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## HOW DO START-UP ACQUISITIONS AFFECT THE DIRECTION OF INNOVATION?

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# HOW DO START-UP ACQUISITIONS AFFECT THE DIRECTION OF INNOVATION?


## Abstract

A start-up engages in an investment portfolio problem by choosing how much to invest in a "rival" project, which threatens the position of an existing incumbent, and a "non-rival" project. Anticipating its acquisition by the incumbent, the start-up strategically distorts its portfolio of projects to increase the (expected) acquisition rents. Depending on parameters, such a strategic distortion may result in an alignment or a misalignment of the direction in which innovation goes relative to what is socially optimal. Moreover, prohibiting acquisitions may increase or decrease consumer surplus. The more (less) the rival project threatens the incumbent and the less (more) the non-rival project appropriates the social surplus, the more likely is that consumers benefit (suffer) following an acquisition. These results are robust to acquisitions where the acquirer takes over the research facilities of the start-up.



JEL Classification: O31, L13, L41

Keywords: Start-ups, Acquisitions, Mergers, Innovation portfolios, Competition policy, Antitrust



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# How Do Start-up Acquisitions Affect the Direction of Innovation?*

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**Abstract**

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**Keywords:** start-ups, acquisitions, mergers, innovation portfolios, competition policy, antitrust

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# 1 Introduction

The potential (anti-)competitive effects of start-up acquisitions have recently raised much scholarly and practitioner attention. Though consolidation processes between firms are certainly not new, big companies in sectors as varied as digital, pharmaceutical and healthcare have acquired a disproportional number of start-ups in the last few years. For example, according to McLaughlin [2020], Amazon, Facebook, Google, Apple and Microsoft bought 21 firms in 2019 and already in the first half of 2020 they had already acquired 27 smaller companies. Admittedly, many start-up acquisitions may have been motivated by the creation of value via quality upgrading and the filling of gaps in the acquirer's product portfolio. However, the acquiring companies are often so large that, absent strong competition within the market, the fear is that start-up acquisitions are suppressing nascent competition that would otherwise benefit consumers. In fact, Cunningham et al. [2021] provide empirical support for the idea that some of the acquisitions observed in the pharmaceutical industry are aimed at discontinuing the innovative products of the target firms and so forestall future competition (see also Gautier and Lamesch [2021]). As a result, there has recently emerged a general debate among academicians and policy makers about whether a more active antitrust intervention is sufficient or merger policy needs reform to address start-up acquisitions (see e.g. Furman et al. [2019]; Crémer et al. [2019]; Scott-Morton et al. [2019]; Bryan and Hovenkamp [2020b]; OECD [2020]; Cabral [2021]; Katz [2021]; Motta and Peitz [2021]). This paper adds to this debate by studying the impact of prohibiting start-up acquisitions on their portfolios of innovation projects. In doing so, the paper's focus is not just on how the elimination of a future competitor causes harm to consumers via higher prices, but also on how a start-up acquisition affects the direction of innovation, which is a margin of inefficiency that has recently attracted significant attention (see Bryan and Lemus [2017]; Chen et al. [2018]; Hopenhayn and Squintani [2021]).[1]

There are at least two important aspects that make start-up acquisitions different from standard mergers. The first is based on the notion of "entry for buyout" in the spirit of Rasmusen [1988], which refers to the idea that the mere anticipation of being bought by a giant company may heavily influence start-ups' business strategy (see also Hollenbeck [2020]; Kamepalli et al. [2020]; Letina et al. [2020]; Cabral [2021]; Katz [2021]; Motta and Peitz [2021]; Gilbert and Katz [2022]). Thus, while building their portfolio of research projects, and anticipating an acquisition, start-ups may pay close attention to the direction large corporations go and give more or less weight to projects that might fit the interests of potential acquirers compared to other, non-rival, projects. Interestingly, the way in which

[1]Though the literature on mergers is extensive, the majority of the merger writings focuses on the acquisition of *existing* firms with mature technologies and products. The earlier literature studied the impact of mergers on prices, insider and outsider profits and consumer surplus (Salant et al. [1983]; Deneckere and Davidson [1985]). Subsequent work examined the trade-off between the increase in market power implied by mergers and the potential efficiency gains arising from either the supply-side (Williamson [1968]; Farrell and Shapiro [1990]) or the demand-side (Klemperer and Padilla [1997]; Moraga-González and Petrikaitė [2013]). Only very recently has the literature incorporated innovation incentives into the analysis of mergers (Federico et al. [2018]; Denicolò and Polo [2018]; Bourreau et al. [2021]; Motta and Tarantino [2021]). In doing this, a couple of papers have pointed out that it is important to look at how mergers affect the portfolio of research projects firms choose to engage in (Gilbert [2019]; Letina [2016]; Moraga-González et al. [2022]). It is this latest angle that this paper intends to develop within the context of start-up acquisitions.

this "innovation for buyout" effect may affect the direction of innovation is *a priori* indeterminate. On the one hand, projects that create much added value for the incumbent firms may be given priority because these projects generate in turn high negotiation rents for the start-ups. On the other hand, projects that highly disrupt the dominant position of potential acquirers and thus generate little added acquisition value may fall out of the start-ups' priority agenda because they create low negotiation rents. Whether such project portfolio adjustment is socially desirable may depend on whether rival projects create more value for consumers than alternative non-rival ones.

The second important reason is that many start-up acquisitions occur at a time in which the target firm is still hardly active, or not at all, in the (relevant) market. Instead, many start-ups are bought during the early stages of their research and development program. A canonical example is that of pharmaceutical firms, which often buy start-ups at their incipient maturation phases (Krieger et al. [2020]; Cunningham et al. [2021]). By taking over the research facilities of the target firms, decisions over the project portfolio change hands from the start-ups to the acquirers. Because the acquirers also anticipate an increase in market power in the product market, their choice of project portfolio is modulated by a different "replacement effect" (Arrow [1962]) compared to that of the start-ups. *A priori*, it is not clear whether this replacement effect is stronger for incumbents than for start-ups (Greenstein and Ramey [1998]; Chen and Schwartz [2013]; Motta and Peitz [2021]).

These reflections lead us to ask how these strategic project portfolio decisions affect the direction of innovation and social welfare. To address this question we formulate a novel model of an industry with an incumbent and an entrant start-up. The start-up engages in an investment portfolio problem. Specifically, the start-up chooses how to allocate its funding across two projects. One of the projects is a "rival" project, in the sense that it is meant to challenge one of the incumbent's dominant products. If successful, this rival project results in a product of strictly higher quality than that of the incumbent. In case of failure, the start-up enters the incumbent's market with a product of (weakly) lower quality than the incumbent's one.[2] The alternative project is a "non-rival" project, that is, a project for which the start-up does not face competition from the incumbent. The two projects also differ from one another in their social returns.

Because firms are motivated by the private returns of the projects in which they engage and they thus neglect part of the social return, start-ups tend to hold biased portfolios of projects. We then ask whether start-up acquisitions aggravate or ameliorate such market distortion. We address this question in two settings. In the first setting, a start-up, anticipating its acquisition, strategically invests to maximize the rents it gets from the integration process. This modelling, which is well suited to identify the "innovation for buyout" effect on project portfolio choice, fits the case of acquisitions in the digital industry where, often, acquirers buy start-ups after the outcome of their research projects is (to a large extent) known.[3] In the second setting, the acquirer takes over the research labs of the start-up, and thereby its investment portfolio choice. This setting, which serves well to examine

[2]This is a common feature in digital markets where property rights are weak and (imperfect) imitation is widespread (see e.g. Cabral [2021]; Calvano and Polo [2021]).

[3]A recent example is the acquisition of *Vilnyx* by *Apple* to incorporate the former's technology to analyze a video's visual, text and audio content into Apple's apps (Gurman [2020]).

how the strength of the "replacement effect" shapes portfolio choice, is better tailored to markets such as pharmaceuticals, in which many start-up acquisitions occur during the early phases of drug development.

To identify the "strategic" portfolio effect of start-up acquisitions, we compare the outcome of a three-stage acquisition game with the outcome of a benchmark two-stage no-acquisition game. Specifically, in the three-stage acquisition game, the start-up first chooses its portfolio of investments; in the second stage, after observing the outcome of its research efforts, the start-up and the incumbent bargain over the surplus generated by the acquisition; finally, in the last stage, firms compete in the market. In the benchmark no-acquisition two-stage game, the start-up first chooses its portfolio of investments and then, upon observing the results of the research projects, the start-up and the incumbent engage in competition.

We first provide general conditions under which the start-up, anticipating its acquisition, strategically distorts its investment portfolio *towards* or *away from* the market of the acquiring firm in order to maximize its acquisition rents. Specifically, if the acquisition rents when the rival project turns successful are greater than the acquisition rents when it fails, compared to when acquisitions are not allowed, the start-up moves its investment portfolio towards the market of the acquiring firm by increasing its investment in the rival project and decreasing it in the non-rival one. Otherwise, the start-up invests more in the non-rival project. We provide a micro-founded model of Cournot competition with vertically differentiated products that illustrates that parameter regions do exist for which these two ways to strategically adjust investments may occur in anticipation of an acquisition.

We then examine the social impact of the start-up's strategic adjustment of the investment portfolio and provide competition policy recommendations. We show that an acquisition may result in an alignment or misalignment of the private and the social incentives to invest. This implies that an acquisition may improve the direction of innovation or worsen it. When the start-up reallocates funding by increasing investment in the rival project and reducing it in the non-rival project, the acquisition improves the direction of innovation provided that the consumer gains from the non-rival project are relatively small compared to the private gains. Likewise, when the start-up invests less in the rival project and more in the non-rival one, the portfolio distortion is reduced if consumers benefit significantly from the non-rival project compared to the private gains.

Although start-up acquisitions may reduce project portfolio distortions, this is not necessarily welfare improving because acquisitions also increase price distortions in the rival market. Therefore, prohibiting acquisitions of potential competitors may involve a trade-off. We identify two types of circumstances under which a reduction in the innovation distortion is sufficiently large so as to make an acquisition consumer welfare improving. The first arises when surplus appropriability in the rival market is relatively high in which case, in anticipation of an acquisition, the start-up moves its portfolio of investments away from the market of the acquiring firm. We show that when consumer surplus in the non-rival market is sufficiently large, the decrease in the innovation distortion has a dominating influence over the increase in the price distortion and overall consumer surplus is higher when acquisitions are allowed. The second situation arises when surplus appropriability in the rival market is low in which case, in anticipation of an acquisition, the start-up moves its portfolio of investments towards the market of the acquiring firm. We show that when both consumer surplus in the non-rival market and the price effects in the rival market are sufficiently small, ovreall consumer surplus is higher if acquisitions are allowed. Based on these results, we come to the conclusion that blanket prohibitions of start-up acquisitions are not warranted and competition policy makers should address them case by case.

In Section 6 of the paper we turn our attention to the alternative setting in which the acquirer takes over the research facilities of the start-up. We show that when surplus appropriability in the market of the incumbent is low, the acquirer benefits relatively more from obtaining a high-quality product than the entrant does, while both benefit equally from the non-rival project. Hence, the acquirer invests more in the rival project and less in the non-rival one than the start-up. When surplus appropriability in the rival project is sufficiently large, it is the opposite and investment in the rival project decreases after an acquisition.

The result that the acquirer may invest more in the rival project compared to the start-up is in contrast with the theoretical results of Cunningham et al. [2021] and Motta and Peitz [2021]. The difference stems from the facts that in our model both the start-up and the acquirer face replacement effects and that these are of different magnitude. Both the start-up and the acquirer choose an investment portfolio so as to equalize the marginal returns from the rival and non-rival projects. The start-up's marginal returns from the rival project are proportional to the profits difference between a seller of high quality and a seller of low quality. That is, a successful start-up that sells high quality replaces an unsuccessful start-up that sells low quality. By contrast, the acquirer's marginal returns are proportional to the difference in the profits of a monopoly seller of high quality and one of low quality. The relative magnitude of these two replacement effects determines the nature of the investment portfolio adjustment if acquisitions are allowed. We again use our micro-founded model of Cournot competition with vertically differentiated products to show that, depending on parameters, investment in the rival project may increase or decrease.[4]

From a social welfare point of view, also in this setting the acquisition of the start-up by the incumbent may result in an alignment between the private incentives to invest and the social incentives, thereby putting the direction in which the market innovates more in line with the socially optimal one. Moreover, we find that prohibiting the acquisition of potential entrants is consumer welfare reducing under conditions similar to those when the acquisition takes place after the outcomes of the research projects become known.

We examine the robustness of our results in a number of additional extensions. In one of the extensions, we consider the case of drastic innovations. In a second extension, we consider the case in which there are $n \geq 2$ incumbent firms. Finally, we consider the case in which, in addition to vertical

[4]Motta and Peitz [2021] present a result similar to Cunningham et al. [2021] but conjecture that it is theoretically possible that an entrant's incentives to invest fall short of those of an incumbent. In this regard, our model of vertical product differentiation with Cournot competition provides an instance in which the Arrow replacement effect of an entrant can be larger or smaller than that of an incumbent (see also Greenstein and Ramey [1998]; Chen and Schwartz [2013]).

product differentiation, there is also significant horizontal differentiation. The main takeaways from these extensions are the following. First, the positive effects of allowing for acquisitions are robust in that they lead the start-up to move its investment portfolio sometimes towards the market of the acquiring firm and sometimes away (depending on the extension considered and the model parameters). Second, regardless of how the investment portfolio changes (towards or away from the incumbent's market), from a normative point of view, the direction of innovation may improve or worsen. Lastly, start-up acquisitions may increase consumer surplus under conditions similar to those in our main model.

## 2 Related literature

Our paper contributes to the recent surge in the academic interest about the effects of mergers on innovation. One branch of this literature focuses on the impact of mergers between existing firms on innovation. Some papers look at the case of single-project firms and center around the question how mergers affect expenditures in R&D (e.g. Federico et al. [2018]; Denicolò and Polo [2018]; Bourreau et al. [2021]; Motta and Tarantino [2021]). Other papers, more related to ours, have examined how mergers impact the variety and diversity of R&D projects firms engage in (e.g. Letina [2016]; Gilbert [2019]; Moraga-González et al. [2022]). In terms of the model, our paper is related to Moraga-González et al. [2022] where mergers between existing firms that invest in a portfolio of research projects of different profitability and social value are examined. However, our paper is tailored to the phenomenon of start-up acquisitions and focuses on how a rent-seeking start-up adjusts its investment portfolio in anticipation of the "innovation for buyout" effect, which is driven by the price effects associated to the acquisition. Their paper, by contrast, centers on how the merged entity adjusts its portfolio of investments to internalize the positive and negative externalities the merging partners exert on one another when they choose their investment portfolios. These positive and negative externalities, which arise because of competition in R&D to profit from the same business opportunities, are not typically present in models of start-up acquisitions because the focus is on the start-up's investment in R&D.

A second branch of the literature focuses on the acquisition of potential competitors. Some papers focus on the Arrow replacement effect. Cunningham et al. [2021] present a model where an entrant with a single multi-stage project may be acquired by an existing firm. They focus on whether the entrant or the acquirer has greater incentives to continue to develop the project further once an initial stage is complete. Because of the Arrow replacement effect, the acquirer has weaker incentives to develop the project further so under some parameters the project is discontinued upon acquisition. This is more likely the greater the overlap between the interests of the acquirer and the entrant's project, and the fewer competitors in the market. Cunningham et al. [2021] also present an empirical analysis of the pharmaceutical industry corroborating these insights. They estimate that around 5-7% of the acquisitions are killer acquisitions. (Gautier and Lamesch [2021] make a similar observation in digital markets.) The paper by Motta and Peitz [2021] features a single-project entrant that may be acquired by an existing incumbent. Like Cunningham et al. [2021], their focus is on the likelihood of project killing after the acquisition of the potential entrant. They also study the probable impact of acquisitions on consumer surplus. They find that whenever the start-up has the ability to continue to develop its project, an acquisition (weakly) reduces consumer surplus. Acquisitions may only be beneficial for consumers when the entrant does not have the resources to develop the project while the incumbent does (see also Fumagalli et al. [2020]). Our model differs from these two papers in two important regards. First, we examine how an acquisition impacts project portfolio choice. Thus, the decision of a firm is not whether to continue or discontinue a project, but how much effort to allocate across a portfolio of projects. This implies that lowering investment in a project is not *per se* consumer welfare reducing because such a decision frees up resources that can be allocated to other projects. Second, our model is one of vertical product differentiation and, as it turns out, the Arrow replacement effect of the incumbent may be larger or smaller than that of the start-up.

The strategic innovation effect of start-up acquisitions has also received considerable attention. In Cabral [2018], Hollenbeck [2020] and Katz [2021] the "innovation for buyout" effect of start-up acquisitions is generally beneficial (see also the discussion in Cabral [2021]), although Cabral [2018] and Katz [2021] also put forward situations in which the "innovation for buyout" effect of start-up acquisitions is harmful. The latter occurs, for example, when innovators have a choice between different types of innovations. In Cabral [2018] this choice is between incremental and radical innovation, while in Katz [2021] the innovator chooses product quality. They show conditions under which the "innovation for buyout" effect results in less radical innovation and lower quality. Related, in Denicolò and Polo [2021] the incumbent's dominance depends on past activity and can be reinforced by repeated acquisitions over time, which makes it possible that the negative entrenchment of monopoly effect outweighs the positive innovation for buyout effect. In a model where a start-up does not have production capabilities, Bryan and Hovenkamp [2020a] study the start-up's incentives to transfer its technology either to a dominant, more efficient, firm or to its less efficient competitor. They show that anticipating its acquisition, the start-up gears its innovative effort towards the interests of the dominant firm. Our paper also shows that, depending on parameters, the "innovation for buyout" effect may be beneficial or harmful to consumers. The mechanism is however different because what is important in our model is whether acquisitions result in a social alignment or misalignment of the start-up's investment portfolio. Callander and Matouschek [2021] and Gilbert and Katz [2022] also study how the prospect of a merger affects the direction of the entrant's investment. In these papers direction is defined as the extent to which the entrant's product (horizontally) differs from that of the incumbent. They show that start-ups tend to choose products that are similar to the incumbent's products in order to enhance the bargaining rents associated to an acquisition rather than differentiating them to relax competition. In their models, start-up acquisitions never result in an increase in consumer surplus.[5] In our model, by contrast, start-up acquisitions may align or misalign the direction of innovation with the socially optimal one and we provide instances in which the consumer surplus gains from direction of innovation improvements dominate the consumers surplus

[5]See also Warg [2022], who shows that acquisitions make it more likely that start-ups choose to produce products that are complementary to the incumbent's products.

losses due to the price effects associated to start-up acquisitions. Further, Gilbert and Katz [2022] also look at the impact of start-up acquisitions on total welfare and conclude that they increase it. Furthermore, they show that antitrust policies that condition on the entrant's choice of product may increase consumer surplus by inducing the entrant to choose a more rivalrous product.

Another paper on the acquisition of potential competitors is by Letina et al. [2020]. In contrast to the work of Cunningham et al. [2021] and Motta and Peitz [2021], they focus on the impact of acquisitions on the variety of projects undertaken by an entrant firm and an incumbent firm. They show that prohibiting start-up acquisitions may lower the variety of projects the entrant and the incumbent activate and thereby increase project duplication and reduce the likelihood of successful innovation, which reduces welfare. The most important difference between our paper and theirs in that the portfolio of projects firms can invest in are intended for different markets, with different profitability and social value.

Finally, in a model with network externalities Kamepalli et al. [2020] show how acquisitions may result in too little entry. This occurs because the consumers' propensity to adopt a new entrant's technology decreases when they anticipate an acquisition to take place. Katz [2021], Motta and Shelegia [2021] and Teh et al. [2022] also study "defensive" strategies by incumbent firms. Katz [2021] mentions the "incumbency for buyout effect," the idea that permissive policy towards acquisitions may trigger defensive investments by the incumbents to deter entry. Motta and Shelegia [2021] focus on how an incumbent firm may deploy a "defensive" (product-copying) strategy to prevent that a start-up develops a rival product, rather than a complementary one, that challenges its dominant position. They show that start-up acquisitions may increase the incentives of the start-up to develop the rival product. In a model with multiple start-ups, Teh et al. [2022] show how the acquisition of the target start-up may create kill zones for non-target start-ups, thereby affecting the direction of their innovative efforts. They also find that the innovation for buyout effect may not be a good defense for start-up acquisitions when taking into account the reaction of non-target start-ups.

The rest of the paper is organized as follows. Section 3 describes the model. In Section 4 we provide a general solution to the investment portfolio problem that applies to a decision maker, no matter whether it is a start-up, acquirer or social planner. In Sections 5.1 and 5.2 we derive the profit-maximizing investment portfolios and the corresponding market outcomes in the case of no-acquisition and acquisition. Section 5.3 examines how, anticipating its acquisition by the incumbent, the start-up distorts its investment portfolio to maximize the acquisition rents and how this affects the direction of innovation. Section 5.4 presents the impact of prohibiting acquisitions on consumer welfare. Section 5.5 illustrates our results using a micro-founded model of Cournot competition and vertically differentiated products; this section also examines the relaxation of some assumptions. Section 6 models acquisitions in which the acquirer takes over the research facilities of the start-up, compares the project portfolio of the start-up with that of the acquirer, derives the implications for the direction of innovation and consumer welfare and provides an example. Finally, Section 7 provides policy implications and Section 8 offers some concluding remarks. All the proofs are relegated to the Appendix.

## 3 Model

We consider an industry with an incumbent ($I$) and a start-up ($E$).[6] The novelty of our approach is that the start-up engages in an investment portfolio problem. Specifically, the start-up has a fixed budget (or a fixed number of scientists) and its decision is how to allocate its funding (or its researchers) across two projects, denoted $A$ and $B$.[7] Project $A$ is a *rival* project in the sense that it is meant to challenge one of the incumbents' markets, which we refer to as market $A$. Project $B$ is a *non-rival* project, that is, independent from the incumbent's businesses.[8]

We assume that the incumbent operates in market $A$ selling a product that we refer to as the incumbent's *basic product*. We assume that the rest of the markets in which the incumbent operates are independent from market $A$. This means that they can be ignored in what follows.[9] We normalise the entrant's fixed investment budget to 1. Let $x$ denote the start-up's investment in project $A$ and, correspondingly, let $1 - x$ be the start-up's investment in project $B$. We assume that investment in a project does not guarantee success, but increases the probability of success. Specifically, let the success probabilities be as in Tullock contests, i.e.,

$$\tau(x, \epsilon_A) = \frac{x}{x + \epsilon_A}, \text{ and } \eta(1 - x, \epsilon_B) = \frac{1 - x}{1 - x + \epsilon_B},$$

denote the probabilities with which projects $A$ and $B$ are successful, respectively. The parameters $\epsilon_A$ and $\epsilon_B$ measure the innovation difficulty of the projects. These success probabilities are increasing in investment and decreasing in innovation difficulty. With this formulation, a project becomes a sure success if its difficulty goes to zero, and a sure failure if its difficulty goes to infinity. The well-known Tullock functional form ensures that all our investment portfolio problems are strictly concave in own investment effort and therefore the first order conditions (FOCs) for expected profit maximization are necessary and sufficient for maxima. Moreover, when $\epsilon_A, \epsilon_B \to 0$ all our decision problems have interior solutions.

[6]Later in Sections 5.5.1 and 6.4.1 we discuss the case in which there are $n$ incumbents.

[7]As mentioned in the Introduction, several authors have already discussed how the "innovation for buyout" effect bears on investment-volume incentives. We exogenously fix the investment budget in order to focus our paper on a new margin, namely, the direction of innovation. We have nevertheless examined an extension of our model where the start-up chooses not only how to allocate its funding across projects but also the amount of funding. We find that, when the cost of raising investment funds is strictly convex, our results on the effects of permitting acquisitions on portfolio choice (Propositions 1 and 4) continue to hold, along with an additional insight on how total investment changes if acquisitions are allowed. Specifically, investment in project A and investment in project B move in the opposite direction and when the investment portfolio moves towards (away) the market of the incumbent firm, the start-up also increases (decreases) its total investment budget. The possibility that total investment increases is a manifestation of the positive "innovation for buyout" effect identified in the literature focusing on the effects of start-up acquisitions on investment volumes. Moreover, provided that the cost of raising funds is sufficiently convex, changes in total investment are bound to be very small and then the normative results based on changes in direction of innovation (Propositions 2 and 5) and prices (Proposition 3) still hold. The proofs of these observations are available from the authors upon request.

[8]Start-ups often entertain several research ideas and choose how much effort to put in each of them. For example, the Singapore-based *Grab* offers not only ride-hailing services (*JustGrab*) but also insurance contracts (*GrabInsure*) and payment systems (*GrabPay*). Similarly, *Uber* has engaged in projects as varied as ride-hailing (*Uber*), food delivery (*Uber Eats*) or freight transportation (*Uber Freight*). Moreover, the start-up incubator *Y Combinator* requires its applicants to provide multiple project ideas when they solicit their seed funding services.

[9]Our results can be generalized to situations where the incumbent also chooses how to allocate its investment budget across the rival project and its other projects. We elaborate on this observation in the Conclusions section.

Conditional on the rival project $A$ being successful, let $\pi^E_{A,s}$ and $\pi^I_{A,s}$ be the payoffs of the start-up and the incumbent from selling their products in market $A$. We assume $\pi^E_{A,s} > \pi^I_{A,s} > 0$, reflecting the fact that a successful entrant enters market $A$ with a product of higher quality than the incumbent's.[10] Let $U_{A,s}$ be the consumer surplus resulting from the market interaction when the rival project $A$ is successful. Alternatively, conditional on project $A$ failing, let $\pi^E_{A,f}$ and $\pi^I_{A,f}$ be the payoffs of the start-up and the incumbent from selling their products in market $A$. In this case, $\pi^I_{A,f} \geq \pi^E_{A,f} \geq 0$ because the incumbent's basic product is of higher quality than the entrant's.[11] Let $U_{A,f}$ be the surplus consumers derive from the market interaction when rival project $A$ is unsuccessful.

As mentioned before, project $B$ is a non-rival project. Conditional on project $B$ being successful, let $\pi^E_{B,s}$ be the start-up's profits and $U_{B,s}$ the implied consumer surplus. Similarly, let $\pi^E_{B,f}$ be the start-up's profits from market $B$ if the project turns unsuccessful, and $U_{B,f}$ the corresponding consumer surplus. Naturally, let us assume that $\pi^E_{B,s} > \pi^E_{B,f}$ and $U_{B,s} > U_{B,f}$. As it will become clear later, the attractiveness of project $B$ depends on the difference between the payoffs $\pi^E_{B,s}$ and $\pi^E_{B,f}$ and such difference will not be affected by acquisitions. Therefore, to shorten expressions, and without of loss of generality, we normalize the payoff in case of project failure to zero, i.e. $\pi^E_{B,f} = 0$. Likewise, we normalize $U_{B,f} = 0$ and refer to $U_{B,s}$ as $U_B$ in what follows.

The choice of investment portfolio affects the likelihood with which projects $A$ and $B$ are realized and hence which products the market delivers to consumers. In what follows, we shall informally speak about the *direction of innovation* implied by the investment portfolio choice of the start-up. We start our analysis with a comparison of the outcome of a three-stage *acquisition* game with the outcome of a benchmark two-stage *no-acquisition* game. In the first stage of the *acquisition* game, *the investment portfolio stage*, the start-up chooses its portfolio of investments. In the second stage, *the acquisition stage*, after observing the outcome of its research efforts in projects $A$ and $B$, the start-up and the incumbent bargain over the surplus generated by the acquisition. In this stage, we implement the Nash bargaining solution and assume that $\delta \in (0, 1]$ is the bargaining power of the start-up and, correspondingly, $1 - \delta$ that of the incumbent. In the last stage, *the market interaction stage*, firms compete in the market to sell their products. In the first part of the paper we do not model this last stage explicitly and instead work directly with the corresponding reduced-form profit levels of the entrant and the incumbent presented above. Later in Sections 5.5 and 6.4 we explicitly model the market interaction between the start-up and the incumbent assuming that they compete in quantities to sell vertically differentiated products. We solve for the subgame perfect Nash equilibrium of this game and compare it to the benchmark *no-acquisition* game where the start-up first chooses its portfolio of investments and then, once the outcomes of its research efforts are realized, the entrant and the incumbent compete in the market to sell their products. By comparing the two outcomes we identify the impact of allowing acquisitions on the direction of innovation and consumer surplus.

The above timing of moves in the acquisition game is adequate to model acquisitions in environments in which start-ups have developed their products before they are bought. This timing of

[10] The case in which $\pi^I_{A,s} = 0$ captures a situation where the start-up innovation is drastic. As discussed in Sections 5.5.1 and 6.4.1, our results do not qualitatively change in such a case.

[11] The case in which $\pi^E_{A,f} = 0$ captures a situation where the entrant cannot enter the market upon failure.

moves, which is in line with e.g. Hollenbeck [2020], Letina et al. [2020], Cabral [2021] and Callander and Matouschek [2021], seems a good modelling choice for the acquisitions by big-tech firms such as Facebook. An alternative modelling choice is one in which the incumbent buys the start-up and takes over its research facilities and the investment portfolio decision. This modelling, which is in line with the paper of Cunningham et al. [2021] and Motta and Peitz [2021], seems more suited to pharmaceutical markets where the acquirer intervenes in the last stages of drug development. We examine the implications of this alternative modelling in Section 6.

# 4 The investment portfolio problem

Our first result concerns the start-up's choice of investment portfolio. Rather than deriving the start-up's optimal investment portfolio for the two different games, we do it in general using a more comprehensive notation that makes it valid irrespective of whether acquisitions are allowed or not. More generally, the result is also valid when, rather than the entrant, we let the social planner choose the portfolio of investments that maximizes consumer surplus. Even more generally, we will also make use of the result derived here in Section 6 where, rather than the start-up, it is the joint entity that chooses its investment portfolio to maximize its expected profits.

Therefore, consider a decision-maker, be it the entrant, the joint entity, or the social planner, who picks its investment portfolio $(x, 1-x)$ to maximize its objective function, be the latter profits or social welfare. No matter the decision-maker, he/she will choose its investment portfolio $(x, 1-x)$ anticipating the expected (private or social) returns on the projects in which it invests. By returns on a project we mean the difference between its payoff in case of success and its payoff in case of failure. Correspondingly, let $R_{A,s}$ denote the payoff, be private or social, from investing in project $A$ when it turns out successful, and $R_{A,f}$ the payoff when it fails. Define $R_{B,s}$ and $R_{B,f}$ similarly and notice that we have normalized $R_{B,f}$ to zero. Then, the problem of a decision-maker is to maximize an expected payoff expression of the form:

$$\mathbb{E}R(x) = \frac{x}{x+\epsilon_A} R_{A,s} + \frac{\epsilon_A}{x+\epsilon_A} R_{A,f} + \frac{1-x}{1-x+\epsilon_B} R_{B,s}. \tag{1}$$

The first term is the probability that project $A$ turns successful, times its corresponding payoff. The second term is the probability that project $A$ fails, times its payoff in such a case. The last term is the probability that project $B$ succeeds times its payoff in that event.

The expression in (1) is strictly concave in $x$. Therefore, if it is maximized at an interior point, the first-order condition (FOC) suffices for a maximum. Taking the FOC of (1) gives:

$$\frac{\epsilon_A}{(x+\epsilon_A)^2} \left(R_{A,s} - R_{A,f}\right) - \frac{\epsilon_B}{(1-x+\epsilon_B)^2} R_{B,s} = 0$$

This FOC implies that the decision-maker should continue to increase its investment in project $A$ until its marginal payoff equals the marginal payoff from project $B$. Note that the marginal payoff from a project is proportional to its returns, i.e. the difference in the payoff that results from success and the payoff in case of failure. These innovation returns are $R_{A,s} - R_{A,f}$ for project $A$ and $R_{B,s}$ for project $B$. Assuming the maximizer is interior, the optimal investment in project $A$ is given by:

$$x\left(R_A/R_B; \epsilon_A, \epsilon_B\right) = \frac{1 + \epsilon_B - \epsilon_A\sqrt{\frac{\epsilon_B R_B}{\epsilon_A R_A}}}{1 + \sqrt{\frac{\epsilon_B R_B}{\epsilon_A R_A}}}, \tag{2}$$

where we have defined $R_A \equiv R_{A,s} - R_{A,f}$ and $R_B \equiv R_{B,s}$ to shorten the expression. The corresponding investment in project $B$ is equal to $1 - x\left(R_A/R_B; \epsilon_A, \epsilon_B\right)$.

Inspection of this expression reveals that in choosing the optimal portfolio of investments what matters for the decision-maker is what we call the *relative returns* on the projects, that is, the ratio $R_A/R_B$. Depending on the decision-maker or the market structure, the returns $R_A$ and $R_B$ take on different values. However, the solution of the optimization problem of the decision-maker always has the form given in expression (2). The following Lemma, which is a straightforward implication of (2), is quite useful to compare investment portfolios in the no-acquisition and acquisition cases.

**Lemma 1.** *The optimal investment level in project $A$ is increasing in the relative returns on the projects $R_A/R_B$. Moreover, it is decreasing in $\epsilon_A$ and increasing in $\epsilon_B$.*

Intuitively, a decision-maker will tilt its investment portfolio towards a particular project when that project's innovation returns increase relative to those of the alternative one, or when the difficulty of that project decreases relative to the difficulty of the alternative one.

# 5 The "innovation for buyout" effect of acquisitions

## 5.1 The no-acquisition benchmark

When acquisitions are banned, the start-up chooses its portfolio of investments as in equation (2) but taking into consideration that the relative returns $R_A/R_B$ on the projects are given by the ratio:

$$\frac{\pi^E_{A,s} - \pi^E_{A,f}}{\pi_B}. \tag{3}$$

The numerator is the difference in profits the start-up makes when its project $A$ is successful rather than futile. The denominator is the same difference but for project $B$. Denote by $x^*_{na}$ the start-up's investment in project $A$ when acquisitions are forbidden. Making use of equation (2), $x^*_{na}$ is given by:

$$x^*_{na} \equiv x\left(\frac{\pi^E_{A,s} - \pi^E_{A,f}}{\pi_B}; \epsilon_A, \epsilon_B\right). \tag{4}$$

The rest of the budget, i.e. $1 - x^*_{na}$, is invested in project $B$.

### 5.2 Acquisitions

When acquisitions are allowed, the start-up chooses its portfolio of investments again as in equation (2) but anticipating the bargaining rents that it will appropriate after merging with the incumbent. As mentioned above, we implement the Nash bargaining solution and assume that $\delta \in (0, 1]$ is the bargaining power of the start-up.[12] Therefore, anticipating its acquisition, the relative returns $R_A/R_B$ on the projects are given by the ratio:

$$\frac{\pi^E_{A,s} + \delta(\pi^m_{A,s} - \pi^E_{A,s} - \pi^I_{A,s}) - [\pi^E_{A,f} + \delta(\pi^m_{A,f} - \pi^E_{A,f} - \pi^I_{A,f})]}{\pi_B}. \tag{5}$$

The first term in the numerator, $\pi^E_{A,s} + \delta(\pi^m_{A,s} - \pi^E_{A,s} - \pi^I_{A,s})$, is the start-up's expected payoff from the rival market in case of project success. Denoting the monopoly profits in case of project success by $\pi^m_{A,s}$, this term equals the disagreement payoff $\pi^E_{A,s}$ plus a share $\delta$ of the bargaining rents $\pi^m_{A,s} - \pi^E_{A,s} - \pi^I_{A,s}$, which we assume are non-negative and hence an acquisitions is incentive-compatible. Denoting the monopoly profits in case of project failure by $\pi^m_{A,f}$, the second term in the numerator equals the disagreement payoff $\pi^E_{A,f}$ plus a share $\delta$ of the bargaining rents $\pi^m_{A,f} - \pi^E_{A,f} - \pi^I_{A,f}$, which we assume are non-negative too. The term in the denominator stays the same as in the no-acquisition case because acquisitions do not have a bearing on the returns from the non-rival market $B$.

Denote by $x^*_a$ the start-up's investment in project $A$ when an acquisition is anticipated. Making use of equation (2), $x^*_a$ is given by:

$$x^*_a \equiv x\left(\frac{\pi^E_{A,s} + \delta(\pi^m_{A,s} - \pi^E_{A,s} - \pi^I_{A,s}) - [\pi^E_{A,f} + \delta(\pi^m_{A,f} - \pi^E_{A,f} - \pi^I_{A,f})]}{\pi_B}; \epsilon_A, \epsilon_B\right). \tag{6}$$

The rest of the budget, i.e. $1 - x^*_a$, is invested in project $B$.

### 5.3 The impact of an acquisition on the direction of innovation

A comparison of the start-up's optimal investment portfolio when acquisitions are banned to that when acquisitions are allowed leads to the following result.

**Proposition 1.** *(i) Anticipating its acquisition, the start-up invests less in project A (and therefore more in project B) than when acquisitions are banned, i.e.* $x^*_a < x^*_{na}$, *if and only if*

$$\pi^m_{A,s} - \pi^E_{A,s} - \pi^I_{A,s} < \pi^m_{A,f} - \pi^E_{A,f} - \pi^I_{A,f}. \tag{7}$$

*(ii) Otherwise, when the inequality in (7) is reversed, the start-up invests more in project A (and therefore less in project B).*

*Proof.* See the Appendix. ☐

[12] For details on the Nash equilibrium of the bargaining stage, see our working paper Dijk et al. [2022].

Proposition 1 describes how the start-up adjusts its investment portfolio in anticipation of an acquisition. As mentioned above, the start-up invests so as to equalize the marginal gains from investing in project $A$ to the marginal gains from investing in project $B$. Each of these marginal gains are proportional to the additional rents a successful innovation generates compared to a futile one. Because in the acquisition case the start-up shares in the surplus brought about by the acquisition, the entrant's incentives to invest are different from those in the no-acquisition benchmark.

Proposition 1 then follows from a comparison of the relative returns in (3) with those in (5). Because an acquisition has no bearing on the rents from market $B$, this comparison boils down to weighing the additional rents a successful project $A$ generates in the acquisition case against those in the no-acquisition case. Thus, anticipating an acquisition, the start-up will invest less in project $A$ if and only if the bargaining surplus generated by the acquisition in case of a successful project $A$, which is equal to $\pi^m_{A,s} - \pi^E_{A,s} - \pi^I_{A,s}$, is lower than the bargaining surplus generated by the acquisition when project $A$ is unsuccessful, which is equal to $\pi^m_{A,f} - \pi^E_{A,f} - \pi^I_{A,f}$. This inequality tends to be satisfied if high-quality is sufficiently high because $\pi^m_{A,s}$ and $\pi^E_{A,s}$ are very close to one another and hence the rents from monopolization of the product market in case of a successful project $A$ are very limited.

This proposition makes the important point that the prospect of an acquisition may move the portfolio of investments of the entrant either towards or away from the market of the acquiring firm. We now investigate the impact of such an alteration from a normative point of view. To do this, we compare the investment portfolios in the no-acquisition and acquisition cases with the investment portfolio that a social planner would choose.

Specifically, we consider a social planner who allocates funding to projects $A$ and $B$ to maximize consumer surplus.[13] Without loss loss of generality, we assume that, while deciding on the investment levels, the social planner takes as given the surplus levels that consumers obtain in the no-acquisition case. Correspondingly, recall that $U_{A,s}$ and $U_{B,s}$ are the surplus levels consumers attain in markets $A$ and $B$ conditional on project success, while $U_{A,f}$ and $U_{B,f}$ (normalized to zero) are the same surpluses but in case of project failure.[14] Then, the social planner will choose its investment portfolio as in equation (2) but factoring an amount of relative returns $R_A/R_B$ equal to the ratio:

$$\frac{U_{A,s} - U_{A,f}}{U_B}, \tag{8}$$

The numerator equals the difference in the surplus consumers obtain when the rival project A is successful rather than futile. The denominator is the same but for project $B$.

Denote by $x^o$ the socially optimal investment in project $A$. Using again (2), $x^o$ is given by:

$$x^o \equiv x\left(\frac{U_{A,s} - U_{A,f}}{U_B}; \epsilon_A, \epsilon_B\right). \tag{9}$$

[13]During the last years, both in Europe and the US, using consumer welfare as the standard for competition enforcement has become the norm.

[14]Notice that if we instead consider a social planner who also controls output, then we need to use the consumer surplus levels corresponding to marginal cost pricing. This would require extra notation without adding any new insight.

The planner invests the rest of the budget, i.e. $1 - x^o$, in project $B$.

Our next proposition compares the portfolios of investments in (4), (6) and (9) to describe how an acquisition affects the direction of innovation activity from the point of view of consumer surplus maximization.

**Proposition 2.** *(i) Assume that $\pi^m_{A,s} - (\pi^E_{A,s} + \pi^I_{A,s}) < \pi^m_{A,f} - (\pi^E_{A,f} + \pi^I_{A,f})$ so that the start-up, anticipating its acquisition, reduces investment in project $A$ and increases it in project $B$. Then:*

- *if $\frac{\pi_B}{U_B} < \frac{\pi^E_{A,s} - \pi^E_{A,f} + \delta[\pi^m_{A,s} - (\pi^E_{A,s} + \pi^I_{A,s}) - (\pi^m_{A,f} - (\pi^E_{A,f} + \pi^I_{A,f}))]}{U_{A,s} - U_{A,f}}$, then $x^o < x^*_a < x^*_{na}$ and thus an acquisition improves the direction of innovation;*
- *if $\frac{\pi_B}{U_B} > \frac{\pi^E_{A,s} - \pi^E_{A,f}}{U_{A,s} - U_{A,f}}$, then $x^*_a < x^*_{na} < x^o$ and thus an acquisition worsens the direction of innovation.*

*(ii) Assume that $\pi^m_s - (\pi^E_{A,s} + \pi^I_{A,s}) > \pi^m_{A,f} - (\pi^E_{A,f} + \pi^I_{A,f})$ so that the start-up, anticipating its acquisition, increases investment in project $A$ and decreases it in project $B$. Then:*

- *if $\frac{\pi_B}{U_B} > \frac{\pi^E_{A,s} - \pi^E_{A,f} + \delta[\pi^m_{A,s} - (\pi^E_{A,s} + \pi^I_{A,s}) - (\pi^m_{A,f} - (\pi^E_{A,f} + \pi^I_{A,f}))]}{U_{A,s} - U_{A,f}}$, then $x^*_{na} < x^*_a < x^o$ and thus an acquisition improves the direction of innovation;*
- *if $\frac{\pi_B}{U_B} < \frac{\pi^E_{A,s} - \pi^E_{A,f}}{U_{A,s} - U_{A,f}}$, then $x^o < x^*_{na} < x^*_a$ and thus an acquisition worsens the direction of innovation.*

*Proof.* See the Appendix. □

Proposition 2 shows that an acquisition may result either in an alignment or misalignment of the private incentives to invest with the social incentives. In particular, Proposition 2 describes two parameter sets in which the direction of innovation improves when the start-up anticipates its acquisition, as well as two parameter sets in which the direction of innovation worsens. These four regions of parameters are depicted in Figure 1. In this figure, on the vertical axis we place $\pi_B/U_B$, which is a measure of the private returns from project $B$ relative to its social returns. In what follows, we shall refer to this ratio as the surplus appropriability in market $B$. Similarly, on the horizontal axis we have $\frac{\pi^E_{A,s} - \pi^E_{A,f}}{U_{A,s} - U_{A,f}}$, which is a measure of surplus appropriability in market $A$. The blue $45^o$ line divides the parameter space into an upper region where the investment in project $A$ in the no-acquisition game is insufficient (and therefore investment in $B$ excessive) compared to the socially optimal portfolio and a lower region where the opposite occurs. This blue line obtains from equalizing the entrant's relative returns of the projects in the no-acquisition case, $\frac{\pi^E_{A,s} - \pi^E_{A,f}}{\pi_B}$, with the planner's relative returns, $\frac{U_{A,s} - U_{A,f}}{U_B}$. Hence, when the surplus appropriability of project $A$ is higher (lower) than that of project $B$, the entrant overinvests (underinvests) in $A$. Likewise, the red curve divides the parameter space into an upper region where the investment in project $A$ in the acquisition game is insufficient (and therefore investment in $B$ excessive) compared to the socially optimal portfolio and a lower region where the opposite holds. The construction of this curve is similar. Finally, the dashed line divides the parameter space into a left area where the start-up increases investment in project $A$

in anticipation of its acquisition and a right area where the opposite adjustment takes place. In Figure 1, the green areas depict the parameter sets for which the direction of innovation improves and the red areas show the parameters for which the direction of innovation worsens if acquisitions are allowed. There are two additional parameter regions for which it is ambiguous whether an acquisition results in a move closer or further away from the socially optimal investment portfolio.

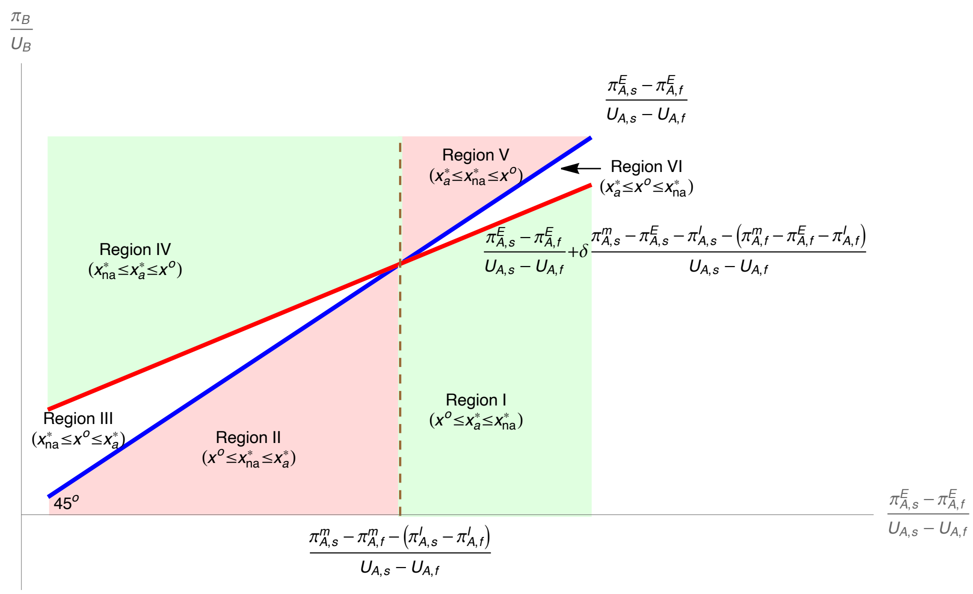



Figure 1: Private and socially optimal innovation portfolios

If parameters fell in region I, the start-up, anticipating its acquisition, would decrease its investment in project $A$ and increase it in project $B$ (cf. Proposition 1). Because in this region of parameters the appropriability of surplus in market $A$ is larger than in market $B$, investment in $A$ is excessive and in $B$ insufficient from the point of view of social welfare maximization. Hence, the direction of innovation would improve if acquisitions were allowed. A similar result holds in Region IV. If the parameters of the model fell in this region, the start-up, anticipating its acquisition, would increase its investment in project $A$ and decrease it in project $B$. Because in this region of parameters, investment in $A$ is insufficient while investment in $B$ is excessive from the point of view of social welfare maximization, the direction of innovation would also improve were acquisitions allowed.

By contrast, if parameters fell in regions II and V, allowing for acquisitions would worsen the direction of innovation. In Region II, an acquisition would result in an increase in investment in $A$ and a decrease in investment in $B$. Because in this region of parameters, investment in $A$ is excessive while investment in $B$ is insufficient from the point of view of social welfare maximization, the direction of innovation would deteriorate if acquisitions were allowed. In Region V we have a similar observation because this is a region of parameters in which investment in $A$ is insufficient and in $B$ excessive and an acquisition results in even less investment in $A$ and even more in $B$.

Finally, Regions III and VI represent parameter spaces where the impact of an acquisition on the direction of innovation is ambiguous. The reason for this ambiguity is that in these two regions of parameters the market moves from a portfolio where investment in project $A$ is excessive and in $B$ insufficient to a portfolio where investment in $A$ is insufficient and in $B$ excessive, or viceversa.

### 5.4 The impact of acquisitions on consumer surplus

We now explore the impact of start-up acquisitions on the welfare of consumers. Proposition 2 shows that, depending on profit values, the acquisition of the start-up may result in an alignment or misalignment between its portfolio of investments and that of the social planner. On this metric only, however, we cannot derive definitive conclusions about the impact of start-up acquisitions on consumer surplus. To do this, we need to consider not only the investment portfolio effects of the acquisitions as per Proposition 2 but also their associated negative price effects. Therefore, we compare consumer surplus in the no-acquisition case:

$$\mathbb{E}U(x_{na}^*) = \frac{x_{na}^*}{x_{na}^* + \epsilon_A} U_{A,s} + \frac{\epsilon_A}{x_{na}^* + \epsilon_A} U_{A,f} + \frac{1 - x_{na}^*}{1 - x_{na}^* + \epsilon_B} U_B, \tag{10}$$

to consumer surplus in the acquisition case:

$$\mathbb{E}U(x_a^*) = \frac{x_a^*}{x_a^* + \epsilon_A} U_{A,s}^m + \frac{\epsilon_A}{x_a^* + \epsilon_A} U_{A,f}^m + \frac{1 - x_a^*}{1 - x_a^* + \epsilon_B} U_B. \tag{11}$$

In this last formula, $U_{A,s}^m$ and $U_{A,f}^m$ denote the surpluses consumers derive in market $A$ in the acquisition case. These surpluses correspond to monopoly pricing and it naturally holds that $U_{A,s}^m \leq U_{A,s}$ and $U_{A,f}^m \leq U_{A,f}$.

The following result provides the consumer surplus implications of a ban on start-up acquisitions.

**Proposition 3.** *(i) Assume that* $\pi_{A,s}^m - \pi_{A,s}^E - \pi_{A,s}^I < \pi_{A,f}^m - \pi_{A,f}^E - \pi_{A,f}^I$ *so that, by Proposition 1,* $x_a^* < x_{na}^*$*. Then, there exists a threshold utility* $\overline{U}_B > 0$ *such that for all* $U_B < \overline{U}_B$*, a prohibition of acquisitions results in an increase in consumer surplus. For* $U_B > \overline{U}_B$*, a prohibition of acquisitions results in a decrease in consumer surplus.*

*(ii) Assume otherwise that* $\pi_{A,s}^m - \pi_{A,s}^E - \pi_{A,s}^I > \pi_{A,f}^m - \pi_{A,f}^E - \pi_{A,f}^I$ *so that, by Proposition 1,* $x_a^* > x_{na}^*$*. Then, if*

$$\frac{(x_a^* - x_{na}^*)\epsilon_A}{(x_a^* + \epsilon_A)} > \frac{x_{na}^*(U_{A,s} - U_{A,s}^m) + \epsilon_A(U_{A,f} - U_{A,f}^m)}{U_{A,s}^m - U_{A,f}^m}, \tag{12}$$

*there exists a threshold* $\underline{U}_B > 0$ *such that for all* $U_B < \underline{U}_B$ *a prohibition of acquisitions results in a decrease in consumer surplus. Otherwise, either when (12) does not hold or when* $U_B > \underline{U}_B$*, a prohibition of acquisitions results in an increase in consumer surplus.*

*Proof.* See the Appendix. □

Proposition 3 puts together the innovation and the price effects of acquisitions. When an acquisition deteriorates the direction of innovation (parameter regions II and V in Figure 1), consumer surplus cannot increase because an acquisition has, in addition, detrimental price effects. However, when an acquisition improves the direction of innovation (parameter regions I and IV in Figure 1) consumer surplus may increase if the price effects are sufficiently small. Proposition 3 puts forward two types of circumstances in which the positive direction of innovation effects of an acquisition dominate the detrimental price effects. The first situation arises in a subset of Region I where, in anticipation of an acquisition, the start-up moves its portfolio of investments away from the market of the acquiring firm. Proposition 3($i$) shows that when consumer surplus in market $B$ is sufficiently large, the decrease in the innovation distortion has a dominating influence over the increase in the price distortion in market $A$ and overall consumer surplus is higher when acquisitions are allowed. The second situation arises in a subset of Region IV where, in anticipation of an acquisition, the start-up moves its portfolio of investments towards the market of the acquiring firm. Proposition 3($ii$) provides conditions under which the surplus of consumers is higher if acquisitions are allowed. These conditions require consumer surplus in market $B$ to be sufficiently small and the price effects in market $A$ too.

### 5.5 Example

In this Section we present an illustrative example of interaction in market $A$ for which all our propositions hold. Specifically, we model interaction in the rival market explicitly as follows. Assume that demand in market $A$ stems from a unit mass of consumers with the well-known quality-augmented quadratic utility function introduced in Sutton [1997] (see also Sutton [2001]):

$$U^A = \sum_{i=1}^{2}\left[\alpha q_i - \left(\frac{\beta q_i}{s_i}\right)^2\right] - \sigma \sum_{i=1}^{2}\sum_{j<i}\frac{\beta q_i}{s_i}\frac{\beta q_j}{s_j} - \sum_{i=1}^{2} p_i q_i.$$

For tractability reasons, we assume away horizontal product differentiation by setting $\sigma = 2$.[15]

The incumbent's basic product has quality $s_\ell > 0$. If the start-up's investment effort in project $A$ turns out to be successful, we assume that the start-up enters the incumbent's market offering a product of higher quality $s_h$ than that of the incumbent, with $s_\ell < s_h < 2s_\ell$.[16] Otherwise, if investment in project $A$ results in failure, we assume that with probability $\mu \in [0, 1]$ the start-up enters the market with the same quality $s_\ell$ as the incumbent and with the remaining probability $1 - \mu$ is unable to enter the market.[17] The start-up and the incumbent engage in quantity competition in market $A$. We normalize the marginal cost of production to zero.

Utility maximization yields the system of demands for the (possibly) vertically differentiated products of the start-up and the incumbent:

$$p(q_i, q_j; s_i, s_j) = \alpha - \frac{2\beta^2 q_i}{s_i^2} - \frac{2\beta^2}{s_i}\frac{q_j}{s_j},\ \ i, j = h, \ell.$$

[15] We refer the reader to Section 5.5.1 for a discussion of the effects of substantial horizontal product differentiation.

[16] The restriction $s_h < 2s_\ell$ serves to rule out drastic innovations, that is, situations in which the incumbent firm would be forced to exit the market after a successful innovation of the entrepreneur. However, this assumption does not alter the main insights of our paper. For a detailed discussion, see Section 5.5.1.

[17] As we will see later, the parameter $\mu \in [0, 1]$ serves to modulate the price effects of acquisitions in case of project failure, which play an important role in the characterization of the effects of acquisitions on consumer surplus (cf. Proposition 3).

It is straightforward to solve for the quantities that constitute a Nash equilibrium of the possible continuation games. The profits and the consumer surplus levels corresponding to the Nash equilibria of the market stage when acquisitions are banned are described in Table 1 (for details see our working paper Dijk et al. [2022]).

| **No-acquisition game** | | |
|---|---|---|
| Project $A$ succeeds & $E$ enters with $s_h$ | | |
| Payoffs | | Utility |
| $\pi^E_{A,s} = \frac{\alpha^2(2s_h - s_\ell)^2}{18\beta^2}$ | $\pi^I_{A,s} = \frac{\alpha^2(2s_\ell - s_h)^2}{18\beta^2}$ | $U_{A,s} = \frac{\alpha^2}{36\beta^2}(s_h + s_\ell)^2$ |
| Project $A$ fails & $E$ enters with $s_\ell$ (prob. $\mu$) | | |
| Payoffs | | Utility |
| $\pi^E_{A,f} = \frac{\alpha^2 s_\ell^2}{18\beta^2}$ | $\pi^I_{A,f} = \frac{\alpha^2 s_\ell^2}{18\beta^2}$ | $U_{A,f} = \frac{\alpha^2 s_\ell^2}{9\beta^2}$ |
| Project $A$ fails & $E$ does not enter (prob. $1-\mu$) | | |
| Payoffs | | Utility |
| $\pi^E_{A,f} = 0$ | $\pi^I_{A,f} = \frac{\alpha^2 s_\ell^2}{8\beta^2}$ | $U_{A,f} = \frac{\alpha^2 s_\ell^2}{16\beta^2}$ |

Table 1: Market stage of the no-acquisition game: payoffs and utility

The first row of payoffs and utility in Table 1 correspond to the situation in which the start-up's investment in project $A$ is successful, in which case the start-up offers a product of high quality and competes with the incumbent's product of low, basic, quality. The second and third rows of payoffs and utility correspond to the case in which the start-up's investment in project $A$ is unsuccessful. The second row gives the payoffs and utility when the start-up enters the market with a low-quality product. The third row corresponds to the case in which project failure makes it impossible for the start-up to enter market $A$.

| **Acquisition game** | |
|---|---|
| Project $A$ succeeds & $E$ enters with $s_h$ | |
| Payoff | Utility |
| $\pi^m_{A,s} = \frac{\alpha^2 s_h^2}{8\beta^2}$ | $U^m_{A,s} = \frac{\alpha^2 s_h^2}{16\beta^2}$ |
| Project $A$ fails & $E$ enters with $s_\ell$ (prob. $\mu$) | |
| Payoff | Utility |
| $\pi^m_{A,f} = \frac{\alpha^2 s_\ell^2}{8\beta^2}$ | $U^m_{A,f} = \frac{\alpha^2 s_\ell^2}{16\beta^2}$ |
| Project $A$ fails & $E$ does not enter (prob. $1-\mu$) | |
| Payoff | Utility |
| $\pi^m_{A,f} = \frac{\alpha^2 s_\ell^2}{8\beta^2}$ | $U^m_{A,f} = \frac{\alpha^2 s_\ell^2}{16\beta^2}$ |

Table 2: Market stage of the acquisition game: payoffs and utility

Table 2 reports the profits and the consumer surplus levels corresponding to the acquisition game.

The reported profits and the consumer surplus levels thus correspond to the monopoly outcomes that ensue when acquisitions are allowed (for details see our working paper Dijk et al. [2022]). The first row of payoffs and utility in Table 2 correspond to the situation in which the start-up's investment in project $A$ is successful. After the acquisition of the start-up, the incumbent becomes a monopolist selling the high-quality product. The second and third rows of payoffs and utility refer to the alternative case in which the start-up's investment in project $A$ is unsuccessful, in which case, after the acquisition of the start-up, the incumbent operates as a monopolist selling a product of basic quality.

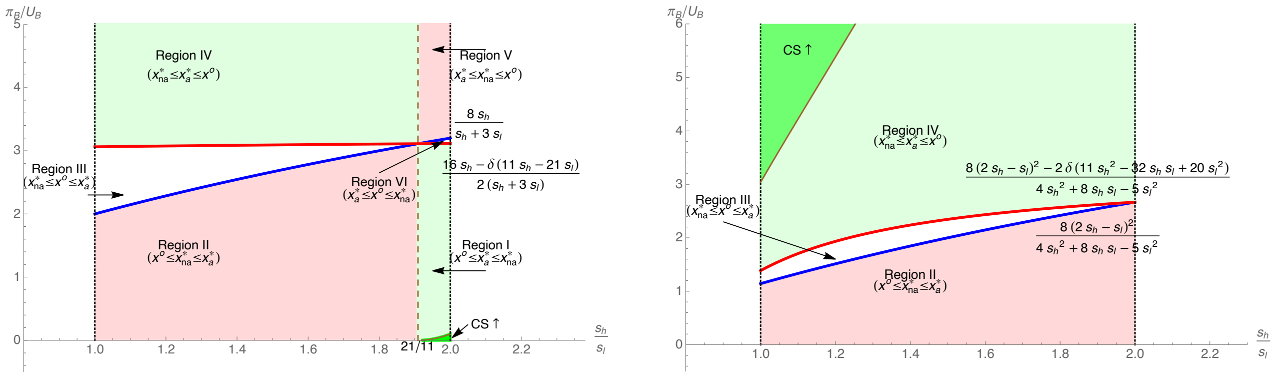
Once we are equipped with the expressions in Tables 1 and 2, it is straightforward to provide support for our Propositions 1-3 in terms of this micro-founded model. As stated in Proposition 1, anticipating its acquisition, the start-up distorts its investment in a direction that depends on whether the bargaining surplus generated by the acquisition in case of project success is greater or smaller than the bargaining surplus in case of an project failure. Specifically, the start-up, anticipating its acquisition, will move its portfolio of investments away from the market of the incumbent when

$$\frac{s_h}{s_\ell} > \frac{16 + \sqrt{36 - 11\mu}}{11}. \tag{13}$$

This condition is analogous to condition (7) for this micro-founded model. If this condition does not hold, the start-up, anticipating its acquisition, will move its portfolio of investments towards the market of the incumbent. The reason for this is intuitive. When $s_h$ is large compared to $s_\ell$, the rents from monopolization of the product market in case of project success are very limited because $\pi^m_{A,s}$ and $\pi^E_{A,s}$ are very close to one another. In fact, in the limit when $s_h \to 2s_\ell$, $\pi^E_{A,s} \to \pi^m_{A,s}$ and $\pi^I_{A,s} \to 0$ and therefore the LHS of (7) converges to zero. Meanwhile, the RHS of (7) is bounded above zero. When the difference between $s_h$ and $s_\ell$ is relatively small, the inequality in (7) is reversed and the start-up will invest more in project $A$ (and less in $B$).

We next use our micro-founded model to provide support for our results on the direction of innovation and consumer surplus (cf. Propositions 2 and 3). For this purpose we distinguish between the $\mu \to 1$ and $\mu \to 0$ cases. As mentioned in footnote 17, the value of $\mu$ serves to modulate the size of the price effects. In fact, as we see in Tables 1 and 2, when $\mu \to 0$ and the entrant cannot enter the market in case of failure, consumer surplus is the same no matter whether acquisitions are allowed or not. This implies that the overall price effects of acquisitions when $\mu \to 0$ are smaller than when $\mu \to 1$ and the entrant enters the market with a product similar to the incumbent's product.

In Figure 2(a) we reproduce Figure 1 for this micro-founded model in the case when $\mu \to 1$. The rest of the parameters are set to $\alpha = 3$, $\beta = 6$, $\delta = 0.85$, $\epsilon_A = 0.3$, $\epsilon_B = 2$ and $U_B = 1$. On the vertical axis we have $\pi_B/U_B$, which is a measure of surplus appropriability in market $B$. On the horizontal axis we have placed the ratio of qualities $s_h/s_\ell$, which is a measure of appropriability for market $A$. The red and the blue thresholds are computed in the same way as in Figure 1, that is, by comparing the private relative returns in the cases of acquisition (red) and no-acquisition (blue) with the social relative returns. The vertical threshold is equal to 21/11, which is equal to the RHS of (13) for $\mu \to 1$. The graph then shows the same 6 regions of parameters as in Figure 1. In the regions




(a) $\mu \to 1$ (b) $\mu \to 0$

Figure 2: Regions of parameters for which direction of innovation improves (light green) and consumer surplus increases (dark green) when acquisitions are allowed.

where the direction of innovation worsens (regions II and V) consumer surplus cannot increase. In the regions where the direction of innovation improves (regions I and IV), consumer surplus may increase provided that the price effects are sufficiently weak. Specifically, in region I the quality difference is relatively large, which implies that the decrease in expected consumer surplus in market $A$ is relatively small because the increase in the quantity distortion is rather limited. As a result, when consumer surplus in market $B$ is sufficiently large (cf. Proposition 3(i)), the decrease in the innovation distortion has a dominating influence over the increase in the quantity distortion in market $A$. Consequently, a prohibition of acquisitions reduces the overall expected consumer surplus. This occurs in the small dark green area in Figure 2(a). Otherwise, when consumer surplus in market $B$ is not sufficiently large, expected consumer surplus increases if acquisitions are prohibited. In region IV, when $s_h$ is not very large compared to $s_\ell$, the increase in the quantity distortion (price effects) is sizeable. Even though the distortion in the direction of innovation becomes smaller after an acquisition, this effect is not sufficiently strong to offset the negative price effects. In terms of Proposition 3(ii), condition (12) never holds in this micro-founded model when $\mu \to 1$ and prohibiting acquisitions results in an increase in consumer surplus.[18]

In Figure 2(b) we reproduce Figure 1 for the situation when $\mu \to 0$, in which case the start-up does not enter the market upon project failure. In this figure we set $\alpha = 3$, $\beta = 2$, $\delta = 0.85$, $\epsilon_A = 2$, $\epsilon_B = 2$ and $U_B = 0.1$. When $\mu \to 0$, (13) cannot hold and hence the start-up will always increase its investment in project $A$ in anticipation of its acquisition. As a result, regions I, V and VI vanish. In contrast to the case when $\mu \to 1$, consumer surplus may rise when an acquisition results in an increase in the investment in project $A$. The difference is that the price effects in case of project failure are now negligible. As a result, the improvement in the direction of innovation in region IV may be sufficiently strong so as to generate an increase in consumer surplus. This occurs in the dark green area of Figure 2(b) where the condition (12) in Proposition 3(ii) holds.

[18]For the proof of this statement, we refer the reader to our working paper Dijk et al. [2022] (see Proposition 5).

### 5.5.1 Robustness

In the above example, we have made several assumptions, most notably that successful innovations are non-drastic, that there is only one incumbent operating in the rival market, and that products are only vertically differentiated. In our working paper Dijk et al. [2022] we explore the robustness of our main results when we relax these assumptions. The main takeaways from these extensions are two. First, the positive effects of allowing for acquisitions are robust in that they lead the start-up to move its investment portfolio sometimes towards the market of the acquiring firm and sometimes away (depending on the extension considered and the model parameters). Second, regardless of how the investment portfolio changes (towards or away from the incumbent's market), from a normative point of view, the direction of innovation may improve or worsen. We next report our findings and refer the reader to our working paper for the details.

Suppose we allow for successful innovations to be drastic, i.e. $s_h > 2s_\ell$. In such a case, the innovator will monopolize market $A$ upon success. It turns out that the start-up, anticipating its acquisition, will always decrease investment in project $A$, and increase it in $B$ by implication. The reason for this should be obvious by now because the acquisition rents are equal to zero when project $A$ is successful, whereas they are positive when project $A$ fails so inequality (7) always holds. In terms of the discussion around Figure 2(a), this means that the parameter spaces depicted by the regions I, V and VI cover the entire set of possibilities (and the regions of parameters II, III and IV no longer exist). By the same argument as in Proposition 2(i), this innovation portfolio adjustment may improve the direction of innovation in Region I. Moreover, provided that project $B$ is sufficiently attractive for consumers, start-up acquisitions may be consumer welfare improving in this region as per Proposition 3(i).

When there are $n \geq 2$ incumbents, start-up acquisitions may no longer be incentive-compatible. The reason for this is that in our model firms compete in quantities and, as it is well-known, the so-called *merger paradox* holds under some conditions. Specifically, suppose the start-up's investment in project $A$ is successful. In that case, only if $s_h$ is sufficiently large compared to $s_\ell$ is a merger incentive-compatible. Alternatively, suppose the start-up's investment in project $A$ is futile. In that case, even if the start-up produces the same quality as the rest of the incumbents an acquisition of the start-up is not incentive-compatible. We show that if acquisitions occur upon success, then they always result in an increase in the start-up's investment in project $A$ and, correspondingly, in a decrease in investment in project $B$. The reason for this is that when the number of incumbents is $n \geq 2$ there is no bargaining surplus in case of an unsuccessful project whatsoever, while in case of success the bargaining surplus is positive. In terms of the discussion around Figure 2(a), this means that with $n \geq 2$ incumbents the parameter spaces depicted by the regions II, III and IV cover the entire set of possibilities (so the regions of parameters I, V and VI no longer exist). We conclude then that the direction of innovation may continue to improve with $n \geq 2$ incumbents. Despite this, in our working paper we show that, by the same arguments as in Propositions 2(ii) and 3(ii), prohibiting acquisitions results in an increase in consumer surplus when $\mu \to 1$.

When products are also horizontally differentiated, so letting $0 < \sigma < 2$, we need to assume

$s_h < \frac{4}{\sigma}s_\ell$ for otherwise the incumbent does not produce after a successful innovation by the start-up (i.e. the innovation is drastic). Moreover, when products are also horizontally differentiated, it is sometimes the case that the acquirer becomes a multi-product monopolist and offers the two qualities in the market. This occurs when $s_h < \frac{2}{\sigma}s_\ell$. Alternatively, when $s_h > \frac{2}{\sigma}s_\ell$, as it was the case in the main body of the paper, the acquirer does not find it profitable to offer both qualities and instead offers only the high-quality product. Focusing on the former case in which the acquirer puts both products in the market and an acquisition is always incentive compatible, we show that relative to the no-acquisition case, the start-up always puts more effort into project $A$ (and therefore less into project $B$), i.e. $x^*_{na} < x^*_a$. What happens is that the additional rents that a successful innovation generates in market $A$ are always greater than those generated in case the innovation fails. In terms of Figure 2(a), we lose again regions I, V and VI. In the remaining regions the effects on the direction of innovation are the same as in the main model, that is, the direction of innovation may improve or worsen as per Proposition 2(ii). Price effects are however so strong that consumer surplus does not increase despite the improvement in the direction of innovation.

# 6 On the timing of acquisitions: the Arrow replacement effect

In our main model, we have assumed that the incumbent acquires the start-up once the outcome of its research effort is known. As we have argued in the Introduction, this timing seems a sensible modelling choice to model start-up acquisitions in the digital industry. However, in the pharmaceutical industry, many acquisitions take place much earlier in the process. In this section, we examine an alternative setting where, when acquisitions are allowed, the incumbent takes over the start-up's research facilities and the innovation portfolio decisions. We then solve a different acquisition game where, first, the incumbent and the start-up negotiate over the expected acquisition surplus, second, the joint entity chooses its portfolio of investments and finally the joint entity produces after knowing the outcome of its research efforts in projects $A$ and $B$. Because the no-acquisition benchmark is exactly the same as that in Section 5 we move directly to the case in which the incumbent takes over the start-up.

## 6.1 Acquisitions

When acquisitions are allowed, the joint entity chooses its portfolio of investments again as in equation (2) but taking into account that the relative returns $R_A/R_B$ on the projects are given by the ratio:

$$\frac{\pi^m_{A,s} - \pi^m_{A,f}}{\pi_B}. \tag{14}$$

The returns from project $B$ are exactly identical to those in the no-acquisition case. However, the returns from project $A$ are different and equal to the expression $\pi^m_{A,s} - \pi^m_{A,f}$; this expression represents the difference between the monopoly profits the joint entity obtains when project $A$ is successful and the monopoly profits it gets when project $A$ is unsuccessful.

Let us denote by $x^m_a$ the joint entity's investment in project $A$ when an acquisition is allowed.

Making use of equation (2), $x_a^m$ is given by:

$$x_a^m \equiv x\left(\frac{\pi_{A,s}^m - \pi_{A,f}^m}{\pi_B}; \epsilon_A, \epsilon_B\right). \tag{15}$$

The rest of the budget, i.e. $1 - x_a^m$, is invested in project $B$.

## 6.2 The impact of an acquisition on the direction of innovation

A comparison of the equilibrium investment portfolio when acquisitions are banned with that when acquisitions are allowed leads to the following result.

**Proposition 4.** *Suppose the incumbent takes over the research facilities of the start-up. Then:*

*(i) The investment effort put into project $A$ by the joint entity is lower than (and therefore that in project $B$ higher than) that of the start-up, i.e. $x_a^m < x_{na}^*$, if and only if*

$$\pi_{A,s}^m - \pi_{A,f}^m < \pi_{A,s}^E - \pi_{A,f}^E. \tag{16}$$

*(ii) Otherwise, when the above inequality is reversed, the investment effort put into project $A$ by the joint entity is higher than (and therefore that in project $B$ is lower than) that of the start-up, i.e. $x_a^m > x_{na}^*$.*

The start-up and the joint entity hold distinct investment portfolios. The reason for this is that, in the no-acquisition case, the start-up's marginal gains from investing in project $A$ are proportional to the profit difference $\pi_{A,s}^E - \pi_{A,f}^E$. By contrast, in the acquisition case, the joint entity's marginal gains from investing in project $A$ are related to the profits difference $\pi_{A,s}^m - \pi_{A,f}^m$. When $\pi_{A,s}^E - \pi_{A,f}^E > \pi_{A,s}^m - \pi_{A,f}^m$ the start-up's incentive to invest in project $A$ is greater than the acquirer's incentive.

These profit differences represent the incremental gains for the two actors from selling a high-quality product in market $A$ relative to selling a low-quality product. For both actors, we observe the so-called Arrow replacement effect. In fact, when project $A$ turns out to be successful, the start-up replaces its competitor-self with a low-quality product by a competitor-self with a high-quality product. Similarly, the joint entity replaces a monopoly-self with a low-quality product by a monopoly-self with a high-quality product.

Depending on how these profits differences compare to one another, the replacement effect of the entrant can be more or less severe than that of the joint entity. Hence, Proposition 4 confirms that also in this setting where acquisitions take place earlier in the process, the prospect of an acquisition may move the portfolio of investments either towards or away from the market of the acquiring firm.

We now investigate the impact of such alteration from a normative point of view. As in Section 5.3, we consider a social planner who chooses investment levels in projects $A$ and $B$ to maximize consumer surplus. While deciding on the investment levels, the social planner takes as given the surplus levels that consumers obtain in the no-acquisition case. Therefore, the socially optimal investment in project $A$, which we again denote by $x^o$, is the same as before and is given by (9). Our next proposition compares the portfolios of investments in (4), (9) and (15) to describe how an acquisition affects the direction of innovation activity.

**Proposition 5.** *Suppose the incumbent takes over the research facilities of the start-up. Then:*

*(i) Assume that* $\pi^m_{A,s} - \pi^m_{A,f} < \pi^E_{A,s} - \pi^E_{A,f}$ *so that the joint entity reduces investment in project A and increases it in project B. Then:*

- *if* $\frac{\pi_B}{U_B} < \frac{\pi^m_{A,s} - \pi^m_{A,f}}{U_{A,s} - U_{A,f}}$, *then* $x^o < x^m_a < x^*_{na}$ *and thus an acquisition improves the direction of innovation;*
- *if* $\frac{\pi_B}{U_B} > \frac{\pi^E_{A,s} - \pi^E_{A,f}}{U_{A,s} - U_{A,f}}$, *then* $x^m_a < x^*_{na} < x^o$ *and thus an acquisition worsens the direction of innovation.*

*(ii) Assume that* $\pi^m_{A,s} - \pi^m_{A,f} > \pi^E_{A,s} - \pi^E_{A,f}$ *so that the joint entity increases investment in project A and decreases it in project B. Then:*

- *if* $\frac{\pi^B}{U^B} > \frac{\pi^m_{A,s} - \pi^m_{A,f}}{U_{A,s} - U_{A,f}}$, *then* $x^*_{na} < x^m_a < x^o$ *and thus an acquisition improves the direction of innovation;*
- *if* $\frac{\pi^B}{U^B} < \frac{\pi^E_{A,s} - \pi^E_{A,f}}{U_{A,s} - U_{A,f}}$, *then* $x^o < x^*_{na} < x^m_a$ *and thus an acquisition worsens the direction of innovation.*

The proof of this result follows the same steps as in Proposition 2 and is therefore omitted. The result in Proposition 5 is similar to that in Proposition 2 in that it provides conditions under which an acquisition may result in an alignment or in a misalignment of the private incentives to invest with the social incentives. Building on this proposition, we can construct Figure 3, which is similar to Figure 1 in that it divides the parameter space into 6 regions for which the green areas denote parameter regions where the direction of innovation improves and the red areas parameter regions where the direction of innovation worsens.

The impact of acquisitions on consumer surplus in this setting where the incumbent takes over the innovation portfolio decisions is similar to that in the "innovation for buyout" setting and we omit providing a detailed result. In regions I, V and VI of Figure 3 where investment in project $A$ decreases, part (i) of Proposition 3 applies. In regions II, III and IV of Figure 3 where investment in project $A$ increases when acquisitions occur, part (ii) of Proposition 3 applies. We then conclude that the results on direction of innovation and consumer surplus are aligned no matter whether acquisitions occur after the start-up chooses its investment portfolio or before.

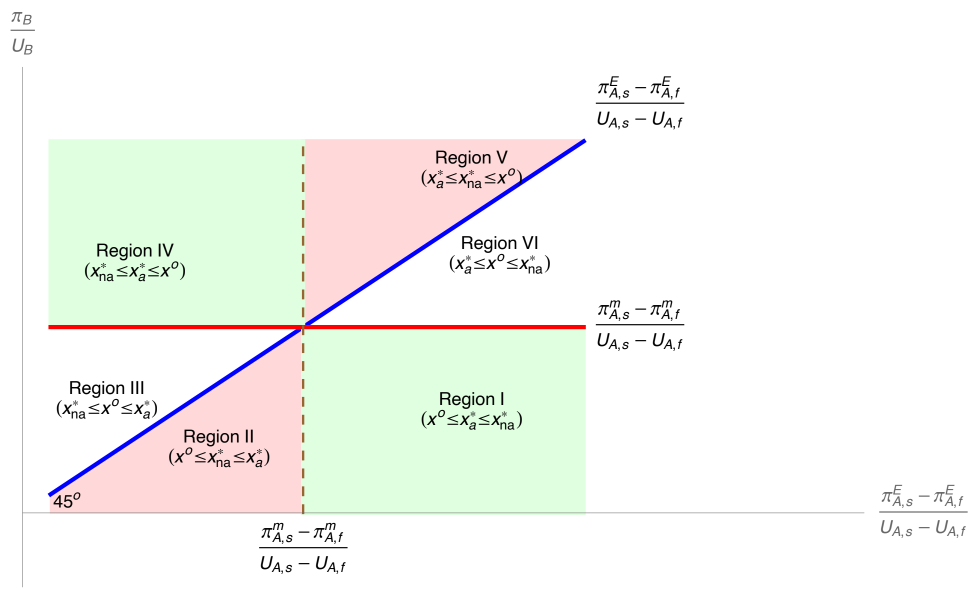



Figure 3: Private and socially optimal innovation portfolios when incumbent takes over research facility of start-up.

### 6.3 Comparison of the "innovation for buyout" and the Arrow replacement effects

It is interesting to compare the conditions under which an acquisition moves the portfolio of investments towards the market of the acquiring firm across the two timing scenarios. In the "innovation for buyout" scenario, the start-up invests more (less) in project $A$ if the acquisition rents when project $A$ is successful are higher (lower) than when it is unsuccessful. This requires that $\pi^m_{A,s} - (\pi^E_{A,s} + \pi^I_{A,s}) > (<) \pi^m_{A,f} - (\pi^E_{A,f} + \pi^I_{A,f})$. This condition can be rewritten as:

$$\pi^m_{A,s} - \pi^m_{A,f} > (<) \pi^E_{A,s} - \pi^E_{A,f} + \underbrace{(\pi^I_{A,s} - \pi^I_{A,f})}_{<0},$$

where the expression in parenthesis on the RHS is negative (as indicated). This implies that if the Arrow replacement effect gives the joint entity incentives to invest more in project A then so does the "innovation for buyout" effect to the start-up. Likewise, if the "innovation for buyout" effect reduces the incentives of the start-up to invest in project A, then the Arrow replacement effect will also weaken the incentives to invest in project $A$ of the joint entity. Together, this means there exist circumstances for which the timing of acquisitions has no bearing on the qualitative effect of acquisitions on the portfolio adjustment. It should then be clear that under such circumstances, acquisitions have the same qualitative impact on the direction of innovation no matter the timing at which they occur.

By contrast, when

$$\pi^E_{A,s} - \pi^E_{A,f} + (\pi^I_{A,s} - \pi^I_{A,f}) < \pi^m_{A,s} - \pi^m_{A,f} < \pi^E_{A,s} - \pi^E_{A,f},$$

then the innovation for buyout effect gives the start-up incentives to invest more in project A in anticipation of its acquisition while the Arrow replacement effect leads the joint entity to invest less in project $A$. This difference in results is due to the extent to which acquisition rents accrue to the decision-maker. In the first timing, the start-up does not factor the rents left to the acquirer into its decision, while the joint entity internalizes all the rents generated by the investment.

### 6.4 Example

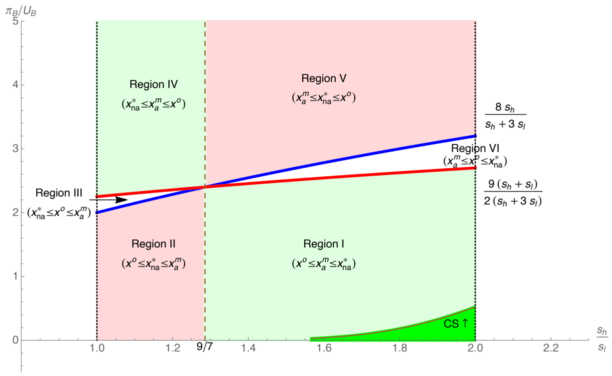
We now return to the micro-founded model of Section 5.5 to provide support for our results when the acquirer takes over the research facilities of the start-up. As explained in Proposition 4, relative to the no-acquisition case, the joint entity distorts its investment in a direction that depends on whether the Arrow replacement effect is larger for the incumbent or the start-up. Plugging the profit expressions from Tables 1 and 2 into condition (16) and solving the inequality, we obtain that the joint entity will move its portfolio of investments away from the market of the incumbent if and only if either of the following conditions hold:

$$\begin{aligned}&(i)\ \mu < 27/28\\&(ii)\ \frac{27}{28} < \mu \le 1 \text{ and } \frac{s_h}{s_\ell} > \frac{8+\sqrt{28\mu-27}}{7}\\&(iii)\ \frac{27}{28} < \mu \le 1 \text{ and } \frac{s_h}{s_\ell} < \frac{8-\sqrt{28\mu-27}}{7}.\end{aligned} \tag{17}$$

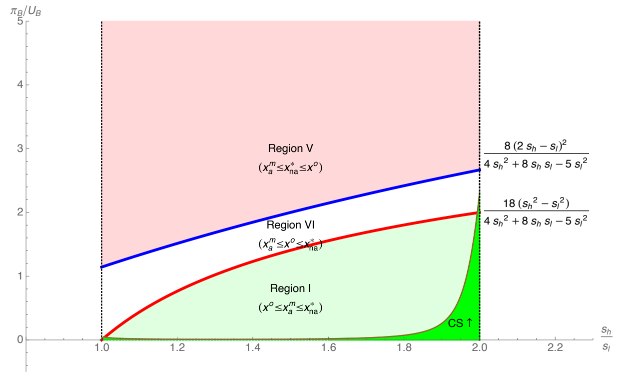
Otherwise, i.e. when $\frac{27}{28} < \mu \le 1$ and $\frac{8-\sqrt{28\mu-27}}{7} < \frac{s_h}{s_\ell} < \frac{8+\sqrt{28\mu-27}}{7}$, the joint entity will move its portfolio of investments towards market $A$.

Condition in (17) is clearly more intricate than the analog condition (13) under which the "innovation for buyout" effect results in the start-up moving its portfolio of investments away from the market of the incumbent firm. Nevertheless, we obtain the same qualitative result, namely, that when acquisitions are allowed, the acquirer sometimes adjusts the start-up's investment portfolio towards its market and sometimes away from it. To illustrate further, let us consider the cases $\mu \to 1$ and $\mu \to 0$. We have represented these cases in Figure 4. Figure 4(a), where we set the parameters to $\alpha = 3$, $\beta = 6$, $\epsilon_A = 0.3$, $\epsilon_B = 2$ and $U_B = 1$, plots the limiting case $\mu \to 1$. In this figure, we again use Tables 1 and 2 to compute the red and blue thresholds, which are derived by comparing the relative returns in the cases of acquisition (red) and no-acquisition (blue) with the social relative returns. When $\mu \to 1$ condition (17) boils down to the condition $s_h > 9s_\ell/7$. So for this region of parameters, the replacement effect of the entrant is less severe than that of the acquirer and investment in project $A$ decreases if acquisitions are allowed. This occurs in regions I, V and VI of Figure 4(a). In these regions the start-up benefits relatively more from obtaining the high quality product than the joint entity does. Hence, the joint entity invests less in project $A$ in the acquisition case than the entrant does in the no-acquisition case. Otherwise, when $s_h < 9s_\ell/7$, the replacement effect of the joint entity will be less severe than the start-up's and investment in project $A$ will correspondingly go up if acquisitions are allowed. This occurs in regions II, III and IV of Figure 4(a).

As in the main model of acquisitions studied in Sections 5, in the regions where the direction of




(a) $\mu \to 1$




(b) $\mu \to 0$

Figure 4: Incumbent takes over research facility of start-up. Regions of parameters for which direction of innovation improves (light green) and consumer surplus increases (dark green) when acquisitions are allowed.

innovation worsens (regions II and V) consumer surplus cannot increase while in the regions where the direction of innovation improves (regions I and IV), consumer surplus may increase provided that the price effects are sufficiently weak. When consumer surplus in market $B$ is sufficiently large, in region I the decrease in the innovation distortion has a dominating influence over the increase in the quantity distortion in market $A$ (cf. Proposition 3(i)). In that case, a prohibition of acquisitions reduces the overall expected consumer surplus. This occurs in the dark green area in Figure 4(a). Otherwise, when consumer surplus in market $B$ is not sufficiently large, expected consumer surplus increases if acquisitions are prohibited. In region IV, the increase in the quantity distortion dominates the improvement in the direction of innovation so that condition (12) in Proposition 3(ii) cannot hold. In such a case, prohibiting acquisitions results in an increase in consumer surplus.[19]

When $\mu \to 0$, the joint-entity will move its portfolio of investments away from the rival market. The replacement effect of the joint entity is always more severe than that of the entrant. As a result, the start-up's incentive to invest in project $A$ is always greater than the acquirer's incentive. In contrast to the first timing, regions II, III and IV vanish and we are left with a graph as in Figure 4(b), where we have plotted the case of $\mu \to 0$. In this graph we fix the parameters to $\alpha = 3$, $\beta = 2$, $\epsilon_A = 0.2$, $\epsilon_B = 0.2$ and $U_B = 0.2$. As before, in region I overall expected consumer surplus may increase provided that consumer surplus in market $B$ is sufficiently large (cf. Proposition 3(i)). This occurs in the dark green area in Figure 4(b).

### 6.4.1 Robustness

We have also checked the robustness of our main results when we relax the assumptions that innovations are non-drastic and that there is only one incumbent in the market. For details, see our working paper Dijk et al. [2022]. We conclude again that, depending on the extension considered and the model parameters, allowing for acquisitions leads the start-up to adjust its investment portfolio

[19]The proof of this statement for $\mu = 1$ can be found in our working paper Dijk et al. [2022] (see Proposition 9) but it is straightforward to extend it to $\mu \in (27/28, 1)$. The detailed derivations are available from the authors upon request.

sometimes towards the market of the acquiring firm and sometimes away. Further, such adjustment of the investment portfolio causes the direction of innovation to improve or worsen from the point of view of social welfare maximization.

Specifically, with $n \geq 2$ incumbents, conditional on the acquisition of the start-up being incentive-compatible, the acquirer's optimal investment portfolio is computed factoring in expression (2) the Cournot profits of a high-quality seller competing with $n-1$ low-quality rivals as returns from a successful rival project, and the Cournot profits of a low-quality seller competing with $n-1$ symmetric rivals as returns from a futile rival project. This modification alters the expressions for the blue and red curves and the vertical threshold that appear in Figure 4(a) and divide the region of parameters into the six distinct areas. In our working paper we show that when $\mu \to 1$ an increase in the number of incumbents only results in quantitative changes, that is, all six regions remain and our results concerning direction of innovation and consumer surplus effects in Propositions 3, 4 and 5 do not qualitatively change. A lower $\mu$ only makes condition (16) more likely to hold, which implies that regions II, III and IV become smaller and, similarly to Figure 4(b), tend to vanish when $\mu \to 0$.

Regarding the case of drastic innovations, all the remarks made in Section 5.5.1 also apply here because, given that the monopoly profits in case of success are equal to the entrant's profits in case of success, the inequality in (16) always holds.

# 7 Policy recommendations

Our results serve as a basis for some antitrust recommendations. The first observation is that a policy change towards tighter regulation of acquisitions may have both positive and negative effects on the direction of innovation and consumer welfare. This implies that blanket prohibitions of start-up acquisitions are not recommended, but rather a case-by-case assessment is preferred.

Our recommendations for case-by-case assessments are best described by referring to the notion of surplus appropriability in a market. If acquisitions are allowed and surplus appropriability is high in the market of the acquiring firm, then rent-seeking start-ups will tend to displace investment from the market of the acquiring firm to other markets. This displacement will improve the direction of innovation when surplus appropriability in the alternative markets is low, and worsen it otherwise. Likewise, if acquisitions are allowed and surplus appropriability is low in the market of the acquiring firm, then rent-seeking start-ups will tend to move investment from other markets towards the market of the acquiring firm. This portfolio adjustment will improve the direction of innovation provided that surplus appropriability in other markets is high, and deteriorate it otherwise. Hence, if the policy maker is mainly preoccupied about direction of innovation, the policy advice is to allow acquisitions if projects differ significantly in appropriability.

The policy maker may not just care about direction of innovation but about overall consumer surplus. In that case, the positive direction of innovation effects have to be compared to the negative price effects of acquisitions. Our analysis provides the following guidelines. When the direction of innovation improves due to the investment portfolio moving towards the market of the incumbent firm and innovations in such a market are incremental, then it is likely that consumer surplus increases. Alternatively, an increase in consumer surplus is possible when the direction of innovation improves due to a move of the investment portfolio towards alternative markets and innovations in the market of the incumbent are sizable.

## 8 Conclusions

Start-up acquisitions have recently spurred much interest among politicians, policy makers and academicians. Many have argued that merger policy has been extremely lenient when it comes to start-up acquisitions and have called for reform. Others have warned that blanket prohibitions are not desirable because they may reduce the incentive for innovation. This paper has contributed to this debate by examining start-up acquisitions from a new angle. In particular, we have asked how the palette of innovation projects of a start-up is affected by acquisitions.

To this end, we have formulated a novel model of an industry with an incumbent and an entrant start-up. The start-up engages in an investment portfolio problem by choosing how to allocate funds across a rival project, intended to challenge the incumbent's dominant position, and a non-rival project. Motivated by the private returns of its projects, a start-up picks a socially suboptimal investment portfolio. We have then examined how an acquisition impacts the optimality of the equilibrium portfolio of projects and consumer surplus.

We have first shown that, anticipating an acquisition, the start-up, purely motivated by rent-seeking, strategically distorts its investment portfolio towards or away from the market of the acquiring firm. Second, we have demonstrated that such adjustment may improve of worsen the direction in which innovation goes from a normative point of view. Finally, we have shown that when the direction of innovation improves, its improvement may be so large so as to dominate the usual quantity distortion. These results have added to the literature by pointing out a new way in which the "innovation for buyout" argument may increase consumer surplus. Later in the paper we have turned to settings in which the acquirer takes over the research facilities of the start-up. In those settings, we have seen how both the start-up and the acquirer face the so-called Arrow "replacement effect" and that it is not necessarily the case that the replacement effect is stronger for acquirers than for start-ups. Also in such settings we have demonstrated that acquisitions may improve or worsen the direction of innovation and hence increase or decrease consumer surplus.

Our analysis can easily be extended to settings where the start-up not only chooses how to allocate its budget across the rival and its non-rival projects but also the magnitude of the budget. It is straightforward to show that when acquisition rents in case of project success are higher than in case of project failure, a start-up, anticipating its acquisition, will increase aggregate investment and move its investment portfolio towards the market of the incumbent, i.e. it will increase investment in project A and decrease it in project B. When acquisition rents in case of project success are instead lower than those in case of project failure, a start-up will decrease aggregate investment and move its investment portfolio away from the market of the incumbent. Therefore, under conditions, allowing for acquisitions may boost investment, improve the direction of innovation and hence increase consumer surplus.

Finally, the qualitative nature of our results should continue to hold even if the incumbent is also active in research and chooses how to allocate its investment budget across the rival project and its other projects. This is most easily seen in the setting where, if acquisitions are permitted, the incumbent takes over the research facilities of the start-up (cf. Section 6). Because the non-rival projects of the entrant and the incumbent do not overlap, it is straightforward to conclude that an acquisition always results in a decrease in joint investment in the rival project. This is the standard insight from merger theory that arises from the internalization of the negative externalities that the entrant and the incumbent impose on one another in the rival market. Because a reduction in aggregate investment in the rival project may improve the direction of innovation and consumer surplus, our conclusion that some acquisitions should be permitted continues to hold even if the incumbent is also active in research.

## Appendix

**Proof of Proposition 1**

The proof of this result follows easily from a comparison of $x^*_{na}$ in (4) and $x^*_a$ in (6). We know from Lemma 1 that investment in the rival project $A$ is increasing in the ratio of relative returns, the result follows from comparing the numerators of (3) and (5). The comparison of such returns gives condition (7). $\square$

**Proof of Proposition 2**

Part (i). We first prove that $x^o < x^*_a < x^*_{na}$ under the stated conditions. Notice that the inequality $\pi^m_{A,s} - (\pi^E_{A,s} + \pi^I_{A,s}) < \pi^m_{A,f} - (\pi^E_{A,f} + \pi^I_{A,f})$ implies $x^*_a < x^*_{na}$ as per Proposition 1. The inequality $x^o < x^*_a$ follows from comparing (6) and (9). The investment level in (9) will be below that in (6) when $\frac{\pi_B}{U_B} < \frac{\pi^E_{A,s} - \pi^E_{A,f} + \delta[\pi^m_{A,s} - (\pi^E_{A,s} + \pi^I_{A,s}) - (\pi^m_{A,f} - (\pi^E_{A,f} + \pi^I_{A,f}))]}{U_{A,s} - U_{A,f}}$. The alternative set of inequalities, $x^*_a < x^*_{na} < x^o$, is proven in the same way but comparing (4) and (9).

Part (ii) is proven similarly. The first set of inequalities, $x^*_{na} < x^*_a < x^o$, follows from part (ii) of Proposition 1 and a comparison of (6) and (9). The second set of inequalities $x^o < x^*_{na} < x^*_a$ follows from part (ii) of Proposition 1 and comparison of (4) and (9). $\square$

**Proof of Proposition 3**

$(i)$ Assume that $\pi^m_{A,s} - \pi^E_{A,s} - \pi^I_{A,s} < \pi^m_{A,f} - \pi^E_{A,f} - \pi^I_{A,f}$, in which case, $x^*_a < x^*_{na}$. This directly implies that the expected consumer surplus in market $B$ is lower if acquisitions are prohibited, i.e.:

$$\frac{1 - x^*_{na}}{1 - x^*_{na} + \epsilon_B} U_B < \frac{1 - x^*_a}{1 - x^*_a + \epsilon_B} U_B. \tag{18}$$

To show the result, we now note that because $U^m_{A,s} \le U_{A,s}$ we have:

$$\frac{x^*_{na}}{x^*_{na} + \epsilon_A} U^m_{A,s} = \left( \frac{x^*_a}{x^*_a + \epsilon_A} + \frac{\epsilon_A}{x^*_a + \epsilon_A} - \frac{\epsilon_A}{x^*_{na} + \epsilon_A} \right) U^m_{A,s} \le \frac{x^*_{na}}{x^*_{na} + \epsilon_A} U_{A,s}.$$

Further, because $U^m_{A,f} \le U^m_{A,s}$, we have:

$$\frac{x^*_a}{x^*_a + \epsilon_A} U^m_{A,s} + \left( \frac{\epsilon_A}{x^*_a + \epsilon_A} - \frac{\epsilon_A}{x^*_{na} + \epsilon_A} \right) U^m_{A,f} \le \frac{x^*_{na}}{x^*_{na} + \epsilon_A} U_{A,s}.$$

Furthermore, because $U^m_{A,f} \le U_{A,f}$, we can write

$$\frac{x^*_a}{x^*_a + \epsilon_A} U^m_{A,s} + \left( \frac{\epsilon_A}{x^*_a + \epsilon_A} - \frac{\epsilon_A}{x^*_{na} + \epsilon_A} \right) U^m_{A,f} + \frac{\epsilon_A}{x^*_{na} + \epsilon_A} U^m_{A,f} \le \frac{x^*_{na}}{x^*_{na} + \epsilon_A} U_{A,s} + \frac{\epsilon_A}{x^*_{na} + \epsilon_A} U_{A,f}.$$

Simplifying gives:

$$\frac{x^*_a}{x^*_a + \epsilon_A} U^m_{A,s} + \frac{\epsilon_A}{x^*_a + \epsilon_A} U^m_{A,f} < \frac{x^*_{na}}{x^*_{na} + \epsilon_A} U_{A,s} + \frac{\epsilon_A}{x^*_{na} + \epsilon_A} U_{A,f}, \tag{19}$$

which means that the expected consumer surplus in market A is higher if acquisitions are prohibited.

Because the expected consumer surplus is a continuous function of $U_B$, putting together (18) and (19) implies the result.

$(ii)$ Suppose now that $\pi^m_{A,s} - \pi^E_{A,s} - \pi^I_{A,s} > \pi^m_{A,f} - \pi^E_{A,f} - \pi^I_{A,f}$. In that case, $x^*_{na} < x^*_a$ and therefore the expected consumer surplus in market $B$ is higher if acquisitions are prohibited, i.e.:

$$\frac{1 - x^*_a}{1 - x^*_a + \epsilon_B} U_B < \frac{1 - x^*_{na}}{1 - x^*_{na} + \epsilon_B} U_B. \tag{20}$$

Regarding market $A$, the expected consumer surplus in market $A$ is also higher if acquisitions are prohibited if and only if:

$$\frac{x^*_a}{x^*_a + \epsilon_A} U^m_{A,s} + \frac{\epsilon_A}{x^*_a + \epsilon_A} U^m_{A,f} < \frac{x^*_{na}}{x^*_{na} + \epsilon_A} U_{A,s} + \frac{\epsilon_A}{x^*_{na} + \epsilon_A} U_{A,f}, \tag{21}$$

Let $\Delta \equiv U_{A,f} - U^m_{A,f}$. Then, rewriting (21) gives:

$$\frac{x^*_a}{x^*_a + \epsilon_A} U^m_{A,s} + \frac{\epsilon_A}{x^*_a + \epsilon_A} U^m_{A,f} < \frac{x^*_{na}}{x^*_{na} + \epsilon_A} U_{A,s} + \frac{\epsilon_A}{x^*_{na} + \epsilon_A} (\Delta + U^m_{A,f}),$$

Note now that $\frac{x^*_a}{x^*_a + \epsilon_A} = \frac{x^*_{na}}{x^*_{na} + \epsilon_A} + \frac{\epsilon_A}{x^*_{na} + \epsilon_A} - \frac{\epsilon_A}{x^*_a + \epsilon_A}$.

$$\left( \frac{x^*_{na}}{x^*_{na} + \epsilon_A} + \frac{\epsilon_A}{x^*_{na} + \epsilon_A} - \frac{\epsilon_A}{x^*_a + \epsilon_A} \right) U^m_{A,s} + \frac{\epsilon_A}{x^*_a + \epsilon_A} U^m_{A,f} < \frac{x^*_{na}}{x^*_{na} + \epsilon_A} U_{A,s} + \frac{\epsilon_A}{x^*_{na} + \epsilon_A} (\Delta + U^m_{A,f}),$$

$$\frac{x^*_{na}}{x^*_{na} + \epsilon_A} \left( U^m_{A,s} - U_{A,s} \right) + \frac{\epsilon_A}{x^*_{na} + \epsilon_A} \left( U^m_{A,s} - U^m_{A,f} - \Delta \right) + \frac{\epsilon_A}{x^*_a + \epsilon_A} \left( U^m_{A,f} - U^m_{A,s} \right) < 0,$$

$$\frac{\epsilon_A}{x^*_{na} + \epsilon_A} \left( U^m_{A,s} - U^m_{A,f} \right) < \frac{x^*_{na}}{x^*_{na} + \epsilon_A} \left( U_{A,s} - U^m_{A,s} \right) + \frac{\epsilon_A}{x^*_a + \epsilon_A} \left( U^m_{A,s} - U^m_{A,f} \right) + \frac{\epsilon_A}{x^*_{na} + \epsilon_A} \Delta,$$

$$\left( \frac{\epsilon_A}{x^*_{na} + \epsilon_A} - \frac{\epsilon_A}{x^*_a + \epsilon_A} \right) \left( U^m_{A,s} - U^m_{A,f} \right) < \frac{x^*_{na} \left( U_{A,s} - U^m_{A,s} \right) + \epsilon_A \Delta}{x^*_{na} + \epsilon_A},$$

which can be rewritten as:

$$\frac{(x^*_a - x^*_{na}) \epsilon_A}{(x^*_a + \epsilon_A)} < \frac{x^*_{na} (U_{A,s} - U^m_{A,s}) + \epsilon_A \Delta}{U^m_{A,s} - U^m_{A,f}}.$$

When the inequality holds the other way around, expected consumer surplus in market $A$ is higher if acquisitions are allowed. Because the expected consumer surplus is a continuous function of $U_B$, when $U_B$ is sufficiently small the increase in consumer surplus in market $A$ dominates the decrease in consumer surplus in market $B$. □

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