\}$ will accept an offer strictly larger than $U_i(p)$ and reject an offer strictly less than $U_i(p)$. By standard arguments, this implies that a winning offer must be exactly $U_i(p)$.

If M makes an offer which is accepted, the subsequent value is equal to $U_{MA}(p) - U_i(p)$. Rejection yields the status quo value $m_i(p)$. It is then straightforward to obtain the second part of the claim. □

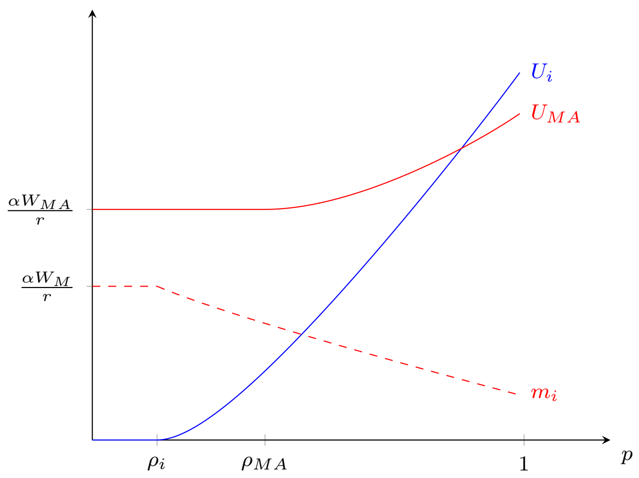


Figure 1: Value Functions

Our model with symmetric information admits a unique equilibrium outcome, in which the occurrence of merger is also in threshold.

Proposition 1. *Suppose that the disruptor type is known to be $i \in \{L, H\}$. Then, in any MPE, we have the following:*

1. *There exists a unique threshold belief, or the "merger threshold", $\mu_i \in (\rho_i, 1]$ such that the monopolist makes a winning offer if $p < \mu_i$ and a losing offer if $p > \mu_i$; the monopolist is indifferent at $p = \mu_i$.*

2. *$\mu_i < 1$ if $r(W^0_{MA} - W^0_M) < \lambda(W^1_i - W^1_{MA})$, and $\mu_i = 1$ otherwise.*

3. *$\mu_H < \mu_L$.*

Proof. See Appendix A.3. □

Proposition 1 states that if the disruptor type is known to be i, M makes a winning offer only below some threshold belief μ_i. Note, however, that this threshold is 1 when $r(W^0_{MA} - W^0_M) \geq \lambda(W^1_i - W^1_{MA})$. This latter condition means that the gain from the synergy effect $(W^0_{MA} - W^0_M)$, multiplied by the discount rate r, exceeds the gain from the replacement effect $(W^1_i - W^1_{MA})$, multiplied by the probability of success λ. It holds, and mergers take place at all beliefs, when the short-run synergy effect is large and/or the agents are impatient

(r is high), or when the long-run replacement effect is small and/or R&D takes a long time to complete (λ is low).

Note that the merger threshold μ_i is implicitly defined by the non-linear equation

$$U_{MA}(\mu_i) - m_i(\mu_i) = U_i(\mu_i). \tag{2}$$

Despite the lack of explicit formulation, it is possible to show that μ_i can lie on either side of ρ_{MA}, the innovation threshold of the post-merger monopolist.

Proposition 2. *Fix $i \in \{L, H\}$, and suppose that $r(W^0_{MA} - W^0_M) < \lambda(W^1_i - W^1_{MA})$. Then, we have the following:*

1. *If c is sufficiently large, $\mu_i < \rho_{MA}$ and all mergers are killer acquisitions.*
2. *If W^1_{MA} and W^1_i are sufficiently large, $\mu_i > \rho_{MA}$ and some mergers are non-killer acquisitions.*

Proof. See Appendix A.4. □

It is straightforward to see why we can have $\mu_i < \rho_{MA}$. By Proposition 1, when the replacement effect exceeds the synergy effect, the merger threshold μ_i is strictly less than 1. However, as c becomes high (with an upper bound given by Assumption 2), M's innovation threshold ρ_{MA} converges to 1, and we have $\mu_i < \rho_{MA}$. In other words, with excessive cost, the monopolist has no interest in pursuing R&D but still has incentives to buy out the disruptor for the synergy benefits.

To show that we can also have $\mu_i \geq \rho_{MA}$, we evaluate the sign of $U_{MA}(p) - m_i(p) - U_D(p)$ at ρ_{MA} and show that it can be positive when both W^1_{MA} and W^1_i are sufficiently large. When W^1_{MA} is sufficiently large, M has incentives to invest in R&D after buying out the disruptor but this also requires W^1_i to be large since we must have $W^1_{MA} < W^1_i$ (Assumption 1).

The unique merger threshold μ_i is illustrated in Figure 2, for the case in which $\mu_i \geq \rho_{MA}$. Mergers occurring at $p \in (\mu_i, \rho_{MA})$ are non-killer acquisitions since R&D continues after the merger. At $p < \rho_{MA}$, M kills off R&D immediately after a merger.

3.2.2 Main Result

We now build on the previous results to characterize equilibria of the asymmetric information game. We want to uncover how the state and type uncertainties interact to shape bargaining

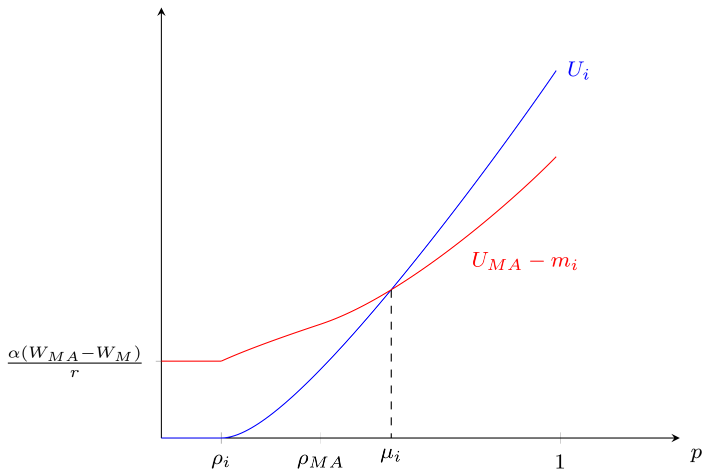


Figure 2: Merger Threshold

and R&D incentives, as well as the interplay between the bargaining and R&D incentives themselves. For the monopolist, the key issue is the dynamics of its takeover bid. Since the monopolist faces multiple types of the target firm, one expects its winning offer to change as the state belief p drifts but this path should be determined also by the type belief q. For the disruptor, we are particularly interested in the possibility of "buyout effect". The prospect of acquisition may encourage type i to invest in R&D at beliefs lower than ρ_i, the benchmark innovation threshold with symmetric information.

To characterize MPBE, we first note that any winning offer must be either $U_H(p)$ or $U_L(p)$, the single-player value of the disruptor formulated in Lemma 1.

Lemma 4. *Fix any MPBE. Also, fix any p. A winning offer is either $U_H(p)$ or $U_L(p)$. Thus, the high ability disruptor invests in R&D if $p > \rho_H$ and stops if $p < \rho_H$, while the low ability disruptor invests in R&D if $p > \rho_L$.*

Proof. Given that there is only a single bargaining opportunity, if merger does not occur, the value of D reverts to the single-player value, which is either $U_H(p)$ or $U_L(p)$. Therefore, any offer above $U_H(p)$ is accepted by both types, any offer between $U_L(p)$ and $U_H(p)$ is only accepted by the low type, while any offer below $U_L(p)$ is rejected by both types. Any winning offer that is strictly greater than $U_H(p)$ is thus dominated by $U_H(p)$, while any winning offer between $U_L(p)$ and $U_H(p)$ is dominated by $U_L(p)$. Hence, in any MPBE, the winning offer is either $U_H(p)$ or $U_L(p)$. Since the winning offer never exceeds $U_H(p)$, and since it never falls below $U_L(p)$, the remainder of the claim follows. □

Since the high type must drop out if the belief falls below ρ_H, there is no buyout effect for the high type. However, it is possible for the low type to remain in the game longer than it would under its single-player threshold ρ_L. This buyout effect for the low ability disruptor is generated by the possibility that it is bought at price $U_H(p)$ instead of $U_L(p)$ at some beliefs.

We now present our main result, where for $i \in \{L, H\}$, ρ_i and μ_i are the innovation and merger thresholds in the single-player and symmetric information benchmarks from Lemma 1 and Proposition 1, respectively. The asymmetric information game admits essentially unique equilibrium outcome, characterized by four (state) belief thresholds.[7]

Proposition 3. *The asymmetric information game admits an MPBE. Moreover, there exist threshold beliefs $(\mu_L^*, \mu_H^*, \rho_L^*, \rho_H^*)$, where $\mu_L^* > \mu_H^* > \rho_L^* > \rho_H^*$, $\mu_L^* = \mu_L$, $\mu_H^* \leq \mu_H$, $\rho_L^* \leq \rho_L$, and $\rho_H^* = \rho_H$, such that every MPBE satisfies the following properties:*[8]

1. *Bargaining*
   (a) *For $p > \mu_L^*$, M makes a losing offer.*
   (b) *For $p \in (\mu_H^*, \mu_L^*)$, M offers $U_L(p)$ and type L accepts.*
   (c) *For $p \in (\rho_L^*, \mu_H^*)$, M offers $U_H(p)$ if $q_0 > \frac{U_H(p) - U_L(p)}{U_{MA}(p) - U_L(p) - m_H(p)} \in (0, 1)$, which both types accept, and $U_L(p)$ if $q_0 < \frac{U_H(p) - U_L(p)}{U_{MA}(p) - U_L(p) - m_H(p)}$, which type L accepts.*
   (d) *For $p \in (\rho_H^*, \rho_L^*)$, M offers $U_H(p)$ and type H accepts.*
2. *R&D*
   (a) *Type H invests in R&D if $p > \rho_H^*$ and stops if $p < \rho_H^*$.*
   (b) *Type L invests in R&D if $p > \rho_L^*$ and stops if $p < \rho_L^*$. If q_0 and W_{MA}^1 are sufficiently high, $\rho_L^* < \rho_L$ and is given by*

$$\rho_L^* = \frac{r\left[c - \beta U_H(\rho_L^*)\right]}{\lambda \alpha W_L^1}.$$

Proof. See Appendix A.5. □

[7]The players' post-bargaining R&D behavior follows the optimal policies derived in Lemma 1.

[8]When p is exactly at each of the thresholds, the players are indifferent and multiple equilibrium outcomes are possible. Similarly, in part 1c, M is indifferent between offering U_L and U_H when q_0 is at the threshold.

R&D behavior differs from the symmetric information benchmark only for the low type. The path of equilibrium offers is depicted in Figure 3.

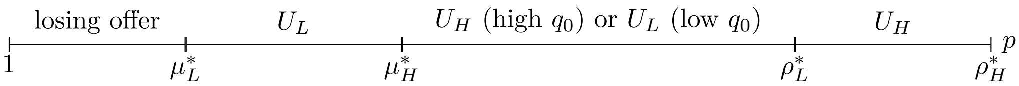


Figure 3: Bargaining Incentives

At p close to 1, the disruptor is unwilling to sell and the monopolist makes a losing offer (part 1a). Then, as the state belief p drifts down and reaches μ_L^*, M begins to buy out the low type by offering U_L (part 1b). Once p falls below μ_H^*, M is willing to raise the (winning) offer from U_L to U_H. But here, both types remain in the game (so $q = q_0$) and whether M chooses to offer U_H or U_L depends on both p and q, where the latter belief on D's private information affects M's outside option (part 1c). Note that $\frac{U_H(p)-U_L(p)}{U_{MA}(p)-U_L(p)-m_H(p)} \in (0,1)$. This means that in this region of beliefs, the offer is always U_H (U_L) if q_0 is sufficiently close to 1 (0). At $p = \rho_L^*$, the low type quits R&D and exits the game, the posterior q jumps to 1, and the offer is U_H until the high type exits at $p = \rho_H^*$ (part 1d).

The interplay between the state belief p and the prior type belief q_0 is illustrated in Figure 4, which shows the regions with winning offers $U_H(p)$ and $U_L(p)$ in the (p, q_0) space. Due to non-linearity of the value functions, we do not have an analytical solution to how the q_0 threshold $\frac{U_H(p)-U_L(p)}{U_{MA}(p)-U_L(p)-m_H(p)}$ responds to p. But, with simulations, we have only found examples where the relationship is monotone so that if M switches the offer from $U_L(p)$ to $U_H(p)$ at $p = \mu_H^*$, then it will maintain the same offer at all $p < \mu_H^*$.

Note that mergers with the low type only occur at $p \leq \mu_L^* = \mu_L$ and mergers with the high type occur at $p \leq \mu_H^* < \mu_H$. Since ρ_{MA} is independent of D's type, this means that Proposition 2 on whether or not a merger is a killer acquisition remains valid with asymmetric information. That is, all mergers are killer acquisitions if c is large, while non-killer acquisitions are also possible.

To better understand the equilibrium bargaining incentives, note first that M's willingness to offer U_L does not depend on q, as it is only accepted by the low type. Therefore, the corresponding merger threshold is the same as in the symmetric information benchmark ($\mu_L^* = \mu_L$). M's incentive to offer U_H however differs from the symmetric information case. This is because its outside option is more valuable, or the status quo value is higher, with asymmetric information. D has low ability with probability $1 - q_0$ and the low type exits sooner than the

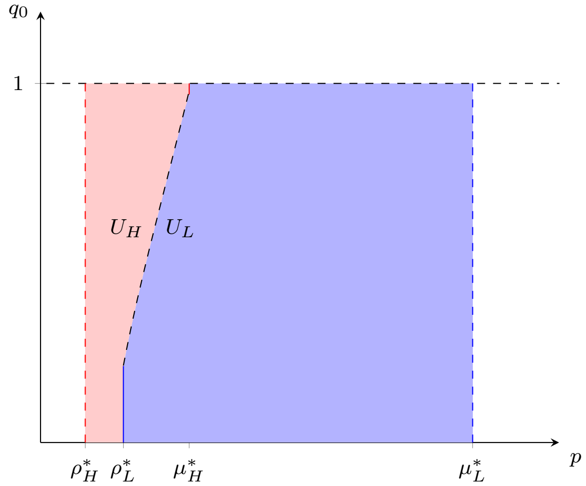


Figure 4: Belief Interplay

high type ($\rho_L^* > \rho_H^*$). Thus, the cutoff below which M is willing to offer U_H is lower with asymmetric information than with symmetric information ($\mu_H^* \leq \mu_H < \mu_L$). From this cutoff μ_H^* until the low type exits at ρ_L^*, the equilibrium offer depends on the prior q_0. If q_0 is high, M's outside option value is low and it chases a merger with greater eagerness (i.e. offers U_H).

As for the R&D incentives, given Lemma 4, it suffices to show the possibility of a buy-out effect, i.e. $\rho_L^* < \rho_L$. We proceed in two steps. In the fist step, we assume that M is willing to make the winning offer U_H at beliefs that are above the single-player innovation threshold of the low type, ρ_L. This increases the value of R&D for the low type, and hence, decreases its innovation threshold. Given this, we then find the value of the low type, similarly to Lemma 1, and derive the threshold ρ_L^* using smooth pasting and value matching. In the second step, we show that when the prior on the high type and the post-merger value of the innovation are large enough, it is indeed the case that M is willing to offer U_H over an interval of beliefs above ρ_L.

Figure 5 puts together M's equilibrium incentives for acquiring both types and their effects on the R&D incentives of the low type. The two single-player value functions, U_H and U_L, represent D's belief-dependent reservation prices. The cutoff μ_L^* is given by the intersection between U_L and $U_{MA} - m_L$, where the latter is M's payoff from buying the low type. The cutoff μ_H^* is given by the intersection between U_H and $U_{MA} - \mathbb{E}(m_i)$, where $\mathbb{E}(m_i)$ is the expected status quo value.[9] Below ρ_L^*, only the high type remains and private information is revealed. Below μ_H^*, M offers U_H (assuming q_0 sufficiently close to 1). This raises the low type's value from U_L to U_L^* while lowering its innovation threshold to ρ_L^*. Note that at $p = 1$, U_L^* and U_L are equalized since it is impossible to receive a winning offer with the replacement effect being larger than the synergy effect.

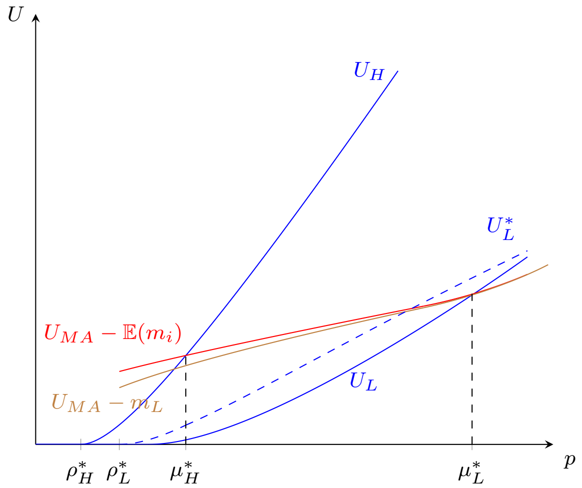


Figure 5: Bargaining and R&D Incentives with Asymmetric Information

4 Social Incentives for Mergers

4.1 Ex Post Merger Policy

Suppose that at some belief p, the two market participants, M and D, agree to merge. But, does the society also agree with this decision *ex post*? To answer the question, we must compare expected welfare from the proposed merger with that from non-merger. That is, for each p, we want to compute the total expected surplus from D continuing the R&D while M serves the market (i.e. non-merger) and compare this with the total expected surplus from M doing both (i.e. merger).

To this end, define a function $V(p; \rho, W^0, W^1)$ as the welfare at belief p given that R&D is pursued until some threshold ρ with flow surpluses being W^0 and W^1 before and after the

[9] Notice that the difference between $U_{MA} - m_L$ and $U_{MA} - \mathbb{E}(m_i)$ is small at p close to 1.

success of R&D, respectively. The welfare function V is similar to the value function U_i found in Lemma 1, except for two differences. First, there may not be smooth pasting at ρ for V, and second, V may be decreasing in p for a range of beliefs.

To see the differences, note that for $i \in \{L, H, MA\}$, the value function U_i is derived for the optimal innovation threshold ρ_i given the flow *profits* Π_i^0 and Π_i^1. But, for the welfare function V, R&D stops at a pre-determined belief ρ, which is going to be either ρ_{MA}, ρ_L, or ρ_H depending on who does the R&D, and this threshold may not be optimal given the flow surpluses W^0 and W^1.[10] As a result, while we have smooth pasting at ρ_i for U_i, it may not be the case for V at ρ. Moreover, if the belief ρ is below the optimal threshold given W^0 and W^1, the function $V(p; \rho, W^0, W^1)$ will be decreasing over a range of beliefs between ρ and the optimal threshold.

Lemma 5. *The welfare function $V(p; \rho, W^0, W^1)$ is given by*

$$\frac{1}{r}\left\{-c + W^0 + \frac{\lambda}{\lambda + r}(W^1 - W^0 + c)p + \left[c - \frac{\lambda}{\lambda + r}(W^1 - W^0 + c)\rho\right]\frac{1-p}{1-\rho}\left[\frac{\Omega(p)}{\Omega(\rho)}\right]^{r/\lambda}\right\},$$

if $p \geq \rho$, and $V(p; \rho, W^0, W^1) = W^0/r$ otherwise.

Proof. See Appendix A.6. □

Now, to evaluate merger at some p, we work with the following two parametrizations of V. First, for the welfare from non-merger, we set $\rho = \rho_i$, $W = W_M^0$, and $W^1 = W_i^1$ for $i \in \{L, H\}$. R&D is pursued by D but the market is served by M, as long as the innovation does not succeed. That is, for $i \in \{L, H\}$, we have

$$V_i(p) := V(p; \rho_i, W_M^0, W_i^1).$$

Second, for the welfare from merger, we set $\rho = \rho_{MA}$, $W = W_{MA}^0$, and $W^1 = W_{MA}^1$, or

$$V_{MA}(p) := V(p; \rho_{MA}, W_{MA}^0, W_{MA}^1).$$

Note here that since $\Pi_{MA}^0 = \alpha W_{MA}^0$ and $\Pi_{MA}^1 = \alpha W_{MA}^1$, it must be that $V_{MA} = U_{MA}$ if $\alpha = 1$ (although $V_i \neq U_i$ for $i \in \{L, H\}$).

[10] See Section 4.2 for a discussion about the socially optimal innovation thresholds.

We now show that with symmetric information, there is a unique threshold μ_i^s below/above which it is socially efficient/inefficient for M to acquire D. This *social* merger threshold μ_i^s coincides with the *market* merger threshold μ_i when the producer extracts full surplus, i.e. $\alpha = 1$, or when the synergy effect is larger than the replacement effect.

Lemma 6. *Suppose that the disruptor type is known to be $i \in \{L, H\}$. We have the following:*

1. *There exists a unique social merger threshold $\mu_i^s \in (0, 1]$ such that $V_i(p) > V_{MA}(p)$ for $p > \mu_i^s$ and $V_i(p) \leq V_{MA}(p)$ for $p \leq \mu_i^s$.*

2. *The social and market merger thresholds coincide, i.e. $\mu_i^s = \mu_i$, when $\alpha = 1$ or when $r(W_{MA}^0 - W_M^0) \geq \lambda(W_D^1 - W_{MA}^1)$. In the latter case, $\mu_i^s = \mu_i = 1$.*

Proof. See Appendix A.7. □

To understand this result, fix $i \in \{L, H\}$. First, it is obvious that when the synergy effect is greater than the replacement effect, it must always be that $V_{MA} > V_i$ and hence mergers are beneficial at all beliefs. When the replacement effect is greater, on the other hand, μ_i^s belongs to $(\rho_i, 1)$ because $V_{MA} < V_i$ at $p = 1$ and $V_{MA} > V_i$ at $p = \rho_i$. The latter is true since i stops R&D at ρ_i.

Next, given that $r(W_{MA}^0 - W_M^0) < \lambda(W_i^1 - W_{MA}^1)$, we want to show that the social and market merger thresholds are the same when $\alpha = 1$. To do so, note that (2), the implicit definition of μ_i, is equivalent to

$$V(p; \rho_i, \alpha W_M^0, \alpha W_i^1) - m_i(p) = V(p; \rho_i, 0, \alpha W_i^1).$$

Substituting out $m_i(p)$, and setting $\alpha = 1$, we find that the definition of μ_i coincides with that of μ_i^s, which is given implicitly by

$$V_i(\mu_i^s) = V_{MA}(\mu_i^s). \tag{3}$$

In other words, when the producer extracts the entire surplus, there is no market failure. A merger happens if and only if there is a gain from trade, in line with the Coasian principles.

Market failure, i.e. $\mu_i^s \neq \mu_i$, arises under $\alpha < 1$. When $\mu_i^s < \mu_i$, inefficient mergers occur over an intermediate range of beliefs, i.e. at $p \in (\mu_i^s, \mu_i)$. Mergers take place *too early*, and the society can benefit from letting the entrant pursue R&D longer. When $\mu_i^s > \mu_i$, every agreed merger is efficient and deadweight losses come from foregone merger opportunities.

Non-linearity of the value functions however makes it analytically intractable to compare μ_i^s and μ_i when $\alpha < 1$. To see the difficulty, suppose that $\rho_{MA} < \min\{\mu_i, \mu_i^s\}$ such that some mergers are non-killer acquisitions. Then, (2), the implicit definition for μ_i, can be written as

$$\begin{aligned}
&-c + \alpha W_{MA}^0 + \frac{\lambda}{\lambda + r}\left(\alpha\left(W_{MA}^1 - W_{MA}^0\right) + c\right)\mu_i \\
&\qquad + \left[c - \frac{\lambda}{\lambda + r}\left(\alpha\left(W_{MA}^1 - W_{MA}^0\right) + c\right)\rho_{MA}\right]\frac{1 - \mu_i}{1 - \rho_{MA}}\left[\frac{\Omega(\mu_i)}{\Omega(\rho_{MA})}\right]^{r/\lambda} \\
&\qquad\qquad = -c + \alpha W_M^0 + \frac{\lambda}{\lambda + r}\left(\alpha\left(W_i^1 - W_M^0\right) + c\right)\mu_i \\
&\qquad\qquad\qquad + \left[c - \frac{\lambda}{\lambda + r}\left(\alpha\left(W_i^1 - W_M^0\right) + c\right)\rho_i\right]\frac{1 - \mu_i}{1 - \rho_i}\left[\frac{\Omega(\mu_i)}{\Omega(\rho_i)}\right]^{r/\lambda}, \quad (4)
\end{aligned}$$

while the full expression for (3) is

$$\begin{aligned}
&-c + W_{MA}^0 + \frac{\lambda}{\lambda + r}(W_{MA}^1 - W_{MA}^0 + c)\mu_i^s \\
&\qquad + \left[c - \frac{\lambda}{\lambda + r}(W_{MA}^1 - W_{MA}^0 + c)\rho_{MA}\right]\frac{1 - \mu_i^s}{1 - \rho_{MA}}\left[\frac{\Omega(\mu_i^s)}{\Omega(\rho_{MA})}\right]^{r/\lambda} \\
&\qquad\qquad = -c + W_M^0 + \frac{\lambda}{\lambda + r}(W_i^1 - W_M^0 + c)\mu_i^s \\
&\qquad\qquad\qquad + \left[c - \frac{\lambda}{\lambda + r}(W_i^1 - W_M^0 + c)\rho_i\right]\frac{1 - \mu_i^s}{1 - \rho_i}\left[\frac{\Omega(\mu_i^s)}{\Omega(\rho_i)}\right]^{r/\lambda}. \quad (5)
\end{aligned}$$

The main difference between (4) and (5) is that in (4), α is multiplied to the term $W_{MA}^1 - W_{MA}^0$ on the left-hand side and to the term $W_i^1 - W_M^0$ on the right-hand side. Note also that $W_i^1 - W_M^0 > W_{MA}^1 - W_{MA}^0$ by Assumption 1. If we replace μ_i in (4) with μ_i^s from (5), the RHS and LHS of (4) will diverge, but the problem is that we cannot pin down whether the order of the magnitude remains the same for all values of α, which affects the non-linear terms indirectly via the thresholds ρ_{MA} and ρ_i.

Some simulation results are offered in Figure 6, where the dashed (solid) curve draws μ_i^s (μ_i) as a function of α.[11] Note that there is a lower bound on the value of α set by Assumption 2. The numerical examples all feature $\mu_i^s < \mu_i$ and also show that μ_i^s can respond

[11] For all numerical examples, we set $W_M^0 = 2$, $W_{MA}^0 = 3$, $W_{MA}^1 = 6$, $\lambda = 1$, and $c = 1.5$. For the remaining parameters, we set $W_i^1 = 7$ and $r = 0.4$ for Figure 6a, $W_i^1 = 8$ and $r = 0.05$ for Figure 6b, $W_i^1 = 10$ and $r = 0.4$ for Figure 6c, and $W_i^1 = 30$ and $r = 0.4$ for Figure 6d.

non-monotonically to changes in α. We have not found any counter-example with $\mu_i^s > \mu_i$. Inefficient early mergers make intuitive sense since D lacks short-run cash flow.

We now look at the evaluation of mergers with incomplete information. When the disruptor type is unknown and the posterior belief is q, the expected welfare from D pursuing R&D is given by

$$V_q(p) := qV_H(p) + (1-q)V_L(p).$$

Note from Proposition 3 that there are two cases in which D's type can be inferred in equilibrium. First, if $p < \rho_L^*$ and D remains in the game, it must be the high type, and hence, $q = 1$. Second, a merger agreed at price $U_L(p)$ must involve the low type, and hence, $q = 0$. In these cases, whether to allow the merger depends on the social merger thresholds μ_H^s and μ_L^s given by Lemma 6 for the symmetric information benchmark.

If $p \in (\rho_L^*, \mu_H^*)$ and a merger occurs at price $U_H(p)$, D is the high ability type with posterior $q = q_0 \in (0, 1)$. In this case, we show that optimal merger policy is also in threshold, but when $\alpha = 1$, the social merger threshold exceeds the laissez-faire merger threshold, in contrast to the symmetric information benchmark where the two thresholds coincide.

Proposition 4. *We have the following:*

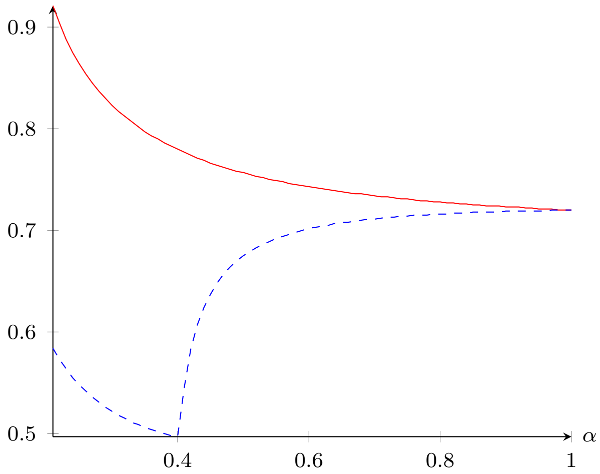
1. *Suppose that a merger is agreed at $p < \rho_L^*$. Then, the socially optimal policy is to block the merger if $\mu_H^s < \mu_H$ and $p \in (\mu_H^s, \mu_H)$.*

2. *Suppose that a merger is agreed at any p and price $U_L(p)$. Then, the socially optimal policy is to block the merger if $\mu_L^s < \mu_L$ and $p \in (\mu_L^s, \mu_L)$.*

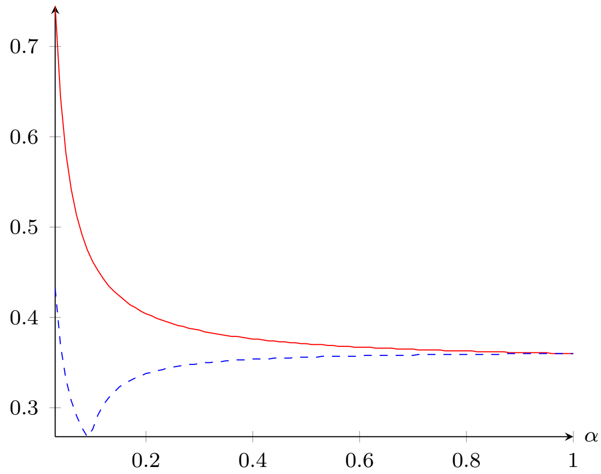
3. *Suppose that a merger is agreed at $p \in [\rho_L^*, \mu_H^*]$ and price $U_H(p)$. Then, there exists a threshold belief $\bar{\mu}^s$ such that the merger is socially optimal for $p \leq \bar{\mu}^s$. If α is sufficiently close to 1, $\bar{\mu}^s > \mu_H^*$.*

Proof. See Appendix A.8. □

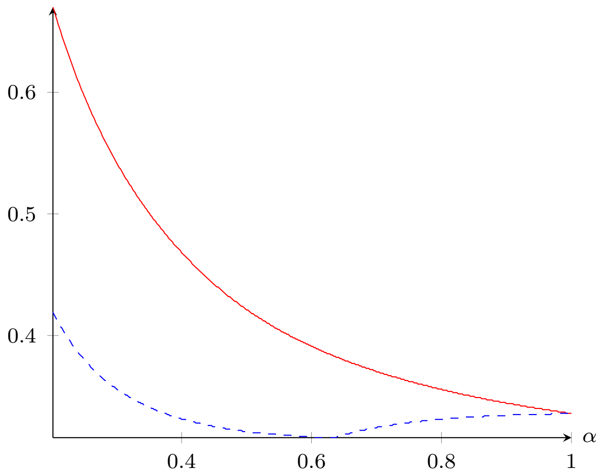
The first two parts of Proposition 4 concern the cases in which the disruptor type is revealed after bargaining takes place and hence follow directly from Lemma 6. The final part says that if a merger is agreed without resolution of the type uncertainty, the merger is socially optimal at least when α is sufficiently large. By part 1c of Proposition 3, this case arises when q_0, the prior on the high type, is relatively large.



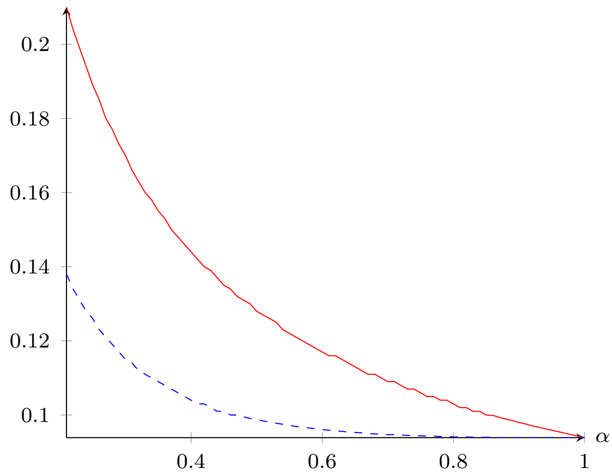
(a)



(b)



(c)



(d)

Figure 6: Social vs. Market Merger Thresholds

To see the logic behind this contrasting result on optimal merger policy, note that the society finds it optimal to shift R&D from D to M when $V_{MA}(p) \geq V_q(p)$. This gives the cutoff $\bar{\mu}^s$ with $q = q_0$. But, if a merger agreement does not reveal private information, the winning offer must be U_H, which is higher than D's average value. In other words, M has to give up an information rent, and suffer from adverse selection, to facilitate a merger. This pushes μ_H^*, the threshold at which M begins to entertain the high type, below $\bar{\mu}^s$ as well as the symmetric information counterpart μ_H. At $p \in (\mu_H^*, \bar{\mu}^s)$, the uninformed society wants a merger but the monopolist's willingness to pay is compatible only with the reservation price of the low ability disruptor.[12] In this sense, mergers happen *too late*, but when they do, there is no efficiency loss to necessitate antitrust intervention. These findings are summarized in Figure 7.

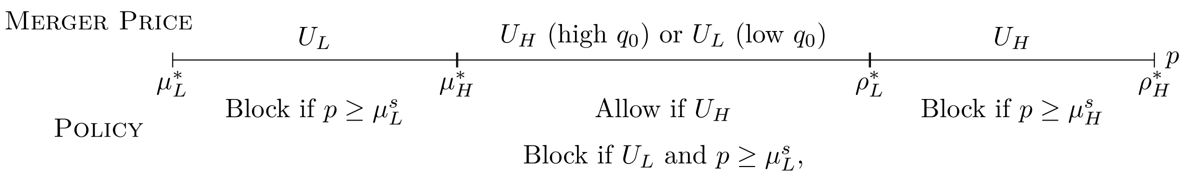


Figure 7: Merger Policy

Again, we do not have an analytical result on the order of $\bar{\mu}^s$ and μ_H^* at low α, but simulations reveal that it is possible to have $\bar{\mu}^s < \mu_H^*$. Figure 8 presents $\bar{\mu}^s$ (dashed) and μ_H^* (solid) as functions of α. Across the four panels, we vary q_0, setting it to be 0.3, 0.5, 0.7, and 0.9 for Figures 8a, 8b, 8c, and 8d, respectively.[13]

4.2 Ex Ante Buyout Effects

The previous section focused on the consequences of mergers ex post, conditional on the arrival of the random bargaining opportunity. To examine the firms' *ex ante* incentives for innovation, and compare them to those of a social planner, we ask the following question. If firm $i \in \{L, H, MA\}$ were to perform R&D, when would the society want the R&D to stop? Let ρ_i^s denote the optimal *social* innovation threshold.

[12] In equilibrium, M offers U_L, and the market learns D's type, at such beliefs.

[13] The other parameter values are fixed. We set $W_M^0 = 2$, $W_{MA}^0 = 3$, $W_{MA}^1 = 6$, $W_L^1 = 10$, $W_H^1 = 15$, $\lambda = 1$, $r = 0.5$, and $c = 1.5$.

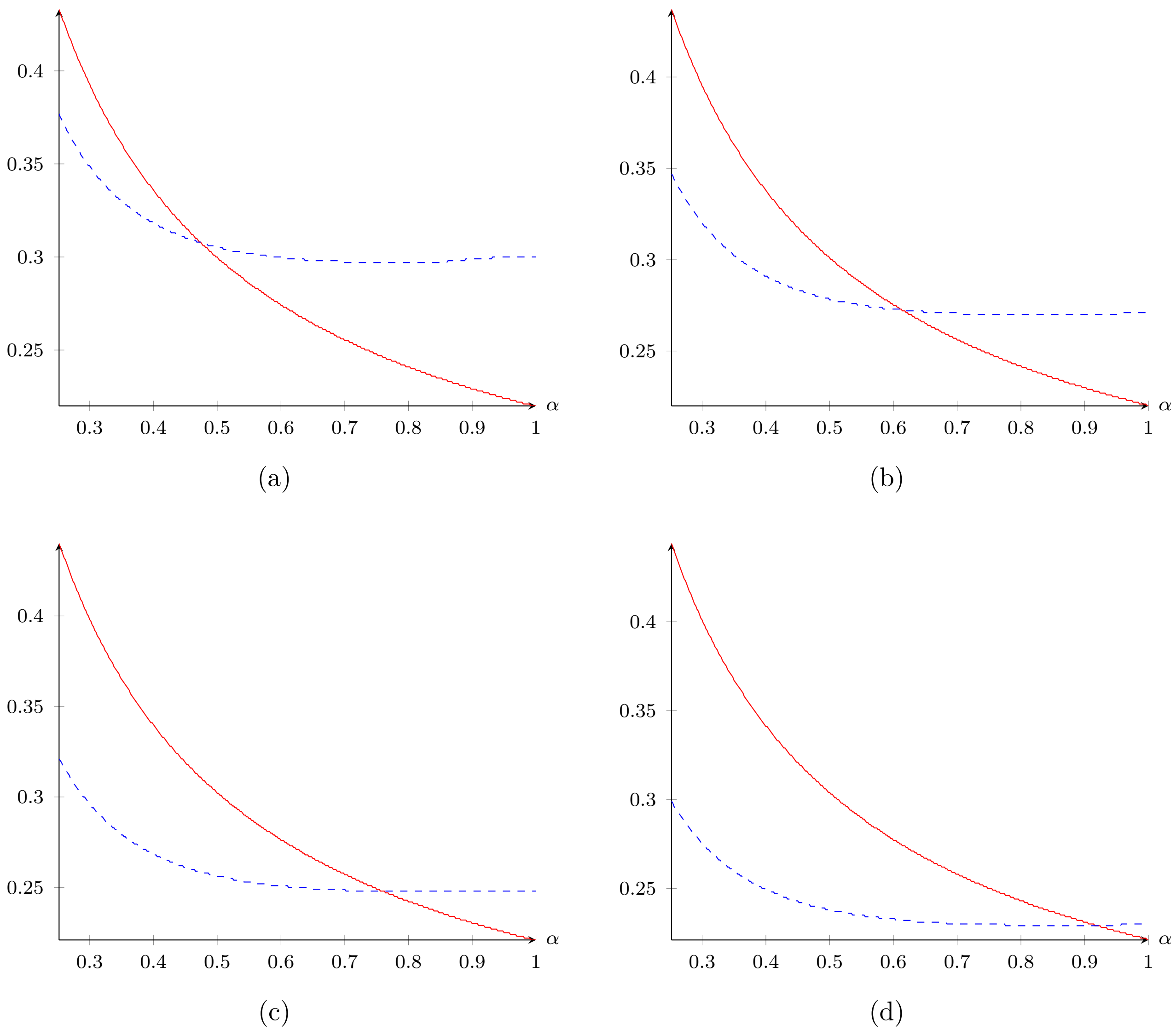


Figure 8: Social vs. Market Merger Thresholds (Incomplete Information)

When M does the R&D (having already acquired D), the only difference between profit and welfare maximization is the factor α. Setting $\Pi^1_{MA} = W^1_{MA}$ and $\Pi^0_{MA} = W^0_{MA}$ in Lemma 1, we obtain

$$\rho^s_{MA} = \frac{rc}{\lambda(W^1_{MA} - W^0_{MA})}.$$

When D does the R&D, there is another difference between profit and welfare maximization. Until the innovation succeeds, the market is served by M, not D. For $i \in \{L, H\}$, setting $\Pi^1_i = W^1_i$ and $\Pi^0_i = W^0_M$ in Lemma 1, we obtain

$$\rho^s_i = \frac{rc}{\lambda(W^1_i - W^0_M)}.$$

It is straightforward to summarize how the private innovation incentives diverge from those of the society in a single-player setting.

Lemma 7. *We have the following:*

1. *The monopolist always under-experiments:* $\rho_{MA} \geq \rho^s_{MA}$ *with equality if* $\alpha = 1$.

2. *The disruptor over-experiments if the private returns to R&D are large and under-experiments otherwise: for* $i \in \{L, H\}$, $\rho_i < \rho^s_i$ *if* $\alpha > \frac{W^1_i - W^0_M}{W^1_i}$ *and* $\rho_i \geq \rho^s_i$ *otherwise.*

Proof. (i) By Lemma 1, it is straightforward to obtain

$$\rho^s_{MA} = \frac{rc}{\lambda(W^1_{MA} - W^0_{MA})} \leq \frac{rc}{\lambda\alpha(W^1_{MA} - W^0_{MA})} = \rho_{MA}.$$

(ii) Fix $i \in \{L, H\}$. Again, by Lemma 1, we have

$$\rho^s_i = \frac{rc}{\lambda\alpha W^1_i}.$$

Comparing this with ρ_i, the claim follows. □

With the monopolist innovating, unless $\alpha = 1$, the social innovation threshold is lower than the private innovation threshold. That is, when the monopolist appropriates less than full returns on its R&D investment, it will stop R&D too early, or at beliefs that are too high, relative to the social planner who takes into account the entire social surplus. There is *under*-experimentation, just like the classic under-investment problem in R&D due to externalities.

When the entrant engages in R&D, the society continues to benefit from the incumbent's production, amounting to W_M^0, but the innovating firm's flow profit is zero. This creates an extra wedge between private and social incentives for experimentation. As a result, the social threshold can be higher or lower than the private threshold, depending on the value of α. If α is close to 1, D stops R&D too late rather than too early. In other words, there is *over*-experimentation. If α is low, D stops R&D too early, and there is under-experimentation.

Now, consider mergers. While there is no buyout effect for the high ability disruptor, Proposition 3 identifies a positive effect of mergers on the R&D incentives of the low ability disruptor. That is, the low type invests in R&D longer than in the single-player case, i.e. $\rho_L^* < \rho_L$ for some parameter values. But, without the merger possibility, the low type can either over- or under-experiment, depending on the value of α which measures private returns to R&D (Lemma 7). Specifically, when α is high, the low type over-experiments ($\rho_L < \rho_L^s$), while when α is low, the low type under-experiments ($\rho_L > \rho_L^s$).

This implies the following. When α is high and the low ability disruptor is already doing too much R&D, the buyout effect only worsens the inefficiency. When α is low and the low ability disruptor is under-experimenting, the buyout effect can reduce the inefficiency. However, it can also push the low ability disruptor to over-experiment. To see this, note that ρ_L^* can become arbitrarily close to zero as βU_H increases. This happens, for example, if W_H^1 is sufficiently high. Since W_H^1 does not affect the social innovation threshold ρ_L^s, we now have excessive R&D because of the buyout effect. We summarize these observations in our last result below (which does not require a separate proof).

Proposition 5. *We have the following:*

1. *If the private returns to R&D are high such that $\rho_L < \rho_L^s$, the buyout effect exacerbates over-experimentation.*
2. *If the private returns to R&D are low such that $\rho_L \geq \rho_L^s$, depending on parameter values, we have either $\rho_L^s \leq \rho_L^* < \rho_L$ or $\rho_L^* < \rho_L^s \leq \rho_L$. In the former case, the buyout effect reduces inefficiency, while in the latter case, it generates over-experimentation.*

5 Implications for Antitrust Policy

Let us discuss policy implications from these findings. For the antitrust authority, the relevant question is whether it should ex post sanction a merger that has already been agreed by two private parties. In the US, for example, the Hart–Scott–Rodino Act imposes a pre-merger filing requirement. While the current guidelines apply to large scale mergers, our analysis applies also to small and medium size mergers that would typically escape such scrutiny.

The results in Section 4.1 suggest that the antitrust authority must carefully assess the informational contents of the proposed merger. Both the belief on the unobservable state p and the belief on private information q matter, as well as α which measures the producer's share of the surplus or private returns to R&D. The results in Section 4.2 imply that with uncertainty, the size of private returns to R&D is a key factor in determining the welfare direction of ex ante buyout effect *vis-à-vis* ex post merger policy.

When the proposed merger reveals the startup's private information, or with complete information, there may be a ground for antitrust intervention. A merger agreed at belief p is inefficient if p is greater than the social merger threshold μ_i^s for $i \in \{L, H\}$. When the merger fails to resolve the type uncertainty, which happens over the region $[\rho_L^*, \mu_H^*]$, the merger price involves information rent and the optimal policy is to allow the merger, as long as private returns to R&D are large (i.e. α is close to 1).[14]

To implement these policies, the regulator must estimate the likelihood of successful innovation and judge whether the agreed merger price involves information rent. Above all, the merger price should reflect the belief p. The market should be pessimistic on a technology startup that has made no meaningful breakthrough in a long time, in which case a merger poses little cause for concern even if it is a killer acquisition. The pessimism should be factored into the price. While fresh startups with beaming expectations are unlikely to sell, the problem case is when the merger occurs at an intermediate belief between the social and market thresholds, i.e. $p \in (\mu_i^s, \mu_i]$. A large takeover bid may indicate such market beliefs.

For gauging the presence of information rent, one potential barometer is market valuation. Many startups are routinely monitored by venture capital industry and others, and in some cases, information may be available on their market value. If a deal is struck at a price significantly higher than the average view of the target firm, it is reasonable to suspect some private information at play. Such anomalous takeover bids may in fact represent efficient market response given the possibility of synergies. If the price matches or falls short of the market expectation, under our distributional assumption, there is no information rent and the

[14] When α is low, it is possible that $\bar{\mu}^s < \mu_H^*$ and mergers are inefficient even with information rent. In such cases (e.g. Figure 8), the optimal policy is similar to the complete information case. The regulator has to judge whether the merger is taking place within the range $(\bar{\mu}^s, \mu_H^*)$.

regulator may proceed to determine whether the merger is happening too early.[15]

For the sake of clarifying our implications, consider the acquisition of Instagram by Facebook in 2012, which has featured prominently in recent debates on killer acquisitions. Facebook saw Instagram as a threat that could potentially steal its business. Rather than competing, Facebook bought Instagram and took over the development of its product. The purchase price was $1 billion, a massive valuation for a startup with just 13 employees. Given that Instagram did agree to sell, and at such a high price, there may have been a role for antitrust intervention at the time. The key issues to resolve are (i) whether there was any information rent in the price of the merger and (ii) the size of private returns to R&D. If there was no information rent, or if there was information rent but the innovation was expected to generate significant consumer surplus and/or spillover externalities, our theory suggests a close examination of the details of the merger.

Finally, it has been argued that the prospect of M&As encourages innovation ex ante. Does this buyout effect weaken the case for ex post merger regulation? We find that with uncertainty, the ex ante effects of mergers may support ex post regulation. When private returns to R&D are large, the buyout effect strengthens over-experimentation and worsens inefficiency. This means that if the disruptor anticipates merger restrictions according to our policy guidelines, its value from R&D will fall, and hence, there will be less R&D and over-experimentation. Even when private returns to R&D are small, one needs to pay close attention to whether over-experimentation results from the buyout effect.

6 Concluding Remarks

In this paper, we addressed the implications of the trade-off between short-run productivity gains and long-run predation losses from a merger in a dynamic model of market competition with uncertainty. A monopoly incumbent confronts a potential entrant experimenting with a disruptive innovation. The incumbent can pursue the R&D if it acquires the disruptor but is less efficient. The disruptor also possesses private information about its ability to appropriate the rents from innovation. Merger acts as an entry-deterring device and protects the status quo, in addition to bringing immediate synergy benefits.

[15] The binary type assumption ensures the possibility of revelation along the equilibrium path. With a continuum of types, private information may never be revealed, in which case winning offers always suffer from adverse selection.

Our model with one-off bargaining opportunity admits essentially unique equilibrium outcome, characterized by multiple threshold beliefs on the unobservable state of nature. As the belief drifts down, the monopolist first offers to buy the low ability disruptor and then switches to an offer that is acceptable to both types. The timing of the switch depends on the prior likelihood of the high ability disruptor. If this prior is high, the monopolist alters its stance early while the low type still remains in the game; otherwise, it waits until the low type quits R&D and exits the game. We identify conditions under which all mergers are killer acquisitions and some mergers are non-killer acquisitions.

Optimal merger policy depends critically on whether the proposed merger reveals private information in equilibrium and the size of private returns to R&D. On the one hand, a merger that reveals the disruptor type may be taking place too early, as long as the producer extracts less than full surplus. The socially optimal policy is to block such mergers. When the type uncertainty is unresolved, on the other hand, the takeover bid reflects information rent. In this case, mergers take place too late but there is no need for intervention if private returns to R&D are large. Our theory suggests that the antitrust authority must carefully evaluate the informational contents of the proposed merger.

We also discuss the effects of mergers on ex ante innovation incentives. Anticipating a takeover bid higher than its own continuation value, the disruptor with low ability invests in R&D longer with the merger possibility. But, if private returns to R&D are large, this buyout effect exacerbates over-experimentation and inefficiency, and uncertainty reinforces the rationale for ex post merger regulations. The outcome is ambiguous if the returns are small. While there is less under-experimentation with mergers, it is also possible that the disruptor switches from under-experimentation to over-experimentation.

Note that our analysis focuses on the problem of monopoly entry deterrence and does not consider horizontal mergers between firms that are already competing in the product market. There is a rapidly growing interest on the effects of such mergers on innovation, where the existing market structure and the reaction by competitors ("production reshuffling") play an important role (e.g. Federico, Langus, and Valletti, 2017; López and Vives, 2019; Bourreau, Jullien, and Lefouili, 2021). The existing studies are however based on static models, and there may be a fruitful avenue of future research for extending our dynamic framework to examine horizontal mergers.

Another way to appraise our work is to view it from the bargaining theory perspective. Although we picked simple bargaining protocol and information structure to focus on industry issues, the environment is novel. The players' values from trade are interdependent, and moreover, uncertain and evolves endogenously with time. In addition, there is asymmetric information. Efficiency calls for trades (mergers) whenever there are mutual gains. To mention some related papers in the bargaining literature, Deneckere and Liang (2006) consider two-player bargaining with interdependent values that are privately known and fixed; Ortner (2017) solves an independent value bargaining problem in which the uninformed player's payoff varies stochastically.

A Appendix

A.1 Proof of Lemma 1

Fix $i \in \{L, H, MA\}$. Assume that it is optimal to do R&D, and consider a small interval of time dt. Let $U_i(p)$ denote the value from investing in R&D. During that time interval, the following can happen:

- R&D is completed with probability $\sim p\lambda dt$; the belief jumps to 1 and the value to $U_i(1) = \Pi_i^1/r$;
- With the complementary probability, nothing happens, the belief drifts down to $p + dp$ according to the law of motion, and the value becomes $U_i(p + dp) \sim U_i(p) + U_i'(p)dp = U_i(p) - U_i'(p)\lambda p(1-p)dt$.

Put together, we obtain

$$U_i(p) = \left[-c + \Pi_i^0\right] dt + p\lambda dt \frac{\Pi_i^1}{r} + (1 - p\lambda dt - rdt) \left[U_i(p) - U_i'(p)\lambda p(1-p)dt\right],$$

which gives the following ODE:

$$\lambda p(1-p)U_i'(p) + (r + \lambda p)U_i(p) = -c + \Pi_i^0 + p\lambda \frac{\Pi_i^1}{r}. \tag{6}$$

First, we can see that

$$\frac{1}{r}\left[-c + \Pi_i^0 + \frac{\lambda}{\lambda + r}(\Pi_i^1 - \Pi_i^0 + c)p\right]$$

is a particular solution to (6). Next, we consider the homogeneous equation $\lambda p(1-p)U_i'(p) + (r+\lambda p)U_i(p) = 0$, which has a solution

$$(1-p)\Omega(p)^\mu,$$

where $\mu = r/\lambda$ and $\Omega(p) = (1-p)/p$. We therefore look for a solution to (6) of the form

$$U_i(p) = \frac{1}{r}\left[-c + \Pi_i^0 + \frac{\lambda}{\lambda + r}(\Pi_i^1 - \Pi_i^0 + c)p\right] + K(1-p)\Omega(p)^\mu, \tag{7}$$

where K is a constant.

To find the constant K and the threshold ρ_i, we use value matching and smooth pasting. Value matching says that at ρ_i, the value from investing in R&D, $U_i(\rho_i)$, must be equal to the value from stopping R&D, which is Π_i^0/r. Smooth pasting says that at ρ_i, the slopes of the value from investing in R&D and not investing in R&D must be the same, so that $U_i'(\rho_i) = 0$.

Let us start with value matching. Setting $U_i(\rho_i) = \Pi_i^0/r$ in (7), we obtain

$$K = \frac{(\lambda + r)c - \lambda(\Pi_i^1 - \Pi_i^0 + c)\rho_i}{r(\lambda + r)(1-\rho_i)\Omega(\rho_i)^\mu}.$$

Thus, the solution (7) is

$$U_i(p) = \frac{1}{r}\left[-c + \Pi_i^0 + \frac{\lambda}{\lambda + r}(\Pi_i^1 - \Pi_i^0 + c)p\right] + \frac{(\lambda + r)c - \lambda(\Pi_i^1 - \Pi_i^0 + c)\rho_i}{r(\lambda + r)} \frac{1-p}{1-\rho_i}\left[\frac{\Omega(p)}{\Omega(\rho_i)}\right]^\mu.$$

To find the threshold ρ_i, we use both the value matching condition $U_i(\rho_i) = \Pi_i^0/r$ and the smooth pasting condition $U_i'(\rho_i) = 0$. Substituting these conditions in (6), we finally obtain

$$\rho_i = \frac{rc}{\lambda\left(\Pi_i^1 - \Pi_i^0\right)}.$$

Note that by Assumptions 1 and 2, we have $\rho_D < \rho_{MA} < 1$.

A.2 Proof of Lemma 2

Fix $i \in \{L, H\}$. When $p \leq \rho_i$, there is no threat of entry and M gets the flow payoff αW_M^0, so its value is $\alpha W_M^0/r$.

Now, let $p > \rho_i$, in which case D invests in R&D, and consider a small interval of time dt. Let $m_i(p)$ denote M's status quo value with entry threat. During dt, the following can happen:

- R&D is completed with probability $\sim p\lambda dt$; the monopolist is replaced and the value becomes 0;
- With the complementary probability, nothing happens, the belief drifts down to $p+dp$ according to the law of motion, and the value becomes $m_i(p+dp) \sim m_i(p) + m_i'(p)dp = m_i(p) - m_i'(p)\lambda p(1-p)dt$.

Put together, we obtain

$$m_i(p) = \alpha W_M^0 dt + (1 - p\lambda dt - rdt)\left[m_i(p) - m_i'(p)\lambda p(1-p)dt\right],$$

which gives the following ODE:

$$\lambda p(1-p)m_i'(p) + (r+\lambda p)m_i(p) = \alpha W_M^0. \tag{8}$$

First, we can see that

$$\frac{\alpha W_M^0}{r}\left(1 - \frac{\lambda}{\lambda + r}p\right)$$

is a particular solution to (8). Next, we consider the homogeneous equation $\lambda p(1-p)m_i'(p) + (r+\lambda p)m_i(p) = 0$, which has a solution

$$(1-p)\Omega(p)^{\mu},$$

where $\mu = r/\lambda$ and $\Omega(p) = (1-p)/p$. We therefore look for a solution to (8) of the form

$$m_i(p) = \frac{\alpha W_M^0}{r}\left(1 - \frac{\lambda}{\lambda + r}p\right) + K(1-p)\Omega(p)^{\mu}, \tag{9}$$

where K is a constant.

To find the constant K, we use value matching: at the threshold ρ_i, D stops R&D and the value becomes $\alpha W_M^0/r$. Setting $m_i(\rho_i) = \alpha W_M^0/r$ in (9), we obtain

$$K = \frac{\frac{\alpha W_M^0}{r}\frac{\lambda}{\lambda+r}\rho_i}{(1-\rho_i)\Omega(\rho_i)^{\mu}}.$$

The solution (9) is thus

$$m_i(p) = \frac{\alpha W_M^0}{r}\left\{\left(1 - \frac{\lambda}{\lambda + r}p\right) + \frac{\lambda}{\lambda + r}\frac{\rho_i}{1-\rho_i}(1-p)\left[\frac{\Omega(p)}{\Omega(\rho_i)}\right]^{r/\lambda}\right\},$$

which can be rewritten as

$$m_i(p) = \frac{\alpha W_M^0}{r}\left\{\left(1 - \frac{\lambda}{\lambda + r}p\right) + \frac{\lambda}{\lambda + r}p\left[\frac{\Omega(p)}{\Omega(\rho_i)}\right]^{\frac{r}{\lambda}+1}\right\}.$$

A.3 Proof of Proposition 1

Fix $i \in \{L.H\}$. By Lemma 3, we know that M makes a winning offer if and only if $U_{MA}(p) - U_i(p) \geq m_i(p)$, which we can rewrite as $U_{MA}(p) - m_i(p) \geq U_i(p)$. Suppose that $r(W^0_{MA} - W^0_M) < \lambda(W^1_i - W^1_{MA})$.

Note that

$$U_i(1) = \frac{\lambda \alpha W^1_i - rc}{r(\lambda + r)},$$

$$U_{MA}(1) = \frac{\lambda \alpha W^1_{MA} + \alpha r W^0_{MA} - rc}{r(\lambda + r)},$$

and

$$m_i(1) = \frac{\alpha W^0_M}{\lambda + r}.$$

It follows that

$$U_{MA}(1) - m_i(1) = \frac{\alpha r(W^0_{MA} - W^0_M) + \alpha \lambda W^1_{MA} - rc}{r(\lambda + r)}$$

and

$$U_{MA}(1) - m_i(1) < U_i(1) \Leftrightarrow r(W^0_{MA} - W^0_M) < \lambda(W^1_i - W^1_{MA}). \tag{10}$$

Also, note that

$$U_{MA}(\rho_i) - m_i(\rho_i) > U_i(\rho_i) = 0.$$

Since both $U_{MA}(p) - m_i(p)$ and $U_i(p)$ are continuous functions, they must cross at least once between ρ_i and 1. We now show that there is a unique μ_i at which they cross. Note that $U_i(p)$ is convex, while $U_{MA}(p) - m_i(p)$ is concave for $p \in (\rho_i, \rho_{MA})$ and either concave or convex for $p \in (\rho_{MA}, 1)$, as it can be written as $A + Bp + C(1-p)\Omega(p)^{\mu}$, where A, B, and C are constants. The concavity or convexity is then determined by the sign of C. In either case, the curves cannot cross more than once given that $U_{MA}(1) - m_i(1) < U_i(1)$.

Next, suppose that $r(W^0_{MA} - W^0_M) \geq \lambda(W^1_i - W^1_{MA})$. Then, by (10), $U_{MA}(1) - m_i(1) \geq U_i(1)$. In this case, M has an incentive to make a winning offer at all p.

We now show that $\mu_H < \mu_L$. Note that the equation defining the merger threshold can be rewritten as

$$U_{MA}(p) = m_i(p) + U_i(p).$$

Here, the LHS does not depend on W^1_i. Therefore, it suffices to show that the RHS is decreasing in W^1_i.

First, the expression for $r(m_i(p)+U_i(p))$ is given by

$$-c+\frac{\lambda}{\lambda+r}(\alpha W_i^1+c)p+\left[c-\frac{\lambda}{\lambda+r}(\alpha W_i^1+c)\rho_i\right]\frac{1-p}{1-\rho_i}\left[\frac{\Omega(p)}{\Omega(\rho_i)}\right]^{r/\lambda} + \alpha W_M^0\left\{\left(1-\frac{\lambda}{\lambda+r}p\right)+\frac{\lambda}{\lambda+r}p\left[\frac{\Omega(p)}{\Omega(\rho_i)}\right]^{\frac{r}{\lambda}+1}\right\}.$$

Collecting the terms that depend on W_i^1 and rearranging, we obtain

$$\frac{\lambda}{\lambda+r}\alpha W_i^1 p+\left[\frac{\Omega(p)}{\Omega(\rho_i)}\right]^{\frac{r}{\lambda}+1}\left\{\left[c-\frac{\lambda}{\lambda+r}(\alpha W_i^1+c)\rho_i\right]\frac{p}{\rho_i}+\alpha W_M^0\frac{\lambda}{\lambda+r}p\right\}.$$

Using the definition of ρ_i, this simplifies to

$$\frac{\lambda p}{\lambda+r}\left[\alpha W_i^1+\left[\frac{\Omega(p)}{\Omega(\rho_i)}\right]^{\frac{r}{\lambda}+1}\left[\frac{\alpha\lambda W_i^1}{r}-c+\alpha W_M^0\right]\right].$$

Then, given that

$$\frac{\partial\left[\frac{1}{\Omega(\rho_i)}\right]^{\frac{r}{\lambda}+1}}{\partial W_i^1}=-\frac{\alpha\lambda}{rc}\left(\frac{r}{\lambda}+1\right)\left[\frac{1}{\Omega(\rho_i)}\right]^{\frac{r}{\lambda}+2},$$

we obtain

$$\frac{\partial\left[\alpha W_i^1+\left[\frac{\Omega(p)}{\Omega(\rho_i)}\right]^{\frac{r}{\lambda}+1}\left[\frac{\alpha\lambda W_i^1}{r}-c+\alpha W_M^0\right]\right]}{\partial W_i^1}= \alpha-\frac{\alpha\lambda}{r}\left[\frac{\Omega(p)}{\Omega(\rho_i)}\right]^{\frac{r}{\lambda}+1}\left[\frac{r}{\lambda}+\left(1+\frac{r}{\lambda}\right)\frac{r}{\alpha\lambda W_i^1-rc}\alpha W_M^0\right],$$

which is negative since $\Omega(p)/\Omega(\rho_i)>1$.

A.4 Proof of Lemma 2

1. Since $r(W_{MA}^0-W_M^0)<\lambda(W_D^1-W_{MA}^1)$, we know from Proposition 1 that there is a unique $\mu_i\in(\rho_i,1)$ such that

$$U_{MA}(\mu_i)-m_i(\mu_i)=U_i(\mu_i).$$

Now, consider the highest value of c given Assumption 2, i.e.

$$c=\frac{\alpha\lambda(W_{MA}^1-W_{MA}^0)}{r}.$$

We then have $\rho_{MA} = 1$. Since $\mu_i < 1$, it follows that $\mu_i < \rho_{MA}$.

2. Recall that μ_i is defined by $U_{MA}(\mu_i) - m_i(\mu_i) = U_i(\mu_i)$ and that for $p < \mu_i$, we have $U_{MA}(p) - m_i(p) > U_i(p)$. We therefore evaluate $U_{MA}(p) - m_i(p) - U_i(p)$ at ρ_{MA} and show that this expression can be positive.

Let $p \leq \rho_{MA}$. Recall that

$$\begin{aligned} U_{MA}(p) &= \frac{\alpha W_{MA}^0}{r} = \frac{\alpha W_M^0}{r} + \frac{\alpha(W_{MA}^0 - W_M^0)}{r}; \\ m_i(p) &= \frac{\alpha W_M^0}{r}\left(1 - \frac{\lambda}{\lambda + r}p\right) + \frac{\alpha W_M^0}{r}\frac{\lambda}{\lambda + r}\frac{\rho_i}{1-\rho_i}(1-p)\left[\frac{\Omega(p)}{\Omega(\rho_i)}\right]^\mu; \\ U_i(p) &= \frac{1}{r}\left[-c + \frac{\lambda}{\lambda + r}(\alpha W_i^1 + c)p\right] + \frac{c - \frac{\lambda}{\lambda+r}(\alpha W_i^1 + c)\rho_i}{r}\frac{1-p}{1-\rho_i}\left[\frac{\Omega(p)}{\Omega(\rho_i)}\right]^\mu. \end{aligned}$$

We therefore have

$$\begin{aligned} U_{MA}(\rho_{MA}) - m_i(\rho_{MA}) &= \frac{\lambda}{\lambda + r}\frac{\alpha W_M^0}{r}\rho_{MA} - \frac{\lambda}{\lambda + r}\frac{\alpha W_M^0}{r}\rho_i\frac{1-\rho_{MA}}{1-\rho_i}\left[\frac{\Omega(\rho_{MA})}{\Omega(\rho_i)}\right]^\mu \\ &\quad + \frac{\alpha(W_{MA}^0 - W_M^0)}{r}; \\ U_i(\rho_{MA}) &= \frac{1}{r}\left[-c + \frac{\lambda}{\lambda + r}(\alpha W_i^1 + c)\rho_{MA}\right] \\ &\quad + \frac{c - \frac{\lambda}{\lambda+r}(\alpha W_i^1 + c)\rho_i}{r}\frac{1-\rho_{MA}}{1-\rho_i}\left[\frac{\Omega(\rho_{MA})}{\Omega(\rho_i)}\right]^\mu. \end{aligned}$$

Rearranging, we find that

$$\begin{aligned} & U_{MA}(\rho_{MA}) - m_i(\rho_{MA}) - U_i(\rho_{MA}) \\ = \; & -\frac{\lambda}{\lambda + r}\frac{\alpha}{r}\rho_{MA}(W_i^1 - W_M^0) + \frac{c}{r}\left(1 - \frac{\lambda}{\lambda + r}\rho_{MA}\right) + \frac{\alpha}{r}\left(W_{MA}^0 - W_M^0\right) \\ & -\frac{1-\rho_{MA}}{1-\rho_i}\left[\frac{\Omega(\rho_{MA})}{\Omega(\rho_i)}\right]^\mu\left[-\frac{\lambda}{\lambda + r}\frac{\alpha}{r}\rho_i\left(W_i^1 - W_M^0\right) + \frac{c}{r}\left(1 - \frac{\lambda}{\lambda + r}\rho_i\right)\right]. \end{aligned}$$

We now look at the limit when $\lambda W_{MA}^1 = \lambda W_i^1 - r(W_{MA}^0 - W_M^0)$ (i.e. the highest possible value of W_{MA}^1 given Assumption 2) and $W_i^1 \to \infty$. In this case, we have

$$\frac{1-\rho_{MA}}{1-\rho_i}\left[\frac{\Omega(\rho_{MA})}{\Omega(\rho_i)}\right]^\mu \to 1$$

and

$$U_{MA}(\rho_{MA}) - m_i(\rho_{MA}) - U_i(\rho_{MA}) \to -\frac{\lambda}{r(\lambda+r)}(\rho_{MA} - \rho_i)\left[c + \alpha(W_i^1 - W_M^0)\right] + \frac{\alpha}{r}\left(W_{MA}^0 - W_M^0\right).$$

As $W_i^1 \to \infty$, the first term goes to zero, as the difference $\rho_{MA} - \rho_i$ is of order $1/(W_i^1)^2$, and we are left with the positive term $\alpha(W_{MA}^0 - W_M^0)/r$.

A.5 Proof of Proposition 3

We proceed in the following steps to prove each of the MPBE properties stated in the claim. Showing the existence of an equilibrium is then immediate. Recall that for $i \in \{L, H\}$, ρ_i and μ_i are the benchmark innovation and merger thresholds with symmetric information from Lemma 1 and Proposition 1, respectively.

Also, recall from Lemma 4 that a winning offer can only be either U_L or U_H. Also, type L remains in the game at least until p drops to ρ_L, which implies that $q = q_0$ if $p > \rho_L$ and the bargaining opportunity does not arrive. Steps 1-3 below assume that type L remains in the game.

Step 1: *M is willing to make the winning offer $U_L(p)$ if and only if $p \leq \mu_L$. Furthermore, if the winning offer is made at $p < \mu_L$, type L accepts it with probability 1.*

Proof. If M makes the winning offer $U_L(p)$, then it is only accepted by the low type, which occurs with probability $(1 - q_0)$, and M's value is $U_{MA}(p) - U_L(p)$. With the complementary probability q_0, the offer is rejected, the posterior q jumps to 1, and M obtains the status quo value $m_H(p)$. If M makes a losing offer, it keeps the expected status quo value $q_0 m_H(p) + (1 - q_0)m_L(p)$.

Thus, M is willing to offer $U_L(p)$ if and only if

$$(1 - q_0)\left[U_{MA}(p) - U_L(p)\right] + q_0 m_H(p) \geq q_0 m_H(p) + (1 - q_0)m_L(p),$$

which can be rearranged into

$$U_{MA}(p) - m_L(p) \geq U_L(p).$$

With equality, this is the condition that defines for the symmetric information merger threshold μ_L.

With strict inequality, the winning offer is strictly better than a losing offer, as stated in Proposition 3, and moreover, if the winning offer is made, it must be accepted for sure in equilibrium. The latter is true because otherwise, M can offer infinitesimally more than $U_L(p)$ to induce acceptance for sure and improve payoff.

Step 2: *There exists a unique threshold $\mu_H^* < \mu_H$ such that M is willing to make the winning offer $U_H(p)$ if and only if $p \leq \mu_H^*$.*

Proof. If M makes the winning offer $U_H(p)$, then it is accepted by both types, and M's value becomes $U_{MA}(p) - U_H(p)$. If M makes a losing offer, the expected status quo value is $q_0 m_H(p) + (1 - q_0) m_L(p)$. Therefore, M is willing to offer $U_H(p)$ if and only if

$$U_{MA}(p) - U_H(p) \geq q_0 m_H(p) + (1 - q_0) m_L(p),$$

which can be rewritten as

$$U_{MA}(p) - [q_0 m_H(p) + (1 - q_0) m_L(p)] \geq U_H(p).$$

The existence of a threshold μ_H^* can be shown via similar arguments to those behind Proposition 1.

To show that $\mu_H^* < \mu_H$, recall that the latter is defined by

$$U_{MA}(\mu_H) - m_H(\mu_H) = U_H(\mu_H)$$

and that

$$U_{MA}(p) - [q_0 m_H(p) + (1 - q_0) m_L(p)] \leq U_{MA}(p) - m_H(\mu_H).$$

Similarly to Step 1, for $p < \mu_H^*$, type H must accept the offer $U_H(p)$ with probability 1 in equilibrium. If not M can offer infinitesimally more than $U_H(p)$ to induce acceptance.

Step 3: *Fix $p \leq \mu_H^*$. Then, M is willing to make the winning offer $U_H(p)$ if and only if*

$$q \geq \frac{U_H(p) - U_L(p)}{U_{MA}(p) - U_L(p) - m_H(p)} \in (0, 1), \tag{11}$$

Furthermore, if $U_H(p)$ is offered at $p < \mu_H^*$, both types must accept it for sure.

Proof. By Proposition 1, we know that $\mu_H < \mu_L$. Thus, by Steps 1 and 2, if $p \leq \mu_H^*$, M is willing to offer both $U_L(p)$ and $U_H(p)$. It is willing to offer $U_H(p)$ if and only if

$$U_{MA}(p) - U_H(p) \geq (1 - q) [U_{MA}(p) - U_L(p)] + q m_H(p).$$

which can be rewritten to give (11). The RHS is strictly positive if $U_{MA}(p)-U_L(p)-m_H(p)>0$ and strictly less than 1 if $U_{MA}(p)-U_H(p)-m_H(p)>0$. This is true since

$$U_{MA}(p)-U_L(p)-m_H(p)>U_{MA}(p)-U_H(p)-m_H(p)>0.$$

The first inequality holds as $U_L(p)<U_H(p)$, while the second because $p<\mu_H$, the symmetric information merger threshold.

For $p>\rho_L^*$, we set $q=q_0$ to obtain (11); for $p<\rho_L^*$, we set $q=1$. The argument for the final part of the claim is identical to the corresponding argument in Step 1.

Step 4: *For $p>\mu_L^*$, M makes a losing offer.*

Proof. By Steps 1 and 2, M is willing to make the offer $U_L(p)$ for $p\leq\mu_L^*$ and $U_H(p)$ for $p\leq\mu_H^*$. Moreover, $\mu_H^*\leq\mu_L^*$. Thus, above μ_L^*, M makes a losing offer.

Step 5: *For $p\in(\mu_H^*,\mu_L^*)$, M offers, and type L accepts, $U_L(p)$.*

Proof. By Step 1, we know that M is willing to make the offer $U_L(p)$ when $p\leq\mu_L^*$, and by Step 2, that M is unwilling to make the offer $U_H(p)$ when $p>\mu_H^*$.

Step 6: *For $p\in(\rho_L^*,\mu_H^*)$, M offers $U_H(p)$ if $q_0>\frac{U_H(p)-U_L(p)}{U_{MA}(p)-U_L(p)-m_H(p)}$, which is accepted by both types, and $U_L(p)$ if $q_0<\frac{U_H(p)-U_L(p)}{U_{MA}(p)-U_L(p)-m_H(p)}$, which is accepted by type L.*

Proof. By Steps 1 and 2, M is willing to offer both $U_L(p)$ and $U_H(p)$ when $p\leq\mu_H^*$. Between the two offers, by Step 3, M prefers $U_H(p)$ when q_0 is high and $U_L(p)$ when it is low.

Step 7: *For $p\in(\rho_H^*,\rho_L^*)$, M offers, and type H accepts, $U_H(p)$.*

Proof. For $p<\rho_L^*$, if D remains, it must be the high type. Since $p<\mu_H^*$, by Step 2, M offers $U_H(p)$.

Step 8: *Type H's innovation threshold in every continuation game is ρ_H.*

Proof. This follows from Lemma 4.

Step 9: *Suppose that the bargaining opportunity has not yet arrived. Then, there exists a unique threshold $\rho_L^*>\rho_H$ such that type L invests in R&D if $p>\rho_L^*$ and stops if $p<\rho_L^*$. Moreover, if q_0 and W_{MA}^1 are sufficiently large, $\rho_L^*<\rho_L$.*

We proceed in two steps. First, we assume that M is willing to make the winning offer $U_H(p)$ for all p less than or equal to, and possibly also for some p above, ρ_L, the single-player threshold for type L. It is then shown that, absent any bargaining opportunity, type L does

R&D until the threshold $\rho_L^* < \rho_L$, where ρ_L^* is as given in the claim. Second, we show that when both q_0 and W_{MA}^1 are sufficiently large, M is indeed willing to make the winning offer $U_H(p)$ at all beliefs below ρ_L.

Step 9A: *Suppose that there exists some $\bar{p} \geq \rho_L$ such that M is willing to make the winning offer $U_H(p)$ for all $p \leq \bar{p}$. Then, there exists some $\rho_L^* \in (\rho_H, \rho_L)$ such that type L invests in (stops) R&D if $p > \rho_L^*$ (if $p < \rho_L^*$). We have $\rho_L^* = \frac{r\left[c-\beta U_H(\rho_L^*)\right]}{\lambda W_L^1}$ as in the claim.*

Proof. To find ρ_L^*, let $p \leq \bar{p}$, so that M is willing to offer $U_H(p)$ if the bargaining opportunity arises, and consider what happens to type L during a small interval of time dt, assuming that it is optimal to invest in R&D.

The following can happen during dt:

- R&D is completed with probability $\sim p\lambda dt$; the belief jumps to 1 and the value to $u(1) = W_L^1/r$;
- With probability $\sim \beta dt$, M makes the offer $U_H(p)$;
- With the complementary probability, nothing happens, the belief drifts down to $p + dp$ according to the law of motion, and the value becomes $U_L(p+dp) \sim U_L(p) + U_L'(p)dp = U_L(p) - U_L'(p)\lambda p(1-p)dt$.

Put together, we obtain

$$U_L(p) = -cdt + p\lambda dt\frac{W_L^1}{r} + \beta dt U_H(p) + (1 - p\lambda dt - \beta dt - rdt)\left[U_L(p) - U_L'(p)\lambda p(1-p)dt\right],$$

which gives the following ODE:

$$\lambda p(1-p)U_L'(p) + (r + \beta + \lambda p)U_L(p) = -c + p\lambda\frac{W_L^1}{r} + \beta U_H(p). \tag{12}$$

Note that the only differences between (12) and (6) are the new terms in β, which correspond to the possibility of type L being purchased at price $U_H(p)$.

At the new threshold ρ_L^*, we can also use value matching and smooth pasting, i.e. we must have $U_L(\rho_L^*) = U_L'(\rho_L^*) = 0$. Substituting these into (12), it is easy to find that the threshold ρ_L^* must satisfy the following equation:

$$\rho_L^* = \frac{r\left[c - \beta U_H(\rho_L^*)\right]}{\lambda W_L^1}.$$

It is clear that $\rho_L^* < \rho_L$. Also, we must have $\rho_L^* > \rho_H$. If not, $\rho_L^* = \rho_H$, and we would then have $U_H(\rho_L^*) = 0$. This implies that $\rho_L^* = rc/\lambda W_L^1 = \rho_L$, a contradiction.

Step 9B: *If q and W_{MA}^1 are sufficiently large, there exists some $\bar{p} \geq \rho_L$ such that it is optimal for M to offer $U_H(p)$ for all $p < \bar{p}$.*

Proof. Given Step 6A, suppose that type L invests in R&D until p reaches $\rho_L^* < \rho_L$. If the bargaining opportunity arrives and there is no agreement, type L returns to its single-player threshold ρ_L. Also, by Step 5, type H's innovation threshold is always $\rho_H < \rho_L^*$.

Consider the value of M under the threat of entry but without the possibility of bargaining, given that type H and type L pursue R&D until ρ_H and ρ_L, respectively. Given these innovation thresholds, we can find the status quo values m_H or m_L, as in Lemma 2, depending on whether D's type is high or low.

At $p > \rho_L^*$, M's posterior belief on type H is equal to the prior q_0, and let us now consider M's incentives to acquire D. Consider the winning offer $U_H(p)$. This makes M's value change from $\mathbb{E}_{i\in\{L,H\}}[m_i(p)] = q_0 m_H(p) + (1-q_0)m_L(p)$ to $U_{MA}(p)$. M is willing to make such an offer whenever $U_{MA}(p) - \mathbb{E}_{i\in\{L,H\}}[m_i(p)] \geq U_H(p)$, which can be written as

$$U_{MA}(p) - [q_0 m_H(p) - (1-q_0)m_L(p)] \geq U_H(p).$$

As $q_0 \to 1$, this condition becomes

$$U_{MA}(p) - m_H(p) \geq U_H(p),$$

which holds when $p \leq \mu_H$. From Proposition 2, we know that we can have $\mu_H \geq \rho_{MA}$ when W_{MA}^1 is sufficiently large, which is enough to prove our claim. Indeed, this shows that M is willing to make the offer $U_H(p)$ at beliefs where type L is still active.

A.6 Proof of Lemma 5

The calculation of V is similar to the calculation of U in the proof of Lemma 1, except that we do not need to derive the optimal threshold, as R&D is assumed to take place until the given threshold ρ. This means that smooth pasting does not apply.

We immediately obtain the value

$$V(p;\rho,W^0,W^1)=\frac{1}{r}\Bigg\{-c+W^0+\frac{\lambda}{\lambda+r}(W^1-W^0+c)p$$
$$+\left[c-\frac{\lambda}{\lambda+r}(W^1-W^0+c)\rho\right]\frac{1-p}{1-\rho}\left[\frac{\Omega(p)}{\Omega(\rho)}\right]^{r/\lambda}\Bigg\}.$$

A.7 Proof of Lemma 6

Fix $i\in\{L,H\}$. First, let us show that there is a unique threshold μ_i^s below which merger is optimal for society. Given the limits at $p=\rho_i$ and $p=1$, the two curves $V_i(p)$ and $V_{MA}(p)$ must cross at least once. Given that both functions are convex, they must cross only once.

At $p=1$, we have

$$V(1;\rho,W^0,W^1)=\frac{1}{r}\left\{-\frac{r}{\lambda+r}c+\frac{\lambda}{\lambda+r}W^1+\frac{r}{\lambda+r}W^0\right\}.$$

We can then see that $V_i(1)>V_{MA}(1)$ when

$$\lambda(W_i^1-W_{MA}^1)>r(W_{MA}^0-W_M^0).$$

That is, when the replacement effect is higher than the synergy effect, then for high beliefs the merger is not beneficial to the society. At $p=\rho_i$, we have

$$\frac{W_M^0}{r}=V_i(\rho_i)<V_{MA}(\rho_i)=\frac{W_{MA}^0}{r}.$$

In this case, merger is beneficial to the society because of the synergy effect. Given the continuity and convexity of the functions V_i and V_{MA}, it follows that there must be a unique threshold μ_i^s below which merger is optimal.

If, however, the synergy effect is greater than the replacement effect, such that $\lambda(W_i^1-W_{MA}^1)\le r(W_{MA}^0-W_M^0)$,, then we always have $V_i(p)\le V_{MA}(p)$, so that the merger is always optimal for society.

We now show that when $\alpha=1$, the thresholds μ_i^s and μ_i coincide. Recall that μ_i is defined as

$$V(\mu_i;\rho_{MA},\alpha W_{MA}^0,\alpha W_{MA}^1)-m_i(\mu_i)=V(\mu_i;\rho_i,0,\alpha W_i^1)$$

Note that we can rewrite the status quo value $m_i(p)$ as

$$m_i(p)=V(p;\rho_i,\alpha W_M^0,\alpha W_i^1)-V(p;\rho_i,0,\alpha W_i^1).$$

Substituting in the previous equality, we obtain

$$V(\mu_i; \rho_{MA}, \alpha W^0_{MA}, \alpha W^1_{MA}) = V(\mu_i; \rho_i, \alpha W^0_M, \alpha W^1_i).$$

When $\alpha = 1$, this coincides with the definition of μ^s_i, or

$$V(\mu^s_i, \rho_{MA}, W^0_{MA}, W^1_{MA}) = V(\mu^s_i; \rho_i, W^0_M, W^1_i).$$

A.8 Proof of Proposition 4

When D's type is unknown, a merger is beneficial to society if and only if

$$V_{MA}(p) \geq q_0 V_H(p) + (1 - q_0) V_L(p).$$

By similar arguments to those behind Lemma 6, it is straightforward to show that the corresponding merger policy is in threshold. Let us refer to the threshold as $\bar{\mu}^s$.

We now show that $\bar{\mu}^s > \mu^*_H$ when $\alpha = 1$. Recall that M is willing to offer U_H if and only if

$$U_{MA}(p) \geq q_0 m_H(p) + (1 - q_0) m_L(p) + U_H(p).$$

Using the fact that $m_i(p) = V(p; \rho_i, \alpha W^0_M, \alpha W^1_i) - V(p; \rho_i, 0, \alpha W^1_i)$, and setting $\alpha = 1$, this can be rewritten as

$$V_{MA}(p) \geq q_0 V_H(p) + (1 - q_0) V_L(p) + (1 - q_0) \left[U_H(p) - U_L(p) \right],$$

which gives the cutoff μ^*_H. Since the RHS is greater than $q_0 V_H(p) + (1 - q_0) V_L(p)$, it follows that $\bar{\mu}^s > \mu^*_H$. By continuity, $\bar{\mu}^s > \mu^*_H$ for α close to 1.

References

Arrow, K. (1962). Economic welfare and the allocation of resources. In *The rate and direction of inventive activity: Economic and social factors*, pp. 609–626. Princeton University Press.

Banerjee, D., C. Teh, and C. Wang (2022). Acquisition-induced kill zones. *Working Paper*.

Bergemann, D. and U. Hege (1998). Venture capital financing, moral hazard, and learning. *Journal of Banking and Finance 22*, 703–735.

Bergemann, D. and U. Hege (2005). The financing of innovation: Learning and stopping. *RAND Journal of Economics 36*, 719–752.

Bergemann, D. and J. Välimäki (1997). Market diffusion with two-sided learning. *RAND Journal of Economics 28*, 773–795.

Bergemann, D. and J. Välimäki (2000). Experimentation in markets. *Review of Economic Studies 67*, 213–234.

Bergemann, D. and J. Välimäki (2002). Entry and vertical differentiation. *Journal of Economic Theory 106*, 91–125.

Bergemann, D. and J. Välimäki (2006). Dynamic pricing of new experience goods. *Journal of Political Economy 114*(4), 713–743.

Bonatti, A. (2011). Menu pricing and learning. *American Economic Journal: Microeconomics 3*, 124–63.

Bourreau, M., B. Jullien, and Y. Lefouili (2021). Mergers and demand-enhancing innovation. *CEPR Discussion Paper No. DP16031*.

Cabral, L. (2021). Merger policy in digital industries. *Information Economics and Policy 54*, 100866.

Callander, S. and N. Matouschek (2022). The novelty of innovation: Competition, disruption, and antitrust policy. *Management Science 68*(1), 37–51.

Chen, C.-H., J. Ishida, and A. Mukherjee (2021). Pioneer, early follower or late entrant: Entry dynamics with learning and market competition. *ISER DP* (1132).

Christensen, C. M. (1997). *The innovator's dilemma: when new technologies cause great firms to fail*. Harvard Business Review Press.

Cunningham, C., F. Ederer, and S. Ma (2021). Killer acquisitions. *Journal of Political Economy 129*(3), 649–702.

Decker, R. A., J. Haltiwanger, R. S. Jarmin, and J. Miranda (2016). Declining business dynamism: What we know and the way forward. *American Economic Review P&P 106*(5), 203–07.

Decker, R. A., J. Haltiwanger, R. S. Jarmin, and J. Miranda (2017). Declining dynamism, allocative efficiency, and the productivity slowdown. *American Economic Review P&P 107*(5), 322–26.

Deneckere, R. and M.-Y. Liang (2006). Bargaining with interdependent values. *Econometrica 74*(5), 1309–1364.

Denicolò, V. and M. Polo (2021). Acquisitions, innovation and the entrenchment of monopoly. *Available at SSRN 3988255*.

Federico, G., G. Langus, and T. Valletti (2017). A simple model of mergers and innovation. *Economics Letters 157*, 136–140.

Fumagalli, C., M. Motta, and E. Tarantino (2020). Shelving or developing? the acquisition of potential competitors under financial constraints. *CEPR Discussion Paper No. DP15113*.

Gilbert, R. J. and D. M. Newbery (1982). Preemptive patenting and the persistence of monopoly. *American Economic Review 72*, 514–526.

Guéron, Y. and J. Lee (2022). Learning by selling, knowledge spillovers, and patents. *Journal of Industrial Economics, forthcoming*.

Henderson, R. M. and K. B. Clark (1990). Architectural innovation: The reconfiguration of existing product technologies and the failure of established firms. *Administrative Science Quarterly*, 9–30.

Keller, G., S. Rady, and M. Cripps (2005). Strategic experimentation with exponential bandits. *Econometrica 73*(1), 39–68.

Letina, I., A. Schmutzler, and R. Seibel (2021). Killer acquisitions and beyond: policy effects on innovation strategies. *University of Zurich, Department of Economics, Working Paper* (358).

López, Á. L. and X. Vives (2019). Overlapping ownership, R&D spillovers, and antitrust policy. *Journal of Political Economy 127*(5), 2394–2437.

Motta, M. and M. Peitz (2021). Big tech mergers. *Information Economics and Policy 54*, 100868.

Murto, P. and J. Välimäki (2011). Learning and information aggregation in an exit game. *Review of Economic Studies 78*(4), 1426–1461.

Ortner, J. (2017). Durable goods monopoly with stochastic costs. *Theoretical Economics 12*(2), 817–861.

Rasmusen, E. (1988). Entry for buyout. *Journal of Industrial Economics*, 281–299.

Teece, D. J. (1986). Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Research Policy 15*(6), 285–305.

Williamson, O. E. (1968). Economies as an antitrust defense: The welfare tradeoffs. *The American Economic Review 58*(1), 18–36.