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KILLER ACQUISITIONS AND BEYOND: POLICY EFFECTS ON INNOVATION STRATEGIES*

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This article provides a theory of strategic innovation project choice by incumbents and start-ups which serves as a foundation for the analysis of acquisition policy. We show that, in spite of countervailing incentives on incumbents and entrants, prohibiting acquisitions has a weakly negative overall innovation effect. We provide conditions determining the size of the effect and conditions under which it is zero. We further analyze the effects of less restrictive policies, including merger remedies and the tax treatment of acquisitions and initial public offerings. Such interventions tend to prevent acquisitions only if the entrant has sufficiently high stand-alone profits.

1. INTRODUCTION

Mergers rarely trigger interventions by competition authorities unless they involve substantial additions of incumbent market shares. In particular, start-up acquisitions are hardly ever challenged.[1] Practitioners and academics have argued that this lenient approach may be flawed, as it does not take risks to potential competition into account.[2]

Acquisitions of small innovative firms by the dominant players in the digital economy have received particular attention.[3] Moreover, Cunningham et al. (2021) show that incumbent firms in the pharmaceutical industry often engage in so-called *killer acquisitions* by purchasing start-ups with the sole purpose of eliminating potential competition, without intending to commer-

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[1] A rare exception was the Federal Trade Commission (FTC)'s intervention against the acquisition of *HeartWare* by *Thoratec*, a maker of left ventricular assist devices, in 2009 on the grounds that "HeartWare alone represents a significant threat to Thoratec's LVAD monopoly;" see https://www.ftc.gov/sites/default/files/documents/cases/2009/07/090730thorateadminccmpt.pdf. Similar arguments played a role in the FTC's treatment of the proposed acquisition of the small rival *Pacific Biosciences* by *Illumina* and the acquisition of *College Park* by *Ossur*, both producers of prosthetic devices (see OECD, 2020).

[2] This concern is reflected in policy reports such as Crémer et al. (2019) ("EU Report"), Furman et al. (2019) ("Furman Report"), or Scott Morton et al. (2019) ("Stigler Report"); see also Salop (2016), Salop and Shapiro (2017), Hovenkamp and Shapiro (2017), and Bryan and Hovenkamp (2020b).

[3] Examples include Facebook's takeovers of *WhatsApp*, *Instagram*, and *Oculus CR*, *Google*'s acquisition of *DoubleClick*, *Waze*, and *YouTube*, and *Microsoft*'s purchases of *GitHub* and *LinkedIn*. For more descriptive statistics on start-up acquisitions, see Gautier and Lamesch (2021).

cialize the innovation.[4] Even when incumbents do commercialize the innovation, acquisitions need not be innocuous, as they may widen the technological lead of a dominant incumbent, making entry ever harder (e.g., Bryan and Hovenkamp, 2020a). Nonetheless, a per se prohibition of start-up acquisitions would not be desirable either: As many observers have pointed out, the prospect of selling the firm may increase the entrant's ex ante innovation incentive, even without commercialization by the incumbent.[5] Since Rasmusen (1988), several academic papers have formalized this "entry-for-buyout logic." However, this logic is incomplete: The option of buying an innovative entrant could crowd out innovation efforts of the incumbent. Therefore, the overall effect of a prohibition of acquisitions on innovation is unclear without further analysis.

Our article analyzes the effect of banning acquisitions in a model in which both, the entrant and the incumbent, may innovate. Moreover, different innovation projects are available, so that firms make strategic project choices determining not only their probability of innovation, but also the correlation between their innovation outcomes and those of the competitors. To illustrate why we are taking this approach, consider a simple version of a standard model where firms only choose how much to invest in R&D.[6] Consider a market with linear inverse demand $p(Q) = 1 - Q$ and constant marginal cost $c = 0$, so that monopoly profits are 1/4 and Cournot duopoly profits per firm are 1/9. Suppose an entrant can generate an innovation that leads to a perfect substitute for the incumbent's product with probability x_E if the entrant invests $K(x_E) = 0.5x_E^2$. The incumbent can similarly invest in R&D with success probability x_I and investment cost $K(x_I) = 0.5x_I^2$. If both firms have successfully innovated, the right to use the innovation is assigned to each firm with probability 0.5. In this setting, the effects of prohibiting acquisitions now depend on the entrant's bargaining power. When the entrant has high bargaining power, the entry-for-buyout logic prevails, and the probability of innovation with a prohibition is lower than without. If the entrant has low bargaining power, the probability of innovation with a prohibition is higher than without.[7] The latter result reflects an increase in the innovation efforts of the incumbent who, having lost the acquisition option to prevent competition by the successful entrant, is now trying to crowd out a successful innovation by the entrant with own innovation activity. However, our analysis will show that this ambiguity result relies on the assumption that the incumbent's strategy set is one-dimensional, allowing her only to choose the overall probability with which she will obtain an innovation.

Contrary to such standard models, our richer model of project choice allows the incumbent to target her R&D toward projects that the entrant invests in as well. Thereby, we can distinguish between investments that increase project variety and those that merely lead to duplication, which is crucial to understand whether the innovation probability and R&D investment move in the same direction. We find that the overall effect of a prohibition of acquisitions on the innovation probability is *always weakly negative*. Nevertheless, a prohibition is justified in many cases. To see this, we show that the size of the innovation effect depends on market characteristics. In particular, we identify circumstances under which the effect is entirely absent, so that the standard procompetitive arguments suffice to justify a prohibition.

Although these results might suggest selective interventions into the market, this could be difficult to implement in practice. Therefore, a central part of our article is a detailed analysis

[4] The use of the "killer" metaphor in the literature is not uniform. Some authors apply the expression "kill zone" to start-up activities that are so close to those of dominant incumbents that they may trigger hostile behavior toward the entrant, without implying that the incumbent would not commercialize the start-up's technologies.

[5] See Bourreau and de Streel (2019), Crémer et al. (2019), Furman et al. (2019), and Cabral (2021).

[6] Such innovation models are in the tradition of, for example, Gilbert and Newbery (1982), Reinganum (1983), Loury (1979), and Lee and Wilde (1980).

[7] When acquisitions are prohibited, the equilibrium investments are (approximately) $x_E = 0.1107$ and $x_I = 0.0077$, with resulting innovation probability $1 - (1 - x_E)(1 - x_I) = 0.1175$. If the entrant receives the entire bargaining surplus under laissez-faire, equilibrium investments are (approximately) $x_E = 0.1382$ and $x_I = 0.0096$ and thus higher than without acquisitions. If the incumbent receives the entire bargaining surplus, equilibrium investments are (approximately) $x_E = 0.1108$ and $x_I = 0.0062$, so that the innovation probability is 0.1162 and thus lower than without acquisitions.

of the effects of several policy instruments which leave the acquisition decision to the firms, but influence acquisition incentives. Specifically, we consider merger remedies, acquisition taxes, and preferential treatment of initial public offerings.

Our model is generic instead of tailored to any single industry, as we do not impose any functional form on demand or profit. Moreover, we do not restrict attention to either process or product innovations. An incumbent monopolist possesses a technology that allows her to operate in a product market without innovation. By contrast, an entrant has to innovate in order to produce. We allow firms to strategically choose in which innovation projects to invest. Such a representation captures important aspects of many real-world innovation decisions.[8] Ex ante, projects only differ with respect to investment costs; ex post, only one project will lead to an innovation. With some probability, this innovation will be drastic, resulting in monopoly profits for the commercializing firm. Otherwise, it will be nondrastic, allowing the entrant to compete. Under a *laissez-faire* policy, the incumbent can acquire the entrant once the innovation outcomes become common knowledge. If an acquisition takes place, the trading surplus is split according to exogenously given shares reflecting bargaining power.[9] The firm possessing the innovation technology then decides whether to commercialize it at some fixed cost or not; thereafter, product market competition takes place. Our model contains a parameter region with high commercialization costs (HCC), where the incumbent does not commercialize the acquired innovation, so that a killer acquisition results, and a region with low commercialization costs (LCC) where the incumbent commercializes the innovation, so that the acquisition is genuine. This is important because both cases are empirically relevant and because it might be difficult for the authorities to distinguish between them.[10]

We fully characterize the equilibrium structure, which enables us to analyze policy effects on innovation strategies. We first focus on the effects of prohibiting start-up acquisitions. Even though incumbents and entrants react differently to the policy, we obtain the clear result that the policy effect on innovation is weakly negative, no matter how the bargaining power is distributed. The reason that the overall innovation probability never increases is that the incumbent has larger incentives to invest only in those projects in which the entrant also invests (i.e., duplicate projects), whereas her incentives to invest in new projects remain unchanged. Compared to standard models where firms only choose the R&D intensity (as in the example sketched above), our framework identifies a novel effect of a more restrictive acquisition policy (change in duplication) and offers qualitatively different predictions (weakly lower innovation probability). Of course, which of the two modeling approaches is adequate depends on the innovation technology for the case at hand, with the multiproject setting being more appropriate whenever there is fundamental uncertainty about the right approach.

Although the weakly negative innovation effect of prohibiting acquisitions appears to vindicate the entry-for-buyout argument, there is an important qualification: Whereas the innovation effect is *strictly* negative in the region with HCC, there is a nondegenerate part of the LCC region where it is entirely absent. Thus, perhaps surprisingly, even though killer acquisitions (which arise with HCC) may appear to be particularly problematic because nondrastic innovations do not reach the market, the procompetitive argument for prohibiting genuine acquisitions (which arise with LCC) is sometimes even clearer because the adverse innovation effect may be zero. Crucially, in all equilibria in the region with HCC, the entrant's incentives determine the variety of innovation projects. As the absence of the acquisition option reduces the entrant's investment incentives, overall variety declines when acquisitions are prohibited. By contrast, when nondrastic innovations are valuable enough for the incumbent

[8] A prominent example for different approaches to an innovation is the development of the Internet. Among several competing methods to connect different networks and transmit data, the packet switching method turned out to be the one efficient enough to enable today's Internet (Leiner et al., 2009).

[9] See Phillips and Zhdanov (2013), Cabral (2018), and Kamepalli et al. (2022) for similar assumptions.

[10] This distinction mirrors the contrast between killer acquisitions and nascent potential competitor theory of harms. The latter case arises if "the acquired product might grow into a rival product, and hence […] controlling that product (but not killing it), removes the competitive threat that it poses" (OECD, 2020, p. 7).

to commercialize, her incentives to innovate may be higher than those of the entrant. In this case, the incumbent's incentives are decisive for the variety of innovation, and they are not affected by policy. Without an adverse innovation effect, prohibiting acquisitions improves welfare because it exclusively enhances competition.

In all other cases, policy has to trade off the positive competition effect of preventing acquisitions against the negative innovation effect. Our results suggest that the procompetitive effect is likely to dominate the adverse innovation effect in markets in which the entrant's bargaining power is low and the incumbent's competitive profits are high. Thus, innovation effects should not be seen as a *carte blanche* for acquisitions. Rather, whether or not acquisitions should be allowed depends on the specifics of the industry.

Determining whether the market conditions justify an intervention may be difficult in practice. In Section 7, we therefore consider several alternative policies. First, we discuss two behavioral remedies: restrictions on the use of the acquired technology and prohibition of "killing" the acquired technology. Such remedies may decrease ex ante innovation incentives, but in complementary cases: Limiting the usage of the acquired technology after an acquisition does not affect innovation for killer acquisitions, but decreases innovation for genuine acquisitions and may turn some of them into killer acquisitions. Conversely, if the "killing" of the entrant's technology is prohibited, some killer acquisitions become genuine. Innovation is unaffected in the case of LCC and diminished in the case of HCC. Second, we analyze tax policies which aim to tilt the decision of the start-up in favor of market entry. Similarly to the behavioral remedies, an increase in acquisition taxes is likely to decrease innovation. In contrast, making initial public offerings (IPOs) more profitable for startups, for instance by lowering the tax burden, fosters innovation. A common attractive feature of all these policy instruments is that, if they have an effect, they may render the acquisition unprofitable in circumstances when an entrant would make substantial profits on its own, suggesting that he would be a viable competitor.

Furthermore, we show in Section 8 that the weakly negative innovation effects of a no-acquisition policy are robust to relaxing several assumptions of the main model. First, we allow for a monotone relationship between the cost of pursuing a project and its probability to generate a drastic innovation. With such project heterogeneity, banning acquisitions may have a particularly pronounced negative effect on the probability of drastic innovations. Intuitively, if the prohibition reduces R&D investment, this affects exactly the projects which are most costly to pursue and thus most likely to lead to a drastic innovation. Otherwise, results turn out to be similar as in the main model. Second, suppose that the size of the innovation (drastic or nondrastic) is not yet known at the time of the acquisition. Such uncertainty leads to more acquisitions, but does not affect the innovation effects of the policy. Third, asymmetries in commercialization costs or the chances of receiving the patent do not influence the innovation effect, though, in the former case, a no-acquisition policy may suffer from the additional inefficiency that an entrant with HCC ends up commercializing the innovation. Fourth, we show that allowing for licensing of innovation does not affect our results. Fifth, we argue that, whereas the existence of a second entrant would tend to reduce investment incentives, the effect of the no-acquisition policy would remain qualitatively similar. Sixth, we argue that extending the space of possible innovation outcomes from two to a continuum would not significantly alter the insights of our analysis.

The remainder of the article is organized as follows: In the main text, we focus on the introduction of the main framework, the results and the discussion. Appendix A contains proofs of our main results whereas Online Appendix B provides the remaining proofs as well as precise statement of results that we only mention briefly in the main text.

2. RELATION TO THE LITERATURE

Cunningham et al. (2021) not only provide empirical evidence for the existence of killer acquisitions, but they also develop a theoretical model to explain the rationale behind discontinuing development. The main difference between their model and ours is that we emphasize the initial innovation decisions, which they do not analyze.

A recent theoretical literature has studied under which circumstances mergers of incumbents increase innovation. Federico et al. (2017, 2018) and Motta and Tarantino (2021) identify negative effects, whereas Denicolò and Polo (2018) find positive effects. In Bourreau et al. (2021), both possibilities arise.[11] In models with multiple research approaches, Letina (2016) and Gilbert (2019) obtain negative effects on R&D diversity; Letina also finds that mergers reduce research duplication. Moraga-González et al. (2022) show that mergers may increase welfare by alleviating biases in the direction of innovation.[12]

Instead of focusing on incumbent innovations, our article asks how acquisition policy affects the R&D project choices of incumbents and entrants.[13] Rasmusen (1988) identified an incentive to enter a market to get bought by the current incumbent, suggesting that a lenient acquisition policy can foster innovative entry.[14] In Phillips and Zhdanov (2013), a laissez-faire policy increases the incumbent's innovation as well as the entrant's.[15] Cabral (2018) obtains the innovation-for-buyout effect in a continuous-time setting. Mermelstein et al. (2020) and Hollenbeck (2020) use computational methods to study the long-run effects of merger policy in dynamic oligopoly models with entry-for-buyout incentives; the latter finds that prohibiting mergers can lead to less innovation and lower long-run consumer welfare. Fumagalli et al. (2023) show that, in spite of potential anticompetitive effects, the prospect of acquisitions by an incumbent may foster start-up innovations by relaxing financial constraints.[16] By contrast, Kamepalli et al. (2022) and Katz (2021) argue that, in the tech industry, a laissez-faire policy may have negative effects on start-up innovations.[17] Whereas Gans and Stern (2000) focus less on acquisition policies, they provide an in-depth analysis of the innovation decisions of entrants who can bargain with incumbents about cooperative agreements such as technology licensing. They show how the terms of the agreement depend on fundamentals such as property rights and stand-alone profits.[18] Unlike our article, none of these papers analyzes the strategic choice of innovation projects.

Several papers deal with the effects of acquisition policy on the type of innovation. Bryan and Hovenkamp (2020a) consider distortions in the innovation decisions of start-ups who produce inputs for competing incumbents, without considering entry into this competition. In Gilbert and Katz (2022) and Dijk et al. (2023), a vertically differentiated entrant can choose whether or not to compete head-to-head with the incumbent. The papers provide conditions under which a restrictive acquisition policy will increase or decrease biases in this decision. In Callander and Matouschek (2022), the entrant can similarly choose the distance to the

[11] A related literature investigates the effects of the number of firms on innovation, see Yi (1999), Norbäck and Persson (2012), and Marshall and Parra (2019). Moreover, many papers discuss the relation between other measures of competitive intensity and innovation; see Vives (2008) and Schmutzler (2013) for unifying approaches.

[12] Bryan and Lemus (2017), Letina and Schmutzler (2019), Bardey et al. (2016), and Bavly et al. (2022) treat other aspects of innovation project choice.

[13] Segal and Whinston (2007) ask how the antitrust treatment of incumbents affects entrants' innovation incentives: A more restrictive policy increases the entrants' short-term benefits from being in the market, but leads to long-term losses in case he becomes dominant himself.

[14] See Mason and Weeds (2013) for similar reasoning.

[15] In their model, large firms can sell their own product and the target's product after the acquisition and there is an additional value from applying an innovation to both products.

[16] The related contribution of Motta and Peitz (2021) focuses mainly on the ex post acquisition and commercialization decisions of a resource-constrained entrant who has previously generated an innovation.

[17] Whereas the results of the two papers are similar, the central mechanisms differ. In Kamepalli et al. (2022), expectations of "techies" (potential early adopters of a new technology) drive the result. In Katz (2021), the key assumption is that potential entrants can choose innovation quality.

[18] They use these insights to investigate the effects of the acquisition option on innovation incentives and on the nature of the strategic interaction between firms. Gans et al. (2002) provide empirical support for the predictions.

incumbent's location. The prospect of an acquisition incentivizes the entrant to locate closer to the existing product, and hence to aim for a less radical and less uncertain innovation.[19]

Contrary to these papers with a new take on the issue of product differentiation, we emphasize differentiation in the innovation process, in the projects that firms apply to achieve a *given* innovation goal. More generally, compared with the existing literature, we focus on identifying market characteristics driving the size of the innovation effect and justifying intervention. On a related note, we show how the case for intervention differs between killer acquisitions and genuine acquisitions. Our emphasis on innovation portfolios allows us to analyze policy effects on project variety and duplication instead of merely on overall innovation efforts. Finally, to our knowledge, we are the first to provide a formal analysis of the innovation effects of a wide range of policies toward start-up acquisitions.

3. THE MODEL

We consider two variants of a multistage game, corresponding to a *laissez-faire policy (A)* which tolerates acquisitions and a *no-acquisition policy (N)*. In both cases, there is an incumbent ($i = I$) who owns a technology with which she can produce goods. In addition, she can invest in R&D. An entrant ($i = E$) has to invest in R&D before he can produce. Before providing the details, we start with an overview of the time structure.

(i) **Investment stage**: Firms simultaneously decide in which research projects to invest, thereby determining the probability of a (patentable) innovation, which can be drastic or nondrastic with exogenously given probability.
(ii) **Acquisition stage**: Under a *laissez-faire policy* firms negotiate an acquisition, which takes place if and only if it strictly increases total payoffs, and they negotiate the acquisition price. Under a *no-acquisition policy*, this stage is dropped.
(iii) **Commercialization stage**: The firm holding the patent (if any) decides whether to commercialize the technology.
(iv) **Market stage**: The incumbent and the entrant receive product market profits, which depend on whether there was an innovation, whether it was drastic or nondrastic and which firm has access to it. Total payoffs result after accounting for potential investment and commercialization costs and acquisition payments.

We now describe the stages in detail. In the *investment stage*, the firms choose in which research projects θ from a continuum $\Theta = [0, 1)$ to invest. If firm i invests in project θ, $r_i(\theta) = 1$. If it does not invest, $r_i(\theta) = 0$. We restrict the firms' choices to the set $\mathcal{R}$ of Lebesgue measurable functions $r : [0, 1) \to \{0, 1\}$. Only one project, $\hat{\theta} \in \Theta$, will result in an innovation (be the *correct* project). All other projects will lead to a dead end and produce no valuable output. Each project is equally likely to be correct. The investment cost of firm i is $\int_0^1 r_i(\theta)C(\theta)d\theta$, where the cost function $C : [0, 1) \to \mathbb{R}_+$ is continuous, differentiable, strictly increasing, convex, and such that $\lim_{\theta \to 1} C(\theta) = \infty$ and $C(0) = 0$.

With exogenously given probability $p < 1$, the correct project $\hat{\theta}$ results in a high technological state (H), corresponding to a drastic innovation compared to the incumbent's current technology.[20] Otherwise, $\hat{\theta}$ results in a low state L, corresponding to a nondrastic innova-

[19] Similar to Callander (2011) and Carnehl and Schneider (2023), the authors postulate a positive relation between distance and novelty of an innovation. Cabral (2018) derives a similar conclusion to Callander and Matouschek (2022) in a very different setting. In Wickelgren (2021), lenient acquisition policy encourages entrants to develop substitutes instead of complements to the incumbent's product. Motta and Shelegia (2021) identify a tendency for rivals to provide complements instead of substitutes to an incumbent's products to stay out of the kill zone (avoid being copied), but argue that the prospect of acquisitions works against this effect, pushing entrants toward developing substitutes.

[20] This is a variant of the standard assumption that the size of the profit effect of an innovation is not perfectly predictable given the R&D investment of a firm. In Section 8, we find that, when more costly projects are more likely to generate drastic innovations, similar results emerge.

tion, allowing the entrant to compete with the incumbent and obtain positive market profits. If a single firm discovers the innovation, it receives a patent. If both firms discover the innovation, the patent is allocated randomly with equal probability.[21] We assume that only the patent holder can use the new technology. Once the correct project has been realized, both firms learn the resulting technology level, summarized in the *interim technology states* $(t_I^{int}, t_E^{int}) \in \mathcal{T} := \{(\ell, 0), (\ell, L), (\ell, H), (L, 0), (H, 0)\}$, where ℓ corresponds to the incumbent's initial technology and 0 corresponds to the entrant's initial technology.[22]

In the second stage of the game under laissez-faire, the *acquisition stage*, the incumbent can acquire the entrant by paying the profits that the latter could obtain in the market plus a share of the (bargaining) surplus $\beta \in (0, 1)$. We will assume that the acquisition takes place if and only if the bargaining surplus is strictly positive. If the entrant is acquired, then any patent held by the entrant is transferred to the incumbent. In the third stage, the *commercialization stage*, the patent holder can bring the new technology to the market at commercialization cost $\kappa > 0$.[23] Thereafter, the *final technology states* $(t_I^{fin}, t_E^{fin}) \in \mathcal{T}$ result. Finally, in the *product market stage*, each firm $i \in \{I, E\}$ with technology t_i facing a competitor j with technology t_j, collects product market profits $\pi_i(t_i, t_j)$. We introduce the following assumptions:

Assumption 1 (Market profits).

(i) Profits are nonnegative: $\pi_i(t_i, t_j) \geq 0$ *for any* t_i *and* t_j. *Monopoly profits are strictly positive, that is,* $\pi_i(t_i, 0) > 0$ *for any* t_i.
(ii) Without an innovation, the entrant cannot compete: $\pi_E(0, t_I) = 0$ *for* $t_I \in \{\ell, L, H\}$.
(iii) Technology H corresponds to a drastic innovation and generates monopoly profit: $\pi(H) := \pi_E(H, \ell) = \pi_I(H, 0) > \max\{\pi_I(L, 0), \pi_I(\ell, 0)\}$ *and* $\pi_I(\ell, H) = 0$.
(iv) Competition decreases total profits: $\max\{\pi_I(L, 0), \pi_I(\ell, 0)\} > \pi_I(\ell, L) + \pi_E(L, \ell)$.

Assumption 1(ii) captures the fundamental asymmetry between incumbent and entrant. We allow profits to be firm-specific functions of technological states, except for drastic innovations, see Assumption 1(iii). Finally, Assumption 1(iv) ensures that the incumbent wishes to acquire the entrant at least sometimes. Assumption 1 is consistent with a wide range of interpretations, applying equally to process and product innovations. In the latter case, we do not rule out that an incumbent will produce her old product as well as the entrant's: One can simply interpret $\pi_I(L, 0)$ as corresponding to a multiproduct monopoly profit. Assumption 1(iv) is natural in this case as well, because a two-product monopolist can always imitate the pricing of differentiated duopolists and thus earn at least as much.

Assumption 2. *Commercialization costs satisfy*

$$(i) \qquad \pi_E(L, \ell) \geq \kappa;$$
$$(ii) \quad \pi(H) - \pi_I(\ell, 0) \geq \kappa.$$

Thus, even with the nondrastic innovation, the entrant's profit is at least as high as the commercialization cost. This avoids the case that the entrant is not viable on its own, and prohibiting acquisitions would not have any procompetitive effect. For the incumbent, the increase in the monopoly profit obtained by using the drastic innovation outweighs the commercialization cost. For the nondrastic innovation, this may or may not be the case. To distinguish between these two possibilities, we separate the parameter space into two regions:

[21] We consider asymmetric chances of receiving patents in Section 8.
[22] More technically, we assume that, simultaneously with the innovation decisions, there is a move of nature determining the correct project and whether the innovation is drastic or nondrastic.
[23] As we show in Section 8, none of our main insights depend on κ being equal for both firms.

DEFINITION 1. The LCC region is the part of the parameter space where $\kappa \leq \pi_I(L,0) - \pi_I(\ell,0)$. The HCC region is the part of the parameter space where $\pi_I(L,0) - \pi_I(\ell,0) < \kappa$.

Importantly, which of the conditions in the definition applies depends not only on commercialization costs, but also (through the profit terms) on the size of the innovation and on the intensity of competition.

We refer to the firms' continuation payoffs at the beginning of the acquisition stage, conditional on the realization of the interim states t_I^{int} and t_E^{int}, as their *values* $v_I(t_I^{int}, t_E^{int})$ and $v_E(t_E^{int}, t_I^{int})$, respectively. These values depend on the policy regime. They are independent of the competitor state if a firm's state is H; we thus simply write $v_I(H)$ and $v_E(H)$. The expected total payoff of the incumbent who chooses an investment function $r_I(\theta)$ when facing an entrant who chooses $r_E(\theta)$ is

$$\begin{aligned}\mathbb{E}\Pi_I(r_I, r_E) = \quad & -\int_0^1 r_I(\theta)C(\theta)d\theta + \int_0^1 r_I(\theta)(1-r_E(\theta))[pv_I(H) + (1-p)v_I(L,0)]d\theta \\ & + \int_0^1 (1-r_I(\theta))r_E(\theta)(1-p)v_I(\ell,L)d\theta + \int_0^1 (1-r_I(\theta))(1-r_E(\theta))v_I(\ell,0)d\theta \\ & + \int_0^1 r_I(\theta)r_E(\theta)\left[p\left(\frac{1}{2}v_I(H)\right) + (1-p)\left(\frac{1}{2}v_I(L,0) + \frac{1}{2}v_I(\ell,L)\right)\right]d\theta.\end{aligned}$$

The first integral captures the innovation costs of an incumbent with strategy r_I. The second integral represents the incumbent's continuation payoff when she discovers an innovation and the entrant does not, conversely for the third integral. The fourth integral represents the continuation payoff when neither firm innovates, and the fifth is for the case when both firms innovate. Similarly, for the entrant we obtain:

$$\begin{aligned}\mathbb{E}\Pi_E(r_E, r_I) = & -\int_0^1 r_E(\theta)C(\theta)d\theta + \int_0^1 r_E(\theta)(1-r_I(\theta))[pv_E(H) + (1-p)v_E(L,\ell)]d\theta \\ & + \int_0^1 r_E(\theta)r_I(\theta)\left[\frac{p}{2}v_E(H) + \frac{1-p}{2}v_E(L,\ell)\right]d\theta.\end{aligned}$$

For the investment stage, characterizing subgame-perfect equilibria amounts to finding functions $r_i, r_j \in \mathcal{R}$ such that $\mathbb{E}\Pi_i(r_i, r_j) \geq \mathbb{E}\Pi_i(r_i', r_j)$ for any $r_i' \in \mathcal{R}$.[24] However, because of the additively separable structure of the objective functions, the game can effectively be decomposed into a continuum of investment games, one for each project. Thus, for any project θ, to find the best-reply investment of firm i we only need to look at the other firm' investment decision $r_j(\theta)$ and we can ignore the investments of both firms in all other projects, which simplifies the equilibrium analysis significantly. Using this approach, we will show that the characterization of the equilibrium investment will rely on *critical projects* θ_{1E}, θ_{2E}, θ_{1I}, and θ_{2I}, which are defined implicitly by requiring that the expected cost of a critical project equals the expected future profit increase it generates:

$$\begin{aligned}C(\theta_{1E}) &= pv_E(H) + (1-p)v_E(L,\ell), \\ C(\theta_{2E}) &= \frac{1}{2}(pv_E(H) + (1-p)v_E(L,\ell)), \\ C(\theta_{1I}) &= pv_I(H) + (1-p)v_I(L,0) - v_I(\ell,0), \\ C(\theta_{2I}) &= \frac{p}{2}v_I(H) + (1-p)\left(\frac{1}{2}v_I(L,0) + \frac{1}{2}v_I(\ell,L)\right) - (1-p)v_I(\ell,L).\end{aligned}$$

[24] Obviously, for any equilibrium (r_I, r_E), any pair of functions $(\tilde{r}_I, \tilde{r}_E)$ which only differ from (r_I, r_E) on a set of measure zero is also an equilibrium. We omit the necessary "almost everywhere" qualifications from the statements of our formal results for ease of exposition.

The critical projects differ for incumbents and entrants and depend on whether the competitor is expected to invest in the same project or not. Accordingly, project θ_{1i} is defined by the requirement that its cost equals the expected value increase to firm i if it invests in the correct project when the other firm does not. Since project costs are increasing in θ, this implies that firm i would want to invest in any $\theta \in [0, \theta_{1i})$ for which it assumes that the competitor does not invest in, and it would not want to invest in any $\theta \in (\theta_{1i}, 1)$ in which it believes the competitor is not investing. Similarly, θ_{2i} is defined by the requirement that its cost equals the expected value increase to firm i if it invests in a correct project in which the other firm invests as well.

When evaluating the different policies, we are interested in the probability and duplication of innovation. Given any strategy profile (r_I, r_E), the *probability* $\mathcal{P}$ that at least one firm innovates is determined by the variety of research projects invested in.

$$\begin{aligned}\mathcal{P}(r_I, r_E) &= \textstyle\int_0^1 (r_I(\theta) + r_E(\theta) - r_I(\theta) r_E(\theta)) d\theta \\ &= \textstyle\int_0^1 \mathbf{1}(r_I(\theta) + r_E(\theta) > 0) d\theta.\end{aligned}$$

Duplication $\mathcal{D}$ is measured by the probability that both firms discover the innovation:

$$\mathcal{D}(r_I, r_E) = \int_0^1 r_I(\theta) r_E(\theta) d\theta.$$

Assumptions 1 and 2 will be maintained throughout the article. In addition, in the main text, we rely on the following condition for expository purposes:

Condition 1 (Condition for simpler exposition).

$$p(\pi(H) - \kappa) + (1-p)(\max\{\pi_I(L, 0) - \kappa, \pi_I(\ell, 0)\} + \pi_I(\ell, L)) \geq 2\pi_I(\ell, 0).$$

It is straightforward to show that Condition 1 holds and is compatible with Assumptions 1 and 2 for a wide range of parameters. For instance, this will be the case if monopoly profits with technology H or L are very large. We do not discuss the condition any further, as we will show in Online Appendix B.2 that we can do without it at the cost of additional complexity (see also the previous working paper version, Letina et al., 2021). Specifically, we will need to allow for richer strategy spaces that include different intensities of investment into each project. We will maintain Condition 1 until Section 8, where we summarize how it can be relaxed without affecting our main results.

4. Innovation outcomes under the laissez-faire policy

Before analyzing the equilibrium in the investment stage game, we begin by summarizing the result of the acquisition subgame.

Lemma 1 (Acquisitions). *Under laissez-faire, the incumbent acquires the entrant if and only if the latter holds a patent for technology L. Commercialization arises in any commercialization subgame, except in the HCC region if the incumbent holds the patent L.*

Intuitively, if the entrant owns technology L, an acquisition increases total profits by eliminating competition, but leaves profits unaffected otherwise. The incumbent's commercialization decision depends on the value of the nondrastic innovation. In the HCC region, commercialization is not worthwhile—eliminating competition is the only acquisition motive, resulting in a *killer acquisition*. In the LCC region, the incumbent commercializes and additionally benefits from a better technology, so that a *genuine acquisition* results.

Here and in the following, we will explicitly distinguish between laissez-faire policy and no-acquisition policy by adding superscripts A (for "acquisition") and N (for "no acquisition"), respectively, to the relevant values and functions. Using Lemma 1, we obtain firm values after the realization of innovation outcomes.

LEMMA 2 (VALUES). *Consider the laissez-faire policy:*

(i) The entrant's values after realization of the innovation outcomes are
$v_E^A(H) = \pi(H) - \kappa$
$v_E^A(L,\ell) = \pi_E(L,\ell) - \kappa + \beta\big(\max\{\pi_I(L,0) - \kappa, \pi_I(\ell,0)\} - \pi_E(L,\ell) - \pi_I(\ell,L) + \kappa\big)$
$v_E^A(0,t_I) = 0$ *for* $t_I \in \{\ell, L, H\}$.

(ii) The incumbent's values after realization of the innovation outcomes are
$v_I^A(H) = \pi(H) - \kappa,$
$v_I^A(L,0) = \max\{\pi_I(L,0) - \kappa, \pi_I(\ell,0)\},$
$v_I^A(\ell,L) = v_I(L,0) - v_E^A(L,\ell),$
$v_I^A(\ell,0) = \pi_I(\ell,0),$
$v_I^A(\ell,H) = 0.$

The values involving technology L require an explanation. After a nondrastic entrant innovation, $(t_I^{int}, t_E^{int}) = (\ell, L)$. The incumbent then acquires the entrant, so that $v_E^A(L,\ell)$ is the acquisition price (the sum of the entrant's stand-alone profit and his share of the surplus). $v_I^A(\ell,L)$ is the monopolist's stand-alone payoff, net of the acquisition price. Finally, the max-operators take into account the difference between the HCC and LCC regions. Using Lemma 2, we can now restrict the ordering of the critical projects, which is essential for the equilibrium properties.

LEMMA 3. *Under laissez-faire, the critical projects must satisfy (i) or (ii):*

(i) $\theta_{2I}^A = \theta_{2E}^A \le \theta_{1I}^A < \theta_{1E}^A$;
(ii) $\theta_{2I}^A = \theta_{2E}^A < \theta_{1E}^A \le \theta_{1I}^A$.

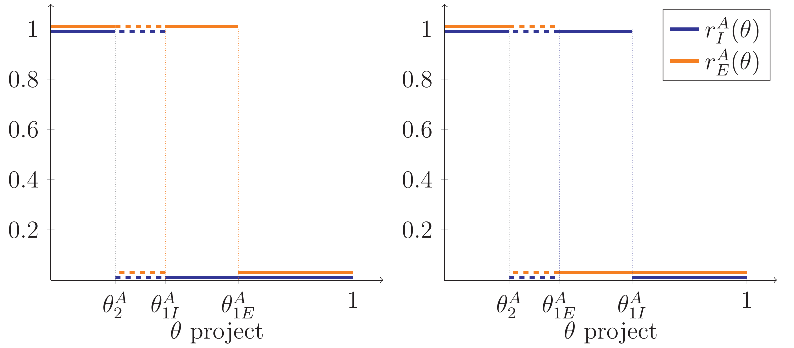
Relation (ii) cannot arise in the HCC case.

Lemma 3 reveals common properties of all equilibria. First, the projects which the incumbent is willing to duplicate (i.e., invest in if the entrant also does) are exactly those which the entrant is willing to duplicate as well; we thus write $\theta_2^A := \theta_{2I}^A = \theta_{2E}^A$.[25] Second, $\theta_{2E}^A < \theta_{1E}^A$, so that the entrant is always willing to invest in a larger range of projects if he is the sole innovator than if the incumbent also invests in these projects. Intuitively, the incumbent's investment reduces the entrant's probability of receiving a patent.[26]

There is a crucial difference between the HCC and LCC cases. Whereas both orderings can arise in the latter case, $\theta_{1I}^A < \theta_{1E}^A$ holds in the HCC region, so that case (ii) is impossible. Intuitively, conditional on the other firm not investing, the entrant is willing to invest in more expensive projects than the incumbent. This reflects the well-known Arrow replacement effect: An L innovation does not increase incumbent profits, and her profit increase from the H innovation is lower than the entrant's, since without the innovation the entrant receives zero profits. Hence, the entrant's willingness to pay to be the sole innovator is greater

[25] To understand why, note that if a project in which both firms invest delivers an H technology, both firms receive the same expected net payoff from investing, because not investing means losing the high innovation to the rival and receiving 0 for sure instead of obtaining the high monopoly profit with probability 1/2. If a project delivers an L technology instead, the entrant gains the acquisition price with probability 1/2 by investing, whereas the incumbent saves the acquisition price with probability 1/2 by investing. Thus, the expected benefits of investing (conditional on the other firm investing) are the same for entrants and incumbents.

[26] For the incumbent $\theta_{2I}^A \le \theta_{1I}^A$ is a result of Condition 1. As mentioned, it allows us to simplify the exposition of our results but is otherwise inconsequential.



NOTES: r_i^A is one if firm i invests and zero otherwise. The dashed lines represent the interval in which exactly one firm invests, but the identity of the investing firm is not determined.

FIGURE 1

EQUILIBRIUM PORTFOLIO OF ENTRANT AND INCUMBENT FOR THE TWO CASES OF LEMMA 3: CASE (I) IN THE LEFT, CASE (II) IN THE RIGHT PLOT

than the incumbent's. This will be important for our result that prohibiting acquisitions has a weakly negative effect on equilibrium investments. In the LCC region, the incumbent has additional investment incentives, as the commercialization of nondrastic innovations may increase monopoly profits. Thus, contrary to the HCC region, the incumbent's critical project θ_{1I}^A may lie above the entrant's critical project θ_{1E}^A in the LCC case, as in ordering (ii). We will identify the circumstances under which this occurs and discuss the implications of this observation after Proposition 3.

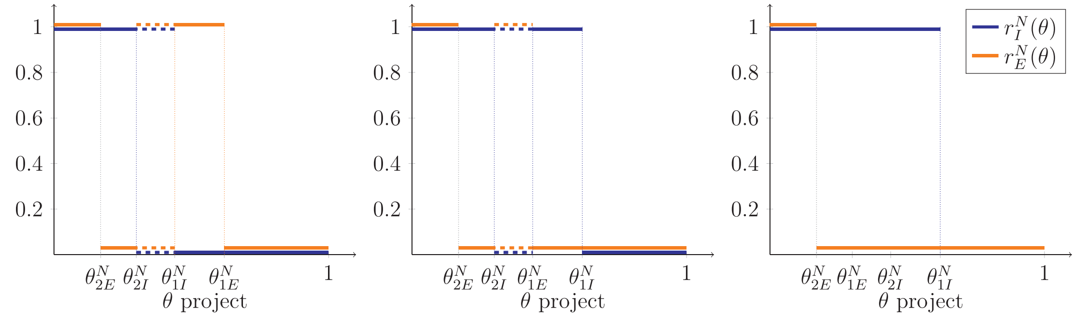
PROPOSITION 1 (EQUILIBRIUM INNOVATION OUTCOMES). *In any equilibrium under laissez-faire,*

(a) The probability of innovation is given by
  (i) $\mathcal{P}(r_I^A, r_E^A) = \theta_{1E}^A$ *if Lemma 3(i) applies.*
  (ii) $\mathcal{P}(r_I^A, r_E^A) = \theta_{1I}^A$ *if Lemma 3(ii) applies.*
(b) The duplication of innovation is given by $\mathcal{D}(r_I^A, r_E^A) = \theta_2^A$.

In Figure 1, we depict the equilibria arising for each potential ordering in Lemma 3. All equilibria have in common that both firms invest in all sufficiently cheap projects, $\theta \in [0, \theta_2^A]$, but neither firm invests in the most expensive projects, $\theta \in (\max\{\theta_{1E}^A, \theta_{1I}^A\}, 1)$. Moreover, for all projects θ in the interval $\theta \in (\theta_2^A, \min\{\theta_{1E}^A, \theta_{1I}^A\})]$, each firm only wants to invest if the other one does not, leading to multiple equilibria. In case (i), the entrant invests in the most expensive project pursued $\theta \in (\theta_{1I}^A, \theta_{1E}^A]$. In case (ii), roles are reversed and the incumbent invests in the most costly projects pursued $\theta \in (\theta_{1E}^A, \theta_{1I}^A]$. The probability of innovation is thus determined by the firm with the highest incentive to invest in new projects. At the same time, duplication incentives are the same for both firms and thus duplication is given by θ_2^A. Whereas (i) and (ii) are both possible in the LCC region, only (i) arises for HCC.

5. INNOVATION OUTCOMES UNDER THE NO-ACQUISITION POLICY

Firm behavior in the commercialization and market stages is unchanged if acquisitions are prohibited. In the acquisition stage, by Lemma 1, such a policy constrains behavior only when the entrant holds a patent for the nondrastic innovation. In this case, under the no-acquisition policy, $v_E^N(L, \ell) = \pi_E(L, \ell) - \kappa$ and $v_I^N(\ell, L) = \pi_I(\ell, L)$. All other values are as in Lemma 2, that is, $v_i^N(t_i^{int}, t_j^{int}) = v_i^A(t_i^{int}, t_j^{int})$ for $(t_i^{int}, t_j^{int}) \neq (L, \ell)$ or (ℓ, L). This results in new possible orderings of the critical projects under the no-acquisition policy.



NOTES: r_i^N is one if firm i invests and zero otherwise. The dashed lines represent the interval in which exactly one firm invests, but the identity of the investing firm is not determined.

FIGURE 2

EQUILIBRIUM PORTFOLIO OF ENTRANT AND INCUMBENT FOR THE THREE CASES OF LEMMA 4: CASE (I) IN THE LEFT, CASE (II) IN THE MIDDLE, AND CASE (III) IN THE RIGHT PLOT

LEMMA 4. *Under the no-acquisition policy, the critical projects have to satisfy* (*i*), (*ii*)*, or* (*iii*)*:*

(i) $\theta^N_{2E} < \theta^N_{2I} \leq \theta^N_{1I} < \theta^N_{1E}$;
(ii) $\theta^N_{2E} < \theta^N_{2I} \leq \theta^N_{1E} \leq \theta^N_{1I}$;
(iii) $\theta^N_{2E} < \theta^N_{1E} < \theta^N_{2I} \leq \theta^N_{1I}$.

Relations (*ii*) *and* (*iii*) *cannot arise in the HCC case.*

Whereas $\theta^A_{2E} = \theta^A_{2I}$ according to Lemma 3, we now have $\theta^N_{2E} < \theta^N_{2I}$, so that incentives to duplicate are always larger for the incumbent than for the entrant. Intuitively, investing in the same project as the entrant allows the incumbent to patent the nondrastic innovation instead of the entrant and thus avoid competition with positive probability. Moreover, by Assumption 1(iv), the incumbent's gain from avoiding competition is always larger than the entrant's profits when entering with a nondrastic innovation. Otherwise, the relations between critical projects are the same as under laissez-faire. This is also true for the ordering which holds only in HCC case, $\theta^N_{1I} < \theta^N_{1E}$, which implies that orderings (ii) and (iii) can only arise in the LCC region.

PROPOSITION 2 (EQUILIBRIUM INNOVATION OUTCOMES). *In any equilibrium under a no-acquisition policy:*

(a) The probability of innovation is given by
(i) $\mathcal{P}(r^N_I, r^N_E) = \theta^N_{1E}$ *if Lemma 4(i) applies.*
(ii) $\mathcal{P}(r^N_I, r^N_E) = \theta^N_{1I}$ *if Lemma 4(ii) or (iii) applies.*
(b) The duplication of innovation is given by $\mathcal{D}(r^N_I, r^N_E) = \theta^N_{2E}$.

Proposition 2 is a direct implication of the equilibrium R&D investments under a no-acquisition policy, which can be found in the proof in Appendix A.3.3. Again, in Figure 2, we depict equilibria arising in each potential ordering in Lemma 4. The equilibrium R&D investments have many similarities to those arising under laissez-faire. Again both firms invest in the cheapest projects, whereas no firms invests in the most expensive ones. However, the set of projects that both firms invest in is now determined by the entrant's duplication incentives. For all intermediate projects one firm invests, either the entrant or the incumbent. As with laissez-faire, in the HCC region, it will be the entrant who invests in the most costly projects, whereas the possibility that the incumbent pursues the most costly projects only arises in the LCC region.

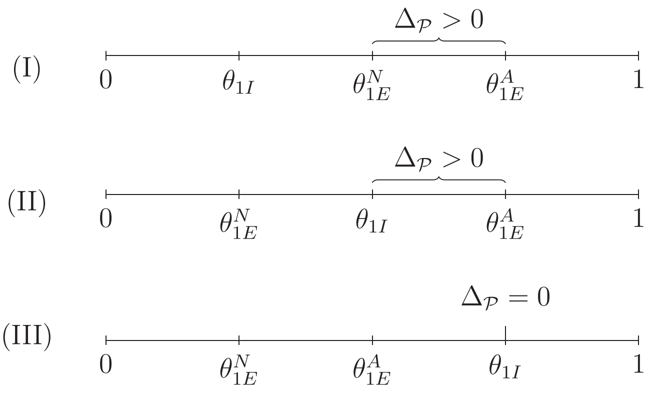


FIGURE 3

THE EFFECT OF PROHIBITING ACQUISITIONS ON INNOVATION PROBABILITY

6. LAISSEZ-FAIRE VERSUS PROHIBITING ACQUISITIONS

We now compare the lassez-faire approach with the no-acquisition policy. In Subsection 6.1, we show that prohibiting start-up acquisitions weakly reduces the equilibrium project variety and innovation probability. Subsection 6.2 analyzes how the size of this effect depends on the market environment. In Subsection 6.3, we discuss the effect of the policy on R&D duplication.

6.1. *The Effect on the Probability of Innovation.* Based on Propositions 1 and 2, the size of the policy effect on innovation probability is $\Delta_{\mathcal{P}} := \mathcal{P}^A - \mathcal{P}^N = \max\{\theta_{1E}^A, \theta_{1I}^A\} - \max\{\theta_{1E}^N, \theta_{1I}^N\}$. Our next result characterizes the sign of $\Delta_{\mathcal{P}}$.

PROPOSITION 3. *Consider the no-acquisition policy.*

(i) In any equilibrium, the probability of innovation is weakly smaller than in any equilibrium under laissez-faire.
(ii) The policy has no effect on the innovation probability in the LCC region if $\theta_{1E}^A \leq \theta_{1I}^A$. Otherwise, the effect is strictly negative.

Proposition 3 shows that restricting acquisitions never increases the probability of innovation. However, (ii) highlights a crucial difference between the LCC and HCC regions. The policy effect is strictly negative in the latter case, but not necessarily in the former. This reflects two simple observations. First, $\theta_{1E}^N < \theta_{1E}^A$: Prohibiting acquisitions reduces the entrant's expected payoff from R&D investments, since he cannot sell the firm. Second, $\theta_{1I}^A = \theta_{1I}^N =: \theta_{1I}$: If the entrant does not invest in the correct project, there is no reason to acquire him, so that the policy does not affect θ_{1I}. Only three possible orderings for θ_{1I} and the entrant's critical projects θ_{1E}^A and θ_{1E}^N are compatible with these two observations:

(I) $\theta_{1I} < \theta_{1E}^N < \theta_{1E}^A$
(II) $\theta_{1E}^N \leq \theta_{1I} < \theta_{1E}^A$
(III) $\theta_{1E}^N < \theta_{1E}^A \leq \theta_{1I}$.

When (I) or (II) applies, θ_{1E}^A, which reflects the entrant's incentives, determines the equilibrium innovation probability under laissez-faire. A ban on acquisitions weakens these incentives and therefore reduces the innovation probability to θ_{1E}^N under ordering (I) or to θ_{1I} under (II). Figures 3(I) and (II) illustrate these two cases, respectively. When (III) applies, θ_{1I} determines the equilibrium innovation probability in both policy regimes. Hence, as illustrated in Figure 3(III), a prohibition of acquisitions has no effect. Importantly, ordering

(III) only applies in the LCC region, which implies that the policy effect is strict in the HCC case.

Proposition 3(ii) gives a condition under which a prohibition of acquisitions has no innovation effect at all, coinciding with case (ii) in Lemma 3 (depicted as case (III) in Figure 3).[27] Note that $\theta_{1I} \geq \theta_{1E}^A$ if and only if $(1-p)v_I^A(L,0) - v_I^A(\ell,0) \geq (1-p)v_E^A(L,\ell)$. Proposition A.2 expresses this condition in terms of fundamentals. We find that a necessary condition for the absence of an innovation effect is that $\pi_I(L,0) - \pi_I(\ell,0) \geq \pi_E(L,\ell)$, so that a nondrastic innovation would increase incumbent monopoly profits by a large amount, whereas the entrant's profit under duopoly competition has to be relatively low (competition is intense or biased against the entrant). We also show that, once this profit condition holds, the innovation effect will be zero if commercialization costs κ, the entrant's bargaining power β, and the probability p of a drastic innovation are sufficiently low.

6.2. *The Size of the Effect on Innovation Probability.* As an input into our subsequent policy discussion, we analyze how the market environment determines the size of the innovation-reducing effect of restricting acquisitions, focusing on the region where orderings (I) and (II) apply, so that the effect is nonzero.

PROPOSITION 4. *Suppose that $\theta_{1I} < \theta_{1E}^A$. Consider any equilibrium under a laissez-faire policy (r_I^A, r_E^A) and any equilibrium under the no-acquisition policy (r_I^N, r_E^N). The size of the policy effect $\Delta_{\mathcal{P}}$ is*

- *(i) strictly increasing in entrant bargaining power β;*
- *(ii) strictly decreasing in the incumbent's profits under competition $\pi_I(\ell, L)$; and*
- *(iii) strictly decreasing in the entrant's profits under competition $\pi_E(L,\ell)$ if $\theta_{1I} < \theta_{1E}^N$, but strictly increasing if $\theta_{1E}^N < \theta_{1I}$.*

This result shows under which circumstances the innovation effect is important. To understand it, recall that in both policy regimes the variety of research projects is determined by the most expensive project any firm is willing to invest in, so that, for $\theta_{1I} < \theta_{1E}^A$, $\Delta_{\mathcal{P}} = \theta_{1E}^A - \max\{\theta_{1E}^N, \theta_{1I}\}$. Thus, the effect of a parameter on the loss of innovation probability is equivalent to its effect on the difference between these critical projects.

An increase in the entrant's bargaining power β increases his payoff after an acquisition and thus θ_{1E}^A.[28] The change neither affects θ_{1E}^N (since acquisitions are not allowed) nor θ_{1I} (since there is no acquisition if the entrant does not innovate). Combining these observations, an increase in β strictly increases $\Delta_{\mathcal{P}}$. Next, an increase in the incumbent's profits under competition $\pi_I(\ell, L)$ neither affects θ_{1E}^N nor θ_{1I}, but it reduces the acquisition surplus and therefore decreases θ_{1E}^A. The overall effect is a strict reduction in $\Delta_{\mathcal{P}}$. Finally, the effect of an increase in the entrant's duopoly profit $\pi_E(L,\ell)$ is more subtle, because $\pi_E(L,\ell)$ increases both θ_{1E}^A and θ_{1E}^N, but the increase is greater for θ_{1E}^N.

To summarize, Proposition 4 shows how the loss of variety depends on bargaining power and the intensity of potential competition as captured by duopoly profits. This result is a useful ingredient in the policy analysis, as it identifies circumstances in which competition authorities can implement a more restrictive acquisition policy without substantial negative effects on innovation. However, this does not mean that interventions are necessarily more desirable in those circumstances, as the positive procompetitive effect may also be smaller. We provide a more detailed policy discussion in Section 9.

[27] An alternative, and much more evident, condition would be $\beta = 0$, as then the entrant does not gain from being acquired. We have excluded this possibility by assuming $\beta > 0$ to show that, even with the entry-for-buyout logic, the innovation effect may be zero under certain conditions.

[28] Although we do not model the sources of bargaining power explicitly, the analysis of Gans and Stern (2000) suggests that it could, for instance reflect intellectual property rights.

6.3. *The Effect on Duplication.* The acquisition policy not only affects variety and thereby the probability of innovation, but also the duplication of innovation. Based on Propositions 1 and 2, the policy effect on duplication is $\Delta_{\mathcal{D}} := \mathcal{D}^A - \mathcal{D}^N = \theta_2^A - \theta_{2E}^N$.

PROPOSITION 5. *Consider the no-acquisition policy. In any equilibrium, the duplication of innovation is strictly smaller than in any equilibrium under laissez-faire.*

Proposition 5 shows that a restrictive acquisition policy always leads to a reduction in duplication of innovation in equilibrium. Equilibrium duplication is determined solely by the entrant's incentive to duplicate. To understand this, consider the no-acquisition policy. Here, the entrant's incentives to duplicate are always below the incumbent's, $\theta_{2E}^N < \theta_{2I}^N$ (see Lemma 4). Under the no-acquisition policy, for projects above the entrant's critical project θ_{2E}^N, it is never optimal for the entrant to invest if the incumbent invests, so the fact that the incumbent's incentives are larger than under laissez-faire does not affect duplication. Thus, the proposition will be true if $\theta_{2E}^N < \theta_{2E}^A$, which is always the case. Ultimately, a ban on acquisitions always has a strictly negative effect on the entrant's incentive to duplicate, because a ban eliminates the prospective gains from selling the firm.

The negative effect of prohibiting acquisitions on equilibrium duplication prevails despite an increase in the incumbent's incentive to duplicate. Intuitively, if the entrant invests in a project, the incumbent gains more from duplicating it under a no-acquisition policy than under laissez-faire: Without the acquisition option, own investments that duplicate the entrant's research are the only means of preventing competitive entry.

By investigating R&D portfolios instead of just total R&D efforts, we can distinguish between innovation investments for duplicative projects and new projects. The assumption that the incumbent can patent her innovation makes acquisitions and innovations substitutes for the incumbent. Thus, prohibiting acquisitions increases incumbent R&D effort in a model with one-dimensional effort choice, but the above analysis shows that this increase is driven exclusively by duplication incentives which do not necessarily translate into an increase in innovation investment. As the example in the introduction shows, a model with a one-dimensional effort choice cannot capture such strategic project choices.

7. ALTERNATIVE POLICIES

Preventing incumbents from acquiring start-ups who produce close substitutes can potentially foster competition, but it may hurt innovation. The above analysis suggests that there are circumstances in which it is beneficial to intervene, but translating these circumstances into criteria which are readily applicable for competition authorities is nontrivial. In the following, we therefore analyze alternative policies that are not contingent on details of the environment, but nevertheless not as crude as outright prohibitions, as their intensity can be adjusted to societal preferences. Even though the effects of these policies differ in detail, they share the common attractive feature that they only prevent acquisitions of entrants who would obtain relatively high stand-alone profits, suggesting they would be viable competitors. Moreover, four of the five policies lead to innovation outcomes that are between those under laissez-faire and a no-acquisition policy, respectively.

7.1. *Behavioral Remedies.* Instead of prohibiting acquisitions completely, competition agencies often impose remedies on the acquiring firm. We consider two possible approaches. The first approach only affects genuine acquisitions (in the LCC region) and has no effect on killer acquisitions (in the HCC region), whereas the second approach only has a bearing on killer acquisitions.

7.1.1. *Restrictions on technology usage.* A behavioral remedy could inhibit the use of the start-up's technology by the incumbent. For instance, the EU only accepted *Google*'s recent acquisition of *Fitbit* conditional on licensing requirements and limitations on data usage. Although the reasons for picking this specific remedy were most likely orthogonal to what we discuss here,[29] restricting technology usage presumably has adverse profit effects on the acquiring firm when the acquisition is genuine. To capture this, we assume that the incumbent's market profit after an acquisition and commercialization of technology L is $\rho\pi_I(L,0)$ where $\rho \in [0,1)$. Lower ρ implies more stringent remedies, with $\rho = 1$ corresponding to a laissez-faire policy. The remedy only affects business operations that are related to the acquired technology, so that the incumbent can use her existing technology ℓ without restrictions, securing herself a post-acquisition market profit of at least $\pi_I(\ell,0)$ independently of ρ. If the incumbent discovers technology L herself, there is no reduction in market profits, as remedies are only imposed in case of an acquisition. Denote with θ_{ki}^{ρ} the critical value $k \in \{1,2\}$ of firm i when the remedy is $\rho \in [0,1)$. We now characterize the effects of imposing such a remedy.

PROPOSITION 6 (RESTRICTIONS ON TECHNOLOGY USAGE). *In the HCC region, restrictions on technology usage do not affect critical values. In the LCC region,*

(i) If $\pi_I(\ell,0) \leq \pi_E(L,\ell) - \kappa + \pi_I(\ell,L)$ and $\rho \leq \frac{\pi_E(L,\ell)+\pi_I(\ell,L)}{\pi_I(L,0)}$, then all critical values are identical to those under a prohibition and the incumbent never acquires the entrant.

(ii) Otherwise, the critical values lie between those with laissez-faire and prohibition of acquisitions and the incumbent acquires the entrant with an L innovation. If $\pi_I(\ell,0) > \pi_E(L,\ell) - \kappa + \pi_I(\ell,L)$ and $\rho \leq \frac{\pi_I(\ell,0)+\kappa}{\pi_I(L,0)}$, then, in contrast to the case without remedies, the incumbent does not commercialize the innovation after acquisitions.

Part (i) shows that strong remedies prevent genuine acquisitions of entrants with high stand-alone profits. For entrants with low stand-alone profits (ii), the remedy leads to innovation strategies that are between those under prohibition and those under laissez-faire. Apart from not addressing killer acquisitions, remedies have another negative effect: They turn some genuine acquisitions into killer acquisitions when the incumbent's benefit from commercializing technology L is not too much larger than κ, so that, with the remedies, commercializing technology L is no longer worthwhile.

7.1.2. *Prohibition of "killing".* Alternatively, competition policy could prevent incumbents from shutting down acquired entrants.[30] Such a remedy would cause the incumbent to forgo some acquisitions that she would otherwise pursue. Our next result characterizes the innovation effect of this policy; we use θ_{ki}^{PK} for the critical values when killing is prohibited.

PROPOSITION 7 (PROHIBITION OF "KILLING"). *In the LCC region, prohibition of killing has no effect. In the HCC region,*

(i) If $\pi_I(L,0) - \pi_I(\ell,L) \leq \pi_E(L,\ell)$, then all critical values are identical to those under a prohibition, and the incumbent never acquires the entrant.

(ii) Otherwise, the critical values lie between those with laissez-faire and prohibition of acquisitions. The incumbent acquires the entrant with the L innovation, but, in contrast with the case without remedies, commercializes the innovation.

When the policy has an innovation effect, it resembles the previous remedy: It prevents acquisitions of entrants with high stand-alone profits (i), and, for entrants with low stand-alone

[29] In the case at hand, the EU was concerned with the network effects generated by a data monopoly.

[30] In practice, this would require competition authorities to conduct ex post reviews to evaluate whether shutting down would constitute a monopolization/abuse of dominance offence. Although not common, this is sometimes done. For instance, after *Mallinckrodt*'s subsidiary *Questcor* acquired the rights for Synacthen from *Novartis*, the FTC successfully took the firm to court for anticompetitive behavior, which was manifest in excessive prices (https://www.ftc.gov/system/files/documents/cases/170118mallinckrodt_complaint_public.pdf). For a broader discussion of conceivable policy responses, see OECD (2020).

profits, it leads to innovation strategies between those under prohibition and those under laissez-faire (ii). Clearly, (killer) acquisitions that are not prevented are turned into genuine acquisitions, which may be the primary intention behind such a policy.

7.2. *Fiscal Policies.* The goal of inducing start-ups to compete with instead of sell out to the incumbent could be achieved by fiscal policies, as suggested by Lemley and McCreary (2021), who group such policies into "sticks" and "carrots." "Sticks" reduce the profitability of acquisitions, whereas "carrots" aim at increasing the profitability of market entry for start-ups. We consider one specific policy of each type and show that, even though these policies may affect *acquisition incentives* in a similar way, there are important differences in *ex ante innovation effects*.

7.2.1. *Taxing acquisitions and prohibiting high-price acquisitions.* One specific "stick" affecting the relative profitability of acquisitions and market entry is an acquisition tax τ. Since the tax reduces the available bargaining surplus, the acquisition price (on which the tax is paid) adjusts endogenously. Starting from a pre-tax value $\bar{B} = \max\{\pi_I(L,0) - \kappa, \pi_I(\ell,0)\} - \pi_E(L,\ell) - \pi_I(\ell,L) + \kappa$, the bargaining surplus falls to some B^τ as a result of the tax. Since the entrant receives β share of the bargaining surplus, then the acquisition price is given by $\pi_E(L,\ell) - \kappa + \beta B^\tau$. The post-tax surplus B^τ is equal to the pre-tax surplus $\bar{B}$ minus the tax paid, or $B^\tau = \bar{B} - \tau(\pi_E(L,\ell) - \kappa + \beta B^\tau)$, from which we can express B^τ in terms of the primitives. Using this expression for B^τ, we show how the critical values θ^τ_{ki} under a tax τ depend on the characteristics of the start-up and the market environment:

PROPOSITION 8 (TAXING ACQUISITIONS).

(i) If $\tau \geq \frac{\bar{B}}{\pi_E(L,\ell)-\kappa}$, then all critical values are identical to those under a prohibition, and the incumbent never acquires the entrant.
(ii) If $0 < \tau < \frac{\bar{B}}{\pi_E(L,\ell)-\kappa}$ then the critical values lie between those under the laissez-faire and the no-acquisition policy, and the incumbent acquires the entrant with the L innovation.

Intuitively, (i) the tax is equivalent to a prohibition of acquisitions if it is so high that even at the minimal acceptable acquisition price (which is equal to the entrant's outside option), the tax bill would be higher than the bargaining surplus. This happens when $\pi_E(L,\ell) - \kappa$, the entrant's profit net of commercialization cost, is high. By contrast (ii), for lower taxes acquisitions of entrants with technology L still take place. The firms' innovation strategies are affected in the same direction, but not to the same extent as under a prohibition of acquisitions. Therefore, compared with a prohibition, a tax results in a smaller negative innovation effect for entrants with low stand-alone profits, but it only prevents acquisitions of entrants with high stand-alone profits.

A very similar logic applies when considering a ban on acquisitions above a certain transaction price, as suggested by Fumagalli et al. (2023). Such a policy would lead to a prohibition if the maximum price allowed is below the entrant's outside option, that is, his stand-alone profit. As long as this maximal transaction price is above the entrant's outside option, the acquisition goes through. However, when it is below the acquisition price under laissez-faire, the entrant can skim less of the bargaining surplus.[31] Still, compared to a full prohibition, a ban on acquisitions with high transaction prices will also result in a smaller negative innovation effect. In contrast to the acquisition tax, however, the incumbent, instead of the public, pockets

[31] Since this policy directly affects the feasible distributions of the bargaining surplus, different bargaining protocols would result in different final acquisition prices. We opt for the acquisition price which is closest to the division of the bargaining surplus which would have realized in the absence of the maximum transaction price policy. Alternatively, the final acquisition price could lie anywhere between the entrant's outside option and the maximum allowed transaction price. This would lead to results which are qualitatively similar, but innovation incentives of the entrant would generally be even lower.

the difference between the acquisition price with and without the policy. An advantage of using a threshold on the transaction price relative to an acquisition tax is that the former is more transparent about which acquisitions are effectively banned. The formal statement of our results can be found in Proposition B.1 in Online Appendix B.1.4.

7.2.2. *Increasing profitability of IPOs.* As an alternative to acquisition taxes, Lemley and McCreary (2021) suggest "carrot" policies to make IPOs more attractive, such as lower taxes on IPO gains or a quicker and more straightforward IPO process.[32] We operationalize such policies by supposing that the net profit of the entrant is given by $\eta\pi_E(H)$ and $\eta\pi_E(L,\ell)$, where $\eta = 1$ represents the status quo and $\eta > 1$ represents the preferential IPO policy. For $i \in \{I, E\}$ and $k \in \{1, 2\}$, denote the critical value when the IPO policy is $\eta > 1$ with θ_{ki}^{η}. The following result shows the effect of such a policy.

PROPOSITION 9 (INCREASING PROFITABILITY OF IPOS). *Consider an IPO policy ($\eta > 1$).*

(i) The incumbent acquires the entrant with the L innovation if and only if $\eta < \dfrac{\bar{B} + \pi_E(L,\ell)}{\pi_E(L,\ell)}$.
(ii) All critical values lie weakly above those under the laissez-faire policy.

According to (i), similarly to an acquisition tax and behavioral remedies, a preferential IPO treatment would prevent acquisitions of entrants with high stand-alone profits. By (ii), policies that increase the profitability of IPOs would increase the entrant's incentives to invest in both variety and duplication of R&D. This is not surprising, as more profitable IPOs increase the entrant's payoffs no matter whether an acquisition takes place or not. A more subtle effect of preferential IPO treatment is that it increases the incumbent's incentive to duplicate R&D projects, because higher entrant payoffs increase the acquisition costs. Since the entrant's duplication incentives increase as well, preferential IPO treatment would unambiguously increase research duplication.

8. ROBUSTNESS

Dropping Condition 1. Condition 1 is equivalent to $\theta_{2I}^{N} \leq \theta_{1I}^{N}$. An important implication of this condition is that the incumbent's incentive to invest into new projects is always larger than her incentive to invest into duplicate projects. Thus, it eliminates the possibility of project intervals where the incumbent would like to invest if the entrant does, but would not like to invest if the entrant does not. If such an interval exists and is in a range where the entrant only wants to invest if the incumbent does not, an equilibrium with binary investment decisions in pure strategies does not exist. In Online Appendix B.2, we list the main results in an alternative model where we circumvent this problem by allowing for continuous investment decisions. There, firms can not only choose in which projects to invest, but also how much to invest, that is, $r_j(\theta) \in [0, 1]$. Because such a modified model leads to complex equilibria with intermediate investment choices, the probability of innovation is not perfectly pinned down by project variety anymore. Nonetheless, both concepts are closely related, so that most results still go through. The only caveat is that, for duplication (Proposition 5), Condition 1 is not entirely without loss of generality. Here, equilibria with intermediate project choice may result in an increase in duplication as a result of a ban on acquisitions. Statements of the formal results that do not rely on Condition 1 can be found in Online Appendix B.2. Since Condition 1 is not necessary for our next results, we drop it in the remainder of the article.

[32] Companies already try to avoid the complicated IPO process by merging with blank-cheque companies known as Spacs. The number of such deals has exploded in 2020 and 2021 to potentially worrying levels. For example, see "Spac boom eclipses 2020 fundraising record in single quarter," O. Aliaj and A. Kasumov, *Financial Times*, March 17, 2021 (https://www.ft.com/content/321400c1-9c4d-40ac-b464-3a64c1c4ca80).

Monotone Relationship between θ and p. Costly projects may be more innovative and thus yield a drastic innovation with higher probability. Our results are robust to such heterogeneity. We now suppose the probability of a drastic innovation $p(\theta)$ is an increasing function of θ, $p : [0, 1) \to [0, 1)$, which is continuous, differentiable, and concave. Keeping all remaining assumptions as in the main model, Proposition B.2 in Online Appendix B.3.1 establishes that prohibiting acquisitions still reduces innovation probability. Although the effects refer to *any* innovation, the fact that, as before, banning acquisitions induces entrants to stop investing in the most expensive projects in their portfolio gives the result an interesting twist: The policy reduces drastic innovations relatively more than nondrastic innovations. Hence, in addition to reducing the overall innovation probability, banning acquisitions changes the direction of the remaining projects away from drastic innovation.

Uncertainty at the Time of Acquisition. In our model, before entering acquisition negotiations, both firms know whether the innovation is drastic or not. In practice, this may be difficult: Extensive testing may be necessary to identify cost savings or quality improvements. We show that the effects of prohibiting an acquisition remain similar if the technology level of an innovation is uncertain at the time of the acquisition. We maintain the setting of Section 3, but assume that only the correct project is revealed at the end of the investment stage, not its technology level. Thus, interim technology states $(t_I^{int}, t_E^{int}) \in \{(0, 0), (0, 1), (1, 0)\}$ are realized, where 1 indicates that the firm received a patent and 0 indicates that it did not. After the acquisition stage, the technology of the correct project is realized as L or H. Thereafter, firms decide on commercialization, before the final technology states $(t_I^{fin}, t_E^{fin}) \in \mathcal{T}$ are realized. Everything else remains as before. Proposition B.3 in Online Appendix B.3.2 shows that, irrespective of the policy regime, uncertainty does not affect equilibrium investments and thus does not change the policy effect. However, uncertainty does influence the frequency of acquisitions. The incumbent will acquire the entrant irrespective of the technology level of the latter's innovation because the expected surplus at the time is positive, since it is a convex combination of a positive acquisition surplus with technology L and no-acquisition surplus with technology H.

Asymmetric Chances of Receiving Patents. We show that the variety of pursued investment projects is invariant to the assumption that firms are equally likely to receive the patent after simultaneous discovery. Let the probability of receiving the patent be $\alpha_I \in (0, 1)$ for the incumbent and $(1 - \alpha_I)$ for the entrant.[33] Proposition B.4 in Online Appendix B.3.3 shows that, regardless of α_I, banning acquisitions weakly reduces the innovation probability. Furthermore, the size of the policy effect is independent of α_I. Therefore, the results on the relation between parameters and the size of the policy effect identified in Proposition 4 are also robust to changes in α_I. This holds because α_I matters only when both firms discover an innovation. Thus, it affects duplication incentives, but not the incentives to invest in projects in which the competitor is not investing. Since variety is given by $\max\{\theta_{1E}, \theta_{1I}\}$, it is not affected by α_I in either policy regime, so that the size of the policy effect does not depend on α_I.

Heterogeneous Commercialization Costs. Due to a better infrastructure or a more developed sales network, the incumbent might be able to commercialize the innovation at a lower cost κ_I than the entrant (κ_E). Adjusting Assumption 2, we suppose $\pi_E(L, \ell) \geq \kappa_E$ and $\pi(H) - \pi_I(\ell, 0) \geq \kappa_I$. We focus on the HCC region, so that $\pi_I(L, 0) - \pi_I(\ell, 0) < \kappa_I$. We add the innocuous assumption that $\pi_E(L, \ell) \leq \pi_I(L, 0)$, requiring that, with an L-technology, the monopolist would obtain market profits at least as high as the entrant would from competing against technology ℓ.[34] Proposition B.5 in Online Appendix B.3.4 shows that banning

[33] The main model corresponds to $\alpha_I = 1/2$.

[34] We do not rely on this natural assumption in the main model, which is why we only add it here.

acquisitions reduces the innovation probability. A prohibition of acquisitions now results in an additional inefficiency, as it forces the entrant to commercialize the H-technology using the cost κ_E instead of letting the incumbent commercialize it at the lower cost κ_I.

Licensing of Innovation. Suppose now that a firm with the better technology can sign a licensing contract with the other firm, which allows the other firm to also use the superior technology. Such a contract could in principle be complex, and could include a fixed-fee component, a per-unit royalty payment, an ad valorem royalty payment, or some combination of all three. Which contract the firms eventually sign will depend on the legal and informational environment, which determine what contracts can be enforced. We capture the richness of licensing environments by modeling the profits following licensing negotiations in reduced form. We maintain the assumption that competition decreases joint profits even when licensing is possible. In Online Appendix B.3.5, we show that licensing can only occur (but does not have to occur) if the entrant discovers the innovation L. Otherwise, there is always a potential monopolist, who would only expose herself to competition by entering into a licensing agreement. Moreover, if Assumptions 1 and 2 hold for the market profits in the game without licensing, they also hold for the (modified) market profits in the game with licensing. Thus, our analysis can be directly applied to the game with licensing and qualitatively the insights remain unchanged.

Multiple Entrants. We now sketch why the effects of a restrictive acquisition policy on innovation should not change substantially with multiple entrants, without going into details of equilibrium existence and characterization. We focus on the HCC region, assuming there are two entrants. Compared with the main model, the analysis changes mainly because firms need to consider that two competitors might invest in some project, which reduces the probability of obtaining a patent. To capture the willingness to invest in such projects, we define critical projects θ_{3i} in a similar way as θ_{1i} and θ_{2i}. Clearly, $\theta_{3i} < \theta_{2i}$, reflecting the lower probability of obtaining a patent when three instead of two firms invest. Crucially, the number of entrants does not affect θ_{1i} and θ_{2i}. Therefore, the highest critical value is still θ_{1E}, no matter which policy regime applies. Moreover, in any equilibrium, for any project $\theta \leq \theta_{1E}$ at least one firm invests a positive amount. Thus, as in the main model, the entrants' critical projects determine variety. Therefore, the policy effect on variety remains the same with multiple entrants as with a single entrant.

Continuum of Technological States. The main effects of our model with two possible innovation outcomes, L or H would be present in a more complex model with a continuum of technological states. Without a formal analysis, we provide an outline of an argument that shows why this is the case. Suppose that the set of possible technological states was given by $\mathbb{R}_+$, where a higher value $t \in \mathbb{R}_+$ represented a better technology, where the likelihood that a successful innovation results in a technology $t \in \mathbb{R}_+$ is given by a density function $p()$. Assuming further that $\pi_i(t_i, t_j)$ is a continuous function and adjusting Assumptions 1 and 2(ii) where needed, we would find cutoff values $\underline{L}$ (the lowest technology that the entrant would commercialize), $\underline{\ell}$ (the lowest technology that the incumbent would commercialize) and $\underline{H}$ (the lowest drastic technology).

While it is natural to assume that $\underline{H} > \underline{L}$ and $\underline{H} > \underline{\ell}$, the ordering of $\underline{L}$ and $\underline{\ell}$ is ex ante unclear. If $\underline{L} < \underline{\ell}$, then the space of possible technological states would be divided into four regions. For $t \in (0, \underline{L})$, the innovation is of such a low value that the entrant would not be feasible on its own, and the incumbent would not have an incentive to acquire it. The behavior in any subgame after an innovation $t > \underline{L}$ follows directly from our analysis: in the interval $(\underline{L}, \underline{\ell})$, it corresponds to the HCC case, in the interval $(\underline{\ell}, \underline{H})$ to the LCC case, and any innovation $t > \underline{H}$ corresponds to a drastic innovation. The overall effects of restrictive policies toward acquisitions would depend on the density p, but would be qualitatively similar to the effect we find in the main model.

One effect that our main model does not capture would occur if the ordering was $\underline{\ell} < \underline{L} < \underline{H}$. In this case, killer acquisitions never happen. Instead, for any innovation $t \in (\underline{\ell}, \underline{L})$, the entrant would not be viable on its own, yet the incumbent would be willing to acquire the entrant and to commercialize the technology. For this ordering, a restrictive policy would have an additional negative effect—when the entrant discovers a technology $t \in (\underline{\ell}, \underline{L})$, the entrant would fail and that innovation would not be commercialized, which would have been the case following an acquisition.

9. POLICY DISCUSSION

Merger analysis usually weighs potential efficiency gains against the reduction in competition. In this section, we focus on the trade-off between ex post competition and ex ante innovation effects instead, while acknowledging that other merger efficiencies may also exist. Though we did not make the effects of competition on consumer surplus explicit in the above analysis, we will base the following discussion on the innocuous assumption that, for any fixed technology level, consumers benefit from entry.[35]

We start by noting that the trade-off is absent in some situations. Aside from the trivial case that the procompetitive arguments for a prohibition are absent if the incumbent is needed to commercialize the innovation (ruled out by Assumption 2), we identified the more interesting possibility that a prohibition has no adverse innovation effects. As discussed at the end of Subsection 6.1, a necessary condition for a zero innovation effect is that a nondrastic innovation would result in a large increase of the incumbent's monopoly profit, whereas the entrant's duopoly profit is low (competition is intense or biased against the entrant). This condition appears plausible in an industry where the incumbent benefits from network effects, making it hard for the entrant to stand on his own feet. Once this profit condition holds, the innovation effect will be zero if commercialization costs, the entrant's bargaining power and the probability of a drastic innovation are sufficiently low. Then, the anticompetitive effect of an acquisition suffices to justify an intervention. Even when the prohibition of acquisitions impedes innovations, this is not always detrimental to consumers: In the HCC case (HCC and low effects of the innovation on monopoly profits), if the chances of a drastic innovation are negligible ($p = 0$), any innovation in the laissez-faire case would be nondrastic and would therefore never reach the market. Prohibiting acquisitions is thus justified.[36]

When there is an innovation effect, the trade-off depends on policy objectives and the market environment in a subtle way. Proposition 4 illustrates the conditions influencing the size of the innovation effect. For instance, it implies that a reduction in the entrant's bargaining power reduces the innovation effect of a prohibition. As it has no effect on the standard procompetitive effect, prohibiting innovations is unambiguously more likely to increase consumer surplus when β is low. Furthermore, in the HCC region, an exogenous reduction in the entrant's duopoly profits $\pi_E(L, \ell)$ increases the size of the adverse innovation effect. However, low entrant profits may reflect more intense competitive interaction between the firms and therefore a higher consumer surplus relative to the monopoly case. Thus, the gains from maintaining competition might also be particularly high in this case. In Online Appendix B.4, we discuss these trade-offs in more detail, using standard differentiated Bertrand and Cournot models. The analysis suggests that, from a consumer perspective, the net gains from prohibiting acquisitions (competition effects minus innovation effects) tend to become smaller as the entrant's bargaining power and the intensity of competition (as captured by the degree of substitution) increase; however only in the Cournot example do they ever become negative.

[35] See Subsection B.4 for a precise formalization of this assumption.

[36] Such losses do, however, potentially arise if $p > 0$: Then, by reducing the entrant's variety of projects, prohibiting the acquisition reduces the chances of occasionally obtaining a breakthrough innovation in this case.

One might therefore conclude that competition authorities should intervene selectively, depending on market characteristics. However, doing so would require precise information, which the agencies might lack. Some of the alternative policies discussed in Section 7 might be advantageous in this respect. Importantly, these policies would prevent acquisitions only in those circumstances when an entrant would earn substantial stand-alone profits, suggesting that he would be a viable competitor. There are pitfalls, however. Remedies that limit the profits that an incumbent can obtain by using the entrant's technology are potentially problematic as they do not address the problem of killer acquisitions and, in some cases, even transform genuine acquisitions into killer acquisitions. Conversely, prohibiting the "killing" turns killer into genuine acquisitions, but similarly decreases innovation incentives and may be difficult to enforce. A more promising approach would be an acquisition tax, which would be easier to implement than prohibiting "killing" while still preventing acquisitions of entrants with high stand-alone value. Another promising policy would be to increase profitability of IPOs, perhaps through lower taxes on IPO profits. Unlike other policies we discussed, this would increase incentives to innovate.[37] Finally, a combination of policies (e.g., a tax on acquisitions and a lower tax on IPO profits) could result in a better outcome than any single policy. Our model provides a framework for the analysis of such combined policies.

Obviously, this policy discussion is limited by the assumptions of our framework. For example, we have not treated the possibility that there are multiple incumbents, which could lead to the possibility that firms acquire entrants to avoid that competitors have access to their technology. Furthermore, our analysis does not directly apply to the interesting case where an incumbent in one market acquires a start-up that has recently entered a related market which the incumbent cannot serve with her existing technology. Moreover, our approach focuses on the short-run policy effects. In the long term, instead of merely killing a potential entrant, the incumbent can combine the knowledge of the two firms to expand its technological lead, which is likely to make entry ever more difficult. It would be interesting to analyze how incumbents and potential entrants target their innovation activities when entry can take place repeatedly and the incumbent's technology improves as a result of acquisitions. Is increasing dominance of the incumbent an inevitable outcome? Will the innovation process eventually slow down because it becomes too hard for entrants to compete? Although these questions are beyond the scope of the current article, our analysis suggests that to answer them it would be expedient to take the policy effects on project choice into account, instead of only the effects on the overall innovation level.

10. CONCLUSION

Recently, there has been a heated debate on the policy toward start-up acquisitions, with particular emphasis on innovation effects. Motivated by this discussion, we provide a theory of the strategic choice of innovation projects by incumbents and start-ups which allows for endogenous acquisition and commercialization decisions. We use this framework for a policy analysis. We first find that prohibiting start-up acquisitions weakly reduces the variety of research projects pursued and thereby the probability of discovering innovations, and that it may induce the incumbent to strategically duplicate the entrant's projects to prevent competition. However, our analysis shows that the negative innovation effect of prohibiting acquisitions may well be absent for innovations with high commercialization potential. Even for less attractive innovations that the incumbent would not want to commercialize, the adverse innovation effects may be negligible, for instance, if the entrant has low bargaining power and the incumbent's duopoly profits are high, so that the competition-enhancing effect of prohibiting acquisitions is likely to dominate in this case. However, an approach that conditions on details of the market environment is arguably impractical, as it imposes heavy informational requirements on competition authorities. Our analysis suggests that a useful alternative might be to

[37] Of course, a possible cost of such a policy is that it leads to lower tax revenues.

rely on policies that weaken the incentives for acquisitions, while leaving the details to the market. Suitable remedies, acquisition taxes and preferable treatments of IPOs would make sure that acquisitions only arise in marginal cases where the entrant would not be very strong on its own.

APPENDIX A

A.1. *Proof of Lemma 1 (Acquisition Subgame).* Consider first the commercialization subgame. The entrant commercializes a technology if the payoff from doing so is at least zero. Since $\pi_E(L,\ell) \geq \kappa$ by Assumption 2(i) and $\pi(H) \geq \kappa$ by Assumptions 1(i) and 2(ii), the entrant commercializes both technologies. The incumbent commercializes a technology if the payoff of doing so is at least $\pi_I(\ell, 0)$. Since $\pi(H) - \kappa \geq \pi_I(\ell, 0)$ by Assumption 2(ii), the incumbent always commercializes the H technology. The incumbent commercializes the L technology if and only if $\pi_I(L, 0) - \pi_I(\ell, 0) \geq \kappa$.

Now consider the acquisitions subgame. There are three possible cases. Either the entrant holds no patent, or he holds the H patent or the L patent. We will examine the three cases in turn. First, suppose that the entrant holds no patent. Then, since the entrant cannot compete without an innovation, the incumbent's profits are the same with or without the acquisition. Thus, the incumbent has no reason to acquire the entrant. Second, suppose the entrant holds a patent on the H technology. Without an acquisition, the entrant commercializes the technology and obtains the payoff $\pi(H) - \kappa$ whereas the incumbent obtains $\pi_I(\ell, H) = 0$. With the acquisition, the incumbent commercializes the technology and obtains the payoff $\pi(H) - \kappa$. Thus, the total payoffs are equal with or without the acquisition. Since the acquisition (by assumption) only goes through if the total payoffs strictly increase, the incumbent does not acquire the entrant. Third, consider the case when the entrant has a patent for the L technology. If there is no acquisition, the entrant commercializes the technology and obtains payoffs $\pi_E(L,\ell) - \kappa$, whereas the incumbent's payoffs are $\pi_I(\ell, L)$. If the incumbent acquires the entrant and commercializes the technology, she obtains $\pi_I(L, 0) - \kappa$, whereas without commercialization she obtains $\pi_I(\ell, 0)$. Thus she will choose to commercialize only if $\pi_I(L, 0) - \kappa \geq \pi_I(\ell, 0)$. The incumbent's payoff is $\max\{\pi_I(L, 0) - \kappa, \pi_I(\ell, 0)\}$, whereas the entrant obtains a payoff of zero. Consequently, the acquisition surplus is positive if and only if $\max\{\pi_I(L, 0) - \kappa, \pi_I(\ell, 0)\} > \pi_E(L,\ell) + \pi_I(\ell, L) - \kappa$. We can add κ to both sides of the inequality and use Assumption 1(iv) to show that this inequality indeed holds:

$$\max\{\pi_I(L, 0), \pi_I(\ell, 0) + \kappa\} \geq \max\{\pi_I(L, 0), \pi_I(\ell, 0)\} > \pi_E(L,\ell) + \pi_I(\ell, L).$$

A.2. *Proofs of the Order of Critical Projects (Lemmas 3 and 4).*

A.2.1. *Proof of Lemma 3.* The result will follow immediately from Steps 1 and 2 below.
Step 1: (a) $\theta^A_{2I} = \theta^A_{2E}$, *(b)* $\theta^A_{2E} < \theta^A_{1E}$, *and (c)* $\theta^A_{2I} \leq \theta^A_{1I}$.

(a) To prove this statement, note that $v^A_I(H) = v^A_E(H)$. Thus,

$$C(\theta^A_{2I}) = \frac{1}{2}\left[pv^A_E(H) + (1-p)\left(v^A_I(L,0) - v^A_I(\ell, L)\right)\right]$$
$$= \frac{1}{2}\left[pv^A_E(H) + (1-p)v^A_E(L,\ell)\right] = C(\theta^A_{2E}).$$

(b) Since $C(\theta^A_{2E}) < C(\theta^A_{1E})$, part (b) of Step 1 follows immediately.
(c) $\theta^A_{2I} \leq \theta^A_{1I}$ if and only if $C(\theta^A_{2I}) \leq C(\theta^A_{1I})$ or equivalently

$$\frac{1}{2}\left[pv^A_I(H) + (1-p)\left(v^A_I(L,0) - v^A_I(\ell, L)\right)\right] \leq pv^A_I(H) + (1-p)v^A_I(L,0) - v^A_I(\ell, 0) \Leftrightarrow$$

$$2v_I^A(\ell,0) - (1-p)v_I^A(L,0) - pv_I^A(H,0) \leq (1-p)v_I^A(\ell,L).$$

Note that Condition 1 can be rewritten as:

$$2v_I^A(\ell,0) - (1-p)v_I^A(L,0) - pv_I^A(H,0) \leq (1-p)\pi_I(\ell,L).$$

Moreover, Assumption 1(iv) implies that $v_I^A(\ell,L) \geq \pi_I(\ell,L)$. Therefore, the result follows.

Step 2: *In the HCC case, only $\theta_{1I}^A < \theta_{1E}^A$ is possible.*

To see this, note that in the HCC case, $\max\{\pi_I(L,0)-\kappa, \pi_I(\ell,0)\} = \pi_I(\ell,0)$ has to hold, so that $v_I^A(L,0) = v_I^A(\ell,0)$. Then, $\theta_{1I}^A < \theta_{1E}^A$ if and only if $C(\theta_{1I}^A) < C(\theta_{1E}^A)$ or equivalently

$$\begin{aligned} pv_I^A(H) + (1-p)v_I^A(L,0) - v_I^A(\ell,0) &< pv_E^A(H) + (1-p)v_E^A(L,\ell) \Leftrightarrow \\ -pv_I^A(\ell,0) &< (1-p)v_E^A(L,\ell), \end{aligned}$$

which always holds.

A.2.2. *Proof of Lemma 4.* Step 1 shows that the critical projects have to satisfy orderings (i), (ii), or (iii) and Step 2 shows that (ii) or (iii) cannot arise in the HCC case.

Step 1: (a) $\theta_{2E}^N < \theta_{2I}^N$, *(b) $\theta_{2E}^N < \theta_{1E}^N$, and (c) $\theta_{2I}^N \leq \theta_{1I}^N$.*

(a) Note that $v_E^N(H) = v_I^N(H)$. $\theta_{2E}^N < \theta_{2I}^N$ holds if and only if $C(\theta_{2E}^N) < C(\theta_{2I}^N)$ or equivalently

$$\begin{aligned} v_E^N(L,\ell) &< v_I^N(L,0) - v_I^N(\ell,L) \Leftrightarrow \\ \pi_E(L,\ell) - \kappa &< \max\{\pi_I(\ell,0), \pi_I(L,0)-\kappa\} - \pi_I(\ell,L), \end{aligned}$$

which is satisfied by Assumption 1(iv).

(b) Since $C(\theta_{2E}^N) < C(\theta_{1E}^N)$, it follows immediately that $\theta_{2E}^N < \theta_{1E}^N$.

(c) $\theta_{2I}^N \leq \theta_{1I}^N$ if and only if:

$$\begin{aligned} C(\theta_{2I}^N) &\leq C(\theta_{1I}^N) \Leftrightarrow \\ \frac{1}{2}\left[pv_I^N(H) + (1-p)\big(v_I^N(L,0) - v_I^N(\ell,L)\big)\right] &\leq pv_I^N(H) + (1-p)v_I^N(L,0) - v_I^N(\ell,0) \Leftrightarrow \\ 2v_I^N(\ell,0) - v_I^N(L,0) - v_I^N(\ell,L) &\leq p\big(v_I^N(H) - v_I^N(L,0) - v_I^N(\ell,L)\big), \end{aligned}$$

which is equivalent to Condition 1.

Step 2: *In the HCC case, only $\theta_{1I}^N < \theta_{1E}^N$ is possible.* The proof is the same as Step 2 in the proof of Lemma 3.

A.3. *Proofs of Innovation Outcomes (Propositions 1 and 2).* Propositions 1 and 2 are implications of the equilibrium R&D investments under laissez-faire and the no-acquisition policy, respectively. We first prove a general equilibrium characterization result for each conceivable constellation of critical projects (Proposition A.1). The proofs of Propositions 1 and 2 in Subsections A.3.2 and A.3.3 are straightforward implications of Proposition A.1.

A.3.1. *General characterization result.* Our equilibrium characterizations (Lemmas A.2 and A.3) rely on the following result:

PROPOSITION A.1. *Any equilibrium under laissez-faire or the no-acquisition policy must satisfy (a)–(e) below. If (a)–(e) all hold, the investment functions $r_E(\theta)$ and $r_I(\theta)$ can be sustained as an equilibrium.*

(a) $r_E(\theta) = 1$ *and* $r_I(\theta) = 1$ *whenever* $\theta \in [0, \theta_{2E}]$
(b) $r_E(\theta) = 0$ *and* $r_I(\theta) = 0$ *whenever* $\theta \in (\max\{\theta_{1I}, \theta_{1E}\}, 1)$
(c) $r_E(\theta) = 1$ *and* $r_I(\theta) = 0$ *whenever* $\theta \in (\theta_{1I}, \theta_{1E}]$
(d) $r_E(\theta) = 1$ *and* $r_I(\theta) = 0$*, or* $r_E(\theta) = 0$ *and* $r_I(\theta) = 1$ *whenever* $\theta \in (\theta_{2I}, \min\{\theta_{1I}, \theta_{1E}\}]$
(e) The equilibrium satisfies $r_E(\theta) = 0$ *and* $r_I(\theta) = 1$ *in all other cases.*

In the proof of Proposition A.1, we will require the following immediate implication of Lemmas 3 and 4.

LEMMA A.1. *Irrespective of policy, the following relations hold:*

(i) $\theta_{1E} > \theta_{2E}$
(ii) $\theta_{2I} \geq \theta_{2E}$
(iii) $\theta_{2I} \leq \theta_{1I}$.

PROOF.

(a) Projects in this interval are (weakly) profitable for the entrant irrespective of the behavior of the incumbent since $\theta \leq \theta_{2E} < \theta_{1E}$ by Lemma A.1(i). Given that the entrant invests, investing is also profitable for the incumbent, as $\theta \leq \theta_{2I}$ by Lemma A.1(ii). Consequently, investment behavior on this interval is consistent with an equilibrium if and only if $r_E(\theta) = 1$ and $r_I(\theta) = 1$.
(b) Projects in this interval are never profitable for the entrant irrespective of the behavior of the incumbent since $\theta_{2E} < \theta_{1E} < \theta$ by Lemma A.1(i). As the entrant does not invest, investment is not profitable for the incumbent as $\theta > \theta_{1I}$.
(c) In this interval, it is a unique best response of the incumbent not to invest irrespective of the investment of the entrant. Therefore, using $\theta \leq \theta_{1E}$, it is always a unique best response of the entrant to choose $r_I(\theta) = 1$.
(d) Projects in this interval are only profitable if the rival firm does not invest. Hence, it is straightforward that only one firm invests in equilibrium. This may be either the entrant or the incumbent.
(e) In (a)–(d), we have shown that, if θ lies in the given interval for each of the cases, we arrive at the respective equilibrium behavior for project θ.
We now show that in all remaining cases one of the following must hold:

(i) $\theta \in (\theta_{2E}, \theta_{2I}]$
(ii) $\theta \in (\max\{\theta_{2I}, \theta_{1E}\}, \theta_{1I}]$.

All equilibria satisfy (a) and (b), but which ones of the remaining cases apply in the interval $(\theta_{2E}, \max\{\theta_{1I}, \theta_{1E}\}$ depends on the exact order of critical projects. We will thus consider cases (c) and (d) and show that, if there are still intervals not covered, they fall into at least one of the listed cases.

Assuming case (c) occurs, we need to characterize the possible constellations in the interval $(\theta_{2E}, \theta_{1I}]$. $(\theta_{2I}, \theta_{1I}]$ corresponds to case (d). Thus, we are left with the interval $(\theta_{2E}, \theta_{2I}]$, which is case (i) above.

Assuming case (d) occurs, we need to characterize the possible constellations in the intervals $(\theta_{2E}, \theta_{2I}]$ and $(\min\{\theta_{1I}, \theta_{1E}\}, (\max\{\theta_{1I}, \theta_{1E}\}]$. For the second interval, if $\theta_{1I} < \theta_{1E}$, we are in case (c) and if $\theta_{1I} \geq \theta_{1E}$, we are in case (ii) above. $(\theta_{2E}, \theta_{2I}]$ corresponds to case (i) above.

Cases (c) and (d) require $\theta_{2I} \leq \theta_{1E}$. Assuming that $\theta_{2I} > \theta_{1E}$ implies that neither (c) or (d) occurs. Cases (i) and (ii) above therefore cover the whole interval $(\theta_{2E}, \theta_{1I}]$.

Having established that we identified the remaining cases, we can use arguments that are standard by now to show that efforts in each of those cases are consistent with equilibrium behavior if and only if $r_E(\theta) = 0$ and $r_I(\theta) = 1$. □

A.3.2. *Proof of Proposition 1.* According to Lemma 3, in the laissez-faire regime one of the following constellations applies:

$$\text{(i) } \theta_2^A < \theta_{1I}^A < \theta_{1E}^A; \qquad \text{(ii) } \theta_2^A < \theta_{1E}^A \leq \theta_{1I}^A.$$

Applying Proposition A.1 to each constellation gives the following result:

Lemma A.2 (Equilibrium R&D investment). *In any equilibrium under laissez-faire,*

$$\begin{aligned} &(A)\ \ r_E(\theta) = 1 && \textit{and } r_I(\theta) = 1 \textit{ for } \theta \in [0, \theta_2^A], \\ &(B)\ \ r_E(\theta) = 0 && \textit{and } r_I(\theta) = 0 \textit{ for } \theta \in (\max\{\theta_{1E}^A, \theta_{1I}^A\}, 1), \\ &(C)\ \ r_E(\theta) = 1 \ \textit{ and } r_I(\theta) = 0, \textit{ or } r_E(\theta) = 0 && \textit{and } r_I(\theta) = 1 \textit{ for } \theta \in (\theta_2^A, \min\{\theta_{1E}^A, \theta_{1I}^A\}]. \end{aligned}$$

(i) If $\theta_2^A < \theta_{1I}^A < \theta_{1E}^A$, a strategy profile is an equilibrium if and only if it satisfies (A), (B), and (C), and $r_E(\theta) = 1$ and $r_I(\theta) = 0$ for $\theta \in (\theta_{1I}^A, \theta_{1E}^A]$.
(ii) If $\theta_2^A < \theta_{1E}^A \leq \theta_{1I}^A$, a strategy profile is an equilibrium if and only if it satisfies (A), (B), and (C), and $r_E(\theta) = 0$ and $r_I(\theta) = 1$ for $\theta \in (\theta_{1E}^A, \theta_{1I}^A]$.

In the constellation of Lemma A.2(i), $r_I(\theta) + r_E(\theta) = 0$ if and only if $\theta \in (\theta_{1E}^A, 1)$. Hence, $\mathcal{P} = \theta_{1E}^A$. In the constellation of Lemma A.2(ii), $r_I(\theta) + r_E(\theta) = 0$ if and only if $\theta \in (\theta_{1I}^A, 1)$. Hence, $\mathcal{P} = \theta_{1I}^A$. Moreover, both in cases (i) and (ii), $r_I(\theta) + r_E(\theta) = 2$ if and only if $\theta \in [0, \theta_2^A]$. Hence, $\mathcal{D} = \theta_2^A$.

A.3.3. *Proof of Proposition 2.* According to Lemma 4, under the no-acquisition policy one of the following three constellations applies:

$$\text{(i) } \theta_{2E}^N < \theta_{2I}^N \leq \theta_{1I}^N < \theta_{1E}^N; \qquad \text{(ii) } \theta_{2E}^N < \theta_{2I}^N \leq \theta_{1E}^N \leq \theta_{1I}^N; \qquad \text{(iii) } \theta_{2E}^N < \theta_{1E}^N < \theta_{2I}^N \leq \theta_{1I}^N.$$

Applying Proposition A.1 to each constellation gives the following result:

Lemma A.3 (Equilibrium R&D investment). *In any equilibrium under a no-acquisition policy,*

$$\begin{aligned} &(A)\ \ r_E(\theta) = 1 && \textit{and } r_I(\theta) = 1 \textit{ for } \theta \in [0, \theta_{2E}^N], \\ &(B)\ \ r_E(\theta) = 0 && \textit{and } r_I(\theta) = 0 \textit{ for } \theta \in (\max\{\theta_{1I}^N, \theta_{1E}^N\}, 1). \end{aligned}$$

(i) If $\theta_{2E}^N < \theta_{2I}^N \leq \theta_{1I}^N < \theta_{1E}^N$, a strategy profile is an equilibrium if and only if, in addition to (A) and (B), the following conditions hold:
(a) $r_E(\theta) = 0$ and $r_I(\theta) = 1$ for $\theta \in (\theta_{2E}^N, \theta_{2I}^N]$,
(b) $r_E(\theta) = 1$ and $r_I(\theta) = 0$ for $\theta \in (\theta_{1I}^N, \theta_{1E}^N]$,
(c) $r_E(\theta) = 1$ and $r_I(\theta) = 0$, or $r_E(\theta) = 0$ and $r_I(\theta) = 1$ for $\theta \in (\theta_{2I}^N, \theta_{1I}^N]$.
(ii) If $\theta_{2E}^N < \theta_{2I}^N \leq \theta_{1E}^N \leq \theta_{1I}^N$, a strategy profile is an equilibrium if and only if, in addition to (A) and (B), the following conditions hold:
(a) $r_E(\theta) = 0$ and $r_I(\theta) = 1$ for $\theta \in (\theta_{2E}^N, \theta_{2I}^N]$,

(b) $r_E(\theta) = 0$ *and* $r_I(\theta) = 1$ *for* $\theta \in (\theta_{1E}^N, \theta_{1I}^N]$,
(c) $r_E(\theta) = 1$ *and* $r_I(\theta) = 0$, *or* $r_E(\theta) = 0$ *and* $r_I(\theta) = 1$ *for* $\theta \in (\theta_{2I}^N, \theta_{1E}^N]$.

(iii) If $\theta_{2E}^N < \theta_{1E}^N \leq \theta_{2I}^N \leq \theta_{1I}^N$, *a strategy profile is an equilibrium if and only if it satisfies (A), (B) and* $r_E(\theta) = 0$ *and* $r_I(\theta) = 1$, *for* $\theta \in (\theta_{2E}^N, \theta_{1I}^N]$.

In the constellation of Lemma A.3(i), $r_I(\theta) + r_E(\theta) = 0$ if and only if $\theta \in (\theta_{1E}^N, 1)$. Hence, $\mathcal{P} = \theta_{1E}^N$. In the constellation of Lemma A.3(ii) and (iii), $r_I(\theta) + r_E(\theta) = 0$ if and only if $\theta \in (\theta_{1I}^N, 1)$. Hence, $\mathcal{P} = \theta_{1I}^N$. Moreover, both in cases (i), (ii), and (iii), $r_I(\theta) + r_E(\theta) = 2$ if and only if $\theta \in [0, \theta_{2E}^N]$. Hence, $\mathcal{D} = \theta_{2E}^N$.

A.4. *The Effects of Prohibiting Acquisitions.* This section contains details on the effects of prohibiting acquisitions, with the proofs of the results of Section 6.

A.4.1. *Proof of Proposition 3.* The result follows from Steps 1–4.

Step 1: $\theta_{1I}^A = \theta_{1I}^N$. To show this, it is sufficient that $C(\theta_{1I}^A) = C(\theta_{1I}^N)$, or equivalently

$$pv_I^A(H) + (1-p)v_I^A(L,0) - v_I^A(\ell,0) = pv_I^N(H) + (1-p)v_I^N(L,0) - v_I^N(\ell,0).$$

This holds since $v_I^A(t,0) = v_I^N(t,0)$ for all $t \in \{\ell, L, H\}$.

Step 2: $\theta_{1E}^N < \theta_{1E}^A$. To show this, it is sufficient that $C(\theta_{1E}^N) < C(\theta_{1E}^A)$. The claim requires that

$$pv_E^N(H) + (1-p)v_E^N(L,\ell) < pv_E^A(H) + (1-p)v_E^A(L,\ell).$$

This holds because

$$p(\pi(H) - \kappa) + (1-p)(\pi_E(L,\ell) - \kappa) < p(\pi(H) - \kappa) + (1-p)v_E^A(L,\ell) \Leftrightarrow$$
$$\pi_E(L,\ell) - \kappa < \beta(\max\{\pi_I(L,0) - \kappa, \pi_I(\ell,0)\} - \pi_I(\ell,L)) + (1-\beta)(\pi_E(L,\ell) - \kappa) \Leftrightarrow$$
$$\pi_E(L,\ell) - \kappa < \max\{\pi_I(L,0) - \kappa, \pi_I(\ell,0)\} - \pi_I(\ell,L),$$

where simple algebra leads to the last inequality, which holds by Assumption 1(iv).

Step 3: *If* $\theta_{1E}^A > \theta_{1I}^A$, *then* $\mathcal{P}^A > \mathcal{P}^N$. Since $\theta_{1E}^A > \theta_{1E}^N$ by Step 2 and $\theta_{1I}^A = \theta_{1I}^N$ by Step 1, we obtain $\theta_{1E}^A > \max\{\theta_{1E}^N, \theta_{1I}^N\}$. Hence, $\mathcal{P}^A > \mathcal{P}^N$.

Step 4: *If* $\theta_{1E}^A \leq \theta_{1I}^A$, *then* $\mathcal{P}^A = \mathcal{P}^N$. If $\theta_{1E}^A \leq \theta_{1I}^A$, then by Steps 1 and 2, $\theta_{1E}^N < \theta_{1I}^N$. Then, $\mathcal{P}^A = \theta_{1I}^A = \theta_{1I}^N = \mathcal{P}^N$.

A.4.2. *Conditions for the absence of an innovation effect.* We now present and prove the result mentioned in Subsection 6.2 which gives conditions under which the innovation effect is zero. Note that we slightly stretch our assumptions on the parameter spaces here: We formally refer to cases where κ, β, or p take on boundary values. However, we think of these cases as the respective parameters being “arbitrarily close to” the boundary value. This helps us to avoid excessive notational burden.

Proposition A.2. *(i) Suppose* $\Pi = (\pi_I(L,0), \pi_I(\ell,0), \pi_I(\ell,L), \pi_E(L,\ell), \pi(H))$ *satisfies Assumption 1. Then, there exists a vector* $(\kappa, p, \beta) \in \mathbb{R}^+ \times [0,1] \times [0,1]$ *such that (a)* (Π, κ) *is consistent with Assumption 2 and (b) the innovation effect is zero if and only if the following condition holds:*

$$\pi_I(L,0) - \pi_I(\ell,0) \geq \pi_E(L,\ell). \tag{A.1}$$

(ii) If (A.1) holds and $\pi_I(\ell,L) < \pi_I(\ell,0)$, *there exists a* $\widehat{p} \in [0,1)$ *and* $\widehat{\beta} \in [0,1)$ *and a weakly decreasing function* $P(\beta)$:$[0,\widehat{\beta}] \to [0,1]$ *with* $P(0) = \widehat{p}$ *and* $P(\widehat{\beta}) = 0$ *such that the innovation*

effect is zero for any (κ, p, β) *such that Assumption 2 holds and*

$$\begin{aligned} \pi_I(L,0) - \pi_I(\ell,0) &\geq \kappa \\ 0 &\leq \beta \leq \widehat{\beta} \\ 0 \leq p &\leq P(\beta). \end{aligned} \tag{A.2}$$

Proof. We will first show that the requirements of consistency with Assumption 2 and absence of an innovation effect are easiest to fulfill if $(\kappa, p, \beta) = (0, 0, 0)$. In other words, if, for fixed vector Π the requirements hold for any $(\kappa, p, \beta) \in \mathbb{R}^+ \times [0, 1] \times [0, 1]$, they hold for $(\kappa, p, \beta) = (0, 0, 0)$. To see this, first note that Assumption 2 requires that

$$\begin{aligned} \pi_E(L,\ell) &\geq \kappa \text{ and} \\ \pi(H) - \pi_I(\ell,0) &\geq \kappa, \end{aligned} \tag{A.3}$$

so that it is easiest to satisfy for $\kappa = 0$. Next, the condition under which there is no innovation effect is that there is commercialization,

$$\pi_I(L,0) - \pi_I(\ell,0) \geq \kappa, \tag{A.4}$$

and

$$(1-p)v_I(L,0) - v_I(\ell,0) \geq (1-p)v_E^N(L,\ell). \tag{A.5}$$

Substituting expressions from Lemma 2 and rearranging, (A.5) can be expressed as

$$(1-p)[(1-\beta)(\pi_I(L,0) - \pi_E(L,\ell)) + \beta\pi_I(\ell,L)] \geq \pi_I(\ell,0). \tag{A.6}$$

To fulfill the commercialization condition (A.4) at least for $\kappa = 0$, Π must satisfy $\pi_I(L,0) \geq \pi_I(\ell,0)$. Then, Assumption 1(iv) implies

$$\pi_I(L,0) - \pi_E(L,\ell) - \pi_I(\ell,L) > 0. \tag{A.7}$$

Thus, the LHS in (A.6) is strictly decreasing in β for $p < 1$. (A.7) implies that $\pi_I(L,0) - \pi_E(L,\ell) > 0$. By Assumption 1(i), $\pi_I(\ell,L) \geq 0$. Therefore, the square bracket in (A.6) is positive and the LHS is decreasing in p as long as $\beta < 1$. Thus, (A.6) is easiest to fulfill if $p = 0$ and $\beta = 0$. All told, therefore, if (A.3),(A.6), and (A.7) hold for any $(\kappa, p, \beta) \in \mathbb{R}^+ \times [0, 1) \times [0, 1]$, they hold for $(\kappa, p, \beta) = (0, 0, 0)$.

Thus, there is no innovation effect for any $(\kappa, p, \beta) \in \mathbb{R}^+ \times [0, 1) \times [0, 1]$ such that Assumption 2 hold if and only if Π satisfies the following four conditions:

$$\begin{aligned} \pi_I(L,0) - \pi_I(\ell,0) &\geq \pi_E(L,\ell), \\ \pi_I(L,0) - \pi_I(\ell,0) &\geq 0, \\ \pi_E(L,\ell) &\geq 0, \\ \pi(H) - \pi_I(\ell,0) &\geq 0. \end{aligned} \tag{A.8}$$

In particular, therefore Condition (A.1) in Proposition A.2 holds. This proves the "only if"-part of (i) of Proposition A.2.

As to the "if"-part, note that $\pi_E(L,\ell) \geq 0$ by Assumption 1(i). Thus, the first three conditions of (A.8) reduce to $\pi_I(L,0) - \pi_I(\ell,0) \geq \pi_E(L,\ell)$. Assumption 1 further implies that this condition implies $\pi(H) - \pi_I(\ell,0) \geq 0$. Hence, the four conditions in (A.8) are fulfilled if

(A.1) holds. Under these conditions, Π and $(\kappa, \beta, p) = (0, 0, 0)$ jointly satisfy all requirements for the absence of an innovation effect. This completes the proof of Proposition A.2.

(ii) Part (i) has already shown that (A.4) and (A.6) both hold for Π and $(\kappa, p, \beta) = (0, 0, 0)$ if Π satisfies (A.1). Next, (A.6) is violated for $(p, \beta) = (0, 1)$: It simplifies to $\pi_I(\ell, L) \geq \pi_I(\ell, 0)$. Similarly, (A.6) is violated for $(p, \beta) = (1, 0)$: It reduces to $0 \geq \pi_I(\ell, 0)$, which is inconsistent with the positivity of monopoly profits (Assumption 1(i)).

Finally, as argued above, by Assumption 1, the LHS of (A.6) is decreasing and continuous in β and in p. Thus, by the intermediate value theorem there exist $\widehat{p}$ and $\widehat{\beta}$ such that (A.6) holds with equality for $(\widehat{p}, 0)$ and $(0, \widehat{\beta})$ and with inequality for $(p, 0)$ with $p < \widehat{p}$ and for $(0, \beta)$ with $\beta < \widehat{\beta}$. Thus, the statement holds for $\beta = 0$ and $\beta = \widehat{\beta}$ with $P(0) = \widehat{p}$ and $P(\widehat{\beta}) = 0$. The fact that the LHS of (A.6) is weakly decreasing then leads to the result for $\beta \in (0, \widehat{\beta})$. □

Intuitively, the necessary condition (A.1) in (i) for the innovation effect to be zero is that the innovation would increase incumbent monopoly profits by a large amount, whereas, under duopoly competition, the entrant's profits would be relatively low (competition is either intense or biased against the entrant). Once this condition on product market profits holds, the innovation effect will be zero according to (ii) if κ, p, and β are sufficiently low. Thus, if these conditions hold together, then one can take decisions entirely based on the competition effect.

A.4.3. *Proof of Proposition 4.* Proposition 3 and $\theta_{1E}^A > \theta_{1I}^A$ imply that $\Delta_{\mathcal{P}} = \mathcal{P}^A - \mathcal{P}^N = \max\{\theta_{1E}^A, \theta_{1I}^A\} - \max\{\theta_{1E}^N, \theta_{1I}^N\} = \theta_{1E}^A - \max\{\theta_{1E}^N, \theta_{1I}^N\} > 0$, where $\theta_{1I}^A = \theta_{1I}^N = \theta_{1I}$ and $\theta_{1E}^A > \theta_{1E}^N$. We will analyze the change of $\Delta_{\mathcal{P}}$ as a result of a change in β, $\pi_I(\ell, L)$ and $\pi_E(L, \ell)$ for all orderings of $\theta_{1I}, \theta_{1E}^A$, and θ_{1E}^N such that $\theta_{1E}^A > \theta_{1I}^A$.

This gives us three cases, which we analyze below. The proposition aggregates the effects in these three cases.

Case 1: If $\theta_{1I} < \theta_{1E}^N < \theta_{1E}^A$, then $\Delta_{\mathcal{P}} = \theta_{1E}^A - \theta_{1E}^N$. Applying the inverse function theorem, we obtain:

(a) $\partial \Delta_{\mathcal{P}} / \partial \beta > 0$ is equivalent with

$$\frac{\partial(\theta_{1E}^A - \theta_{1E}^N)}{\partial \beta} = \frac{(1-p)(\max\{\pi_I(L,0)-\kappa, \pi_I(\ell,0)\} - \pi_I(\ell,L) - \pi_E(L,\ell) + \kappa)}{C'(\theta_{1E}^A)} > 0,$$

which follows from Assumption 1(iv).

(b) $\partial \Delta_{\mathcal{P}} / \partial \pi_I(\ell, L) < 0$ is equivalent with

$$\frac{\partial(\theta_{1E}^A - \theta_{1E}^N)}{\partial \pi_I(\ell, L)} = \frac{-(1-p)\beta}{C'(\theta_{1E}^A)} < 0.$$

(c) $\partial \Delta_{\mathcal{P}} / \partial \pi_E(L, \ell) < 0$ is equivalent with

$$\frac{\partial(\theta_{1E}^A - \theta_{1E}^N)}{\partial \pi_E(L, \ell)} = \frac{(1-p)(1-\beta)}{C'(\theta_{1E}^A)} - \frac{(1-p)}{C'(\theta_{1E}^N)} < 0 \Leftrightarrow$$

$$(1-\beta) < \frac{C'(\theta_{1E}^A)}{C'(\theta_{1E}^N)},$$

where the inequality follows from the convexity of C.

Case 2: If $\theta_{1E}^N < \theta_{1I} < \theta_{1E}^A$, then $\Delta_{\mathcal{P}} = \theta_{1E}^A - \theta_{1I}$. Again applying the inverse function theorem:

(a) $\partial\Delta_{\mathcal{P}}/\partial\beta > 0$ is equivalent with

$$\frac{\partial(\theta_{1E}^A - \theta_{1I})}{\partial\beta} = \frac{(1-p)(\max\{\pi_I(L,0)-\kappa,\pi_I(\ell,0)\}-\pi_I(\ell,L)-\pi_E(L,\ell)+\kappa)}{C'(\theta_{1E}^A)} > 0,$$

which follows from Assumption 1(iv).

(b) $\partial\Delta_{\mathcal{P}}/\partial\pi_I(\ell, L) < 0$ is equivalent with

$$\frac{\partial(\theta_{1E}^A - \theta_{1I})}{\partial\pi_I(\ell, L)} = \frac{-(1-p)\beta}{C'(\theta_{1E}^A)} < 0.$$

(c) $\partial\Delta_{\mathcal{P}}/\partial\pi_E(L, \ell) > 0$ is equivalent with

$$\frac{\partial(\theta_{1E}^A - \theta_{1I})}{\partial\pi_E(L, \ell)} = \frac{(1-p)(1-\beta)}{C'(\theta_{1E}^A)} > 0.$$

Case 3: If $\theta_{1E}^N = \theta_{1I} < \theta_{1E}^A$, then $\Delta_{\mathcal{P}} = \theta_{1E}^A - \max\{\theta_{1I}, \theta_{1E}^N\}$. Provided that the derivative exists, the effect on variety is

$$\frac{\partial(\theta_{1E}^A - \max\{\theta_{1I}, \theta_{1E}^N\})}{\partial x}.$$

Note that $\partial\theta_{1I}/\partial x = 0$ and $\partial\theta_{1E}^N/\partial x = 0$ for $x \in \{\beta, \pi_I(\ell, L)\}$, which implies that the derivative exists and $\partial \max\{\theta_{1I}, \theta_{1E}^N\}/\partial x = 0$. Therefore, $\partial\Delta_{\mathcal{P}}/\partial\beta = \partial\theta_{1E}^A/\partial\beta > 0$ and $\partial\Delta_{\mathcal{P}}/\partial\pi_I(\ell, L) = \partial\theta_{1E}^A/\partial\pi_I(\ell, L) < 0$.

A.4.4. *Proof of Proposition 5.* For $\theta_{2E}^N < \theta_2^A$, we need $C(\theta_{2E}^N) < C(\theta_2^A)$ or equivalently

$$\begin{aligned}
v_E^N(L, \ell) &< v_E^A(L, \ell) \Leftrightarrow \\
\pi_E(L, \ell) - \kappa &< \beta(\max\{\pi_I(L, 0) - \kappa, \pi_I(\ell, 0)\} - \pi_I(\ell, L)) + (1-\beta)(\pi_E(L, \ell) - \kappa) \Leftrightarrow \\
\pi_E(L, \ell) - \kappa &< \max\{\pi_I(L, 0) - \kappa, \pi_I(\ell, 0)\} - \pi_I(\ell, L),
\end{aligned}$$

which holds by Assumption 1(iv). Hence, $\mathcal{D}(r_I^N, r_E^N) < \mathcal{D}(r_I^A, r_E^A)$.

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Figure 4: Effect of prohibiting acquisitions on consumer surplus.

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