Financial Frictions and Startup Antitrust

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Abstract

Anticompetitive startup acquisitions increase investment at startups who remain independent. I extend Myers-Majluf to allow startups to sell out to an incumbent. In equilibrium, low type startups sell in an acquisition, medium types issue equity, and high types underinvest. Blocking acquisitions causes low types to instead issue equity, lowering equity valuations and causing high types to underinvest. The welfare loss caused by underinvestment can overwhelm the welfare gains from greater competition. My channel differs substantially from existing defenses of anticompetitive acquisitions based on technological synergies or entry.

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1 Introduction

Politicians and regulators are increasing scrutiny of startup acquisitions. In June 2021, the U.S. House Judiciary Committee advanced the Platform Competition and Opportunity Act to restrict the ability of large technology companies to acquire potential nascent competitors. In November 2020, the Department of Justice filed an antitrust lawsuit against Visa's proposed acquisition of Plaid on the grounds that the acquisition would stifle nascent competition in online payments. In 2019, the FTC delayed Roche's acquisition of Spark Therapeutics, a gene therapy startup, over concerns that the acquisition would weaken incentives to develop Spark's early stage treatments for hemophilia.

I study the welfare effects of blocking startup acquisitions when startups face financial frictions stemming from asymmetric information. I extend Myers and Majluf's canonical model of asymmetric information and financing constraints to show that blocking acquisitions can discourage investment at non-merging firms. The key insight is that blocking acquisitions changes the composition of firms who remain standalone. Under asymmetric information, this change in composition can increase financing costs and reduce investment at firms who were not planning to merge.

To make my model concrete, I discuss it in the context of the biotech industry. The biotech industry is an appropriate setting for the model for several reasons. First, long development cycles mean financial frictions are likely to matter for investment decisions. Second, empirical work in this industry has uncovered important facts that challenge traditional defenses of acquisitions based on synergies or entry. Cunningham et al. (2021) show that in the pharmaceutical industry, acquirors tend to kill projects at target firms that overlap with the acquiror's product pipeline. Nonetheless, the model is applicable in any setting where both asymmetric information and anticompetitive motives affect financing and acquisition decisions.

In the model, a biotech firm has a publicly observed first period investment opportunity to develop a drug candidate, and has private information about the likelihood its technology platform will generate future drug candidates. The biotech has to make a decision between not investing in today's drug candidate, financing it with equity, or selling out to an incumbent. Because neither the market nor the incumbent have information about the biotech's technology platform, equity and acquisition prices will depend endogenously on the set of firms who choose to be acquired or issue equity.

In this environment, banning acquisitions causes low type firms to instead issue equity. This switch lowers the market's inference and therefore valuation of all equity issuers. The higher cost of equity finance pushes some high type firms to not undertake the first period investment opportunity, creating a welfare loss. The model predicts that the market level effects of acquisitions can differ from the effect of acquisitions on the target firm. Even in the absence of synergies or new entry, blocking acquisitions can be harmful because it tightens financial constraints and causes underinvestment at standalone firms.

I contribute primarily to two literatures. First, I contribute to an industrial organization literature on antitrust and innovation, and in particular a literature on how to regulate acquisitions of nascent competitors (Shapiro, 2012; Federico et al., 2019; Bryan and Hovenkamp, 2020; Katz, 2020; Kamepalli et al., 2020; Cunningham et al., 2021). My key contribution is to show how antitrust can have financial market spillovers. Optimal antitrust in my model reduces to a tradeoff between anticompetitive mergers and underinvestment. Once corporate finance is taken into account, blocking mergers can hurt welfare even if acquisitions do not incentivize entry or create technological synergies.

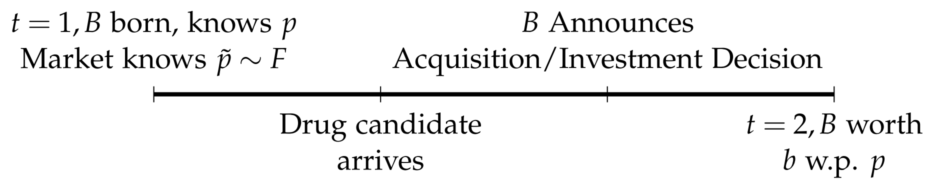
Second, I contribute to a corporate finance literature on the real consequences of asymmetric information (Myers and Majluf, 1984; Nachman and Noe, 1994; Philippon and Skřeta, 2012). My main contribution is to illustrate how corporate finance can shape the costs and benefits of regulation. A central idea in the literature on asymmetric information and capital structure is that firms' financing choices signal information. Antitrust policy, by blocking firms from being acquired, can have effects on the information signalled by equity issuers.

In contemporaneous work, Fumagalli et al. (2020) also study the interaction between financial constraints and antitrust policy. Our papers are similar in that they both point out that regulation of startup acquisitions should take into account the effect of regulation on financial frictions. However, because their paper focuses on agency frictions, they obtain different conclusions about how to regulate "killer acquisitions" in which acquired projects are more likely to be terminated than standalone projects. I survey the papers in these areas in more detail in section 4.

2 Theory

In this section I present a model of optimal antitrust when the target firm faces financial frictions stemming from asymmetric information. The model contains two main parts. First, I characterize the equilibria of a financing game in the spirit of Myers and Majluf (1984) in which firms can either sell themselves to an incumbent, raise equity to invest in a project, or choose not to invest. Second, I study how blocking acquisitions changes equilibrium financing conditions and consumer surplus. I show that blocking mergers can cause firms to underinvest. Optimal antitrust then weighs the benefits of promoting competition against the cost of exacerbating financial frictions.

Figure 1: Sequence of events in the model



2.1 The Financing Game

Figure 1 illustrates the sequence of events in the model. There are two periods $t = 1,2$. At $t = 1$ a biotech firm B is born with knowledge that at $t = 2$, its technology platform will be worth b with probability p and 0 otherwise. The value of b is public information. The market and incumbent acquiror do not know p, but instead treat the type as a continuous random variable $\tilde{p} \sim F$, with F supported on $\left[\underline{\rho}, \overline{\rho}\right] \equiv \mathcal{P} \subset [0,1]$ with a density f.

In period 1, the biotech has a publicly observed opportunity to invest in a drug candidate with NPV a and cost I. Both a and I are public information. After the investment opportunity arrives, the biotech has three options: it can sell out to an incumbent, it can finance the investment by raising equity, or it can choose not to invest. The biotech announces its action, the market makes inferences based on the action, and then payoffs are realized. In general payoffs will depend on the market's inferences. Last, at $t = 2$, the platform realizes its value of b with probability p.

In the model I make a crucial distinction between the drug candidate, whose characteristics are common knowledge, and the technology platform, whose type is known by the startup but not by the financial market or the acquiror. For example, Moderna, one of the biotechs behind a COVID-19 vaccine, was founded to commercialize the technology platform of mRNA vaccines. The investment opportunity a represents a new mRNA vaccine, b represents the value of treating other diseases, and p represents the probability that mRNA vaccines will be useful in treating those other diseases. The assumption that there is perfect information over the drug candidate while there is asymmetric information over the technology platform can be justified by the fact that existing products can be evaluated without understanding why the technology works. In the case of Moderna, it's possible to evaluate the quality of its COVID-19 vaccine using traditional clinical trials, while evaluating mRNA vaccines' future prospects of curing cancer or heart disease would require deeper knowledge about the new technology.

I next outline the payoffs from the biotech's actions. I assume that the biotech, investors, and acquirors all are risk neutral with a zero discount rate. This assumption allows me to focus in on how asymmetric information influences financing decisions while ignoring gains from trade from different time or risk preferences.

2.1.1 Underinvestment

If the biotech does not invest in the drug candidate a, its payoff derives entirely from the platform value. In the second period, the platform is worth b with probability p. Let n denote the action to not invest, and define $S_n \subset \mathcal{P}$ to be the set of biotechs who do not invest. Throughout the paper I will also refer to this lack of investment as "underinvestment", as in a standard setup without asymmetric information the firm would undertake all positive NPV investments. Define the value of not investing as V^n; it is equal to

$$V^n(p) = pb$$

2.1.2 Issuing Equity

Alternatively, the biotech can issue equity and invest in the drug candidate. Let e denote the action to issue equity, and let $S_e \subset \mathcal{P}$ index the equilibrium subset of firms that issue equity by their probabilities of success p. If the startup decides to issue equity, competitive investors offer to give I to the company for a fraction ϕ of the company. Therefore after issuing equity the original owners of the biotech have a payoff of

$$V^e(p) = (1-\phi)(a + I + pb)$$

If $S_e \neq \emptyset$, then competitive equity markets requires that

$$\phi = \frac{I}{a + I + b\mathbb{E}\left[\tilde{p} \,|\, \tilde{p} \in S_e\right]} \in (0,1)$$

This value of ϕ is pinned down by the fact that equity investors must earn zero expected profit on their investment. If the drug candidate is successful, then the entire firm will be worth $a + I + bp$. Under this value of ϕ, equity investors break even on their investment:

$$\mathbb{E}\left[\phi(a + I + b\tilde{p}) \,|\, \tilde{p} \in S_e\right] = \mathbb{E}\left[\frac{I}{a + I + b\mathbb{E}\left[\tilde{p} \,|\, \tilde{p} \in S_e\right]} \times (a + I + b\tilde{p}) \middle| \tilde{p} \in S_e\right] = I$$

2.1.3 Acquisition

Last, the biotech can decide to sell itself to an incumbent. Let $S_a \subset \mathcal{P}$ be the equilibrium subset of biotechs who decide to be acquired. I assume that the biotech has all the bargaining power in setting the acquisition price, and offers a take it or leave it offer of R to the incumbent that leaves the incumbent with zero expected profit. I assume that the incumbent derives the same value from the technological platform and the drug candidate as the biotech, but also generates a synergy value $\sigma \geq 0$. Therefore if $S_a \neq \emptyset$, the payoff from an acquisition V^a and acquisition price R are equal to

$$V^a(p) = R = a + b\mathbb{E}[\tilde{p}\,|\tilde{p} \in S_a] + \sigma$$

The synergy value σ is meant to capture all the potential reasons the acquiror might obtain more value from the drug candidate than the biotech would. This includes productive efficiency gains from the incumbent's expertise in drug development or the difference between duopoly and monopoly profits that the incumbent captures by killing the new drug candidate. For the purpose of characterizing the equilibrium, the source of synergy value is not important. I consider how different sources of synergy value affect the welfare analysis in section 2.4.

2.1.4 Equilibrium Definition

Given the primitives $\{f, a, I, b, \sigma\}$ of the model, I look for a Perfect Bayesian Equilibrium in pure strategies.

Definition 1. A Perfect Bayesian Equilibrium is defined by a partition of $\mathcal{P}$ into three disjoint sets S_a, S_e, S_n such that

1. (Each type takes the best action) For all $x \in \{a, e, n\}$, for all $p \in S_x$, we have that $V^x(p) = \max_{x \in \{a,e,n\}} V^x(p)$.
2. (Equity prices are consistent and competitive) If $P(\tilde{p} \in S_e) > 0$, then the share of the company sold is equal to $\phi = \frac{I}{a+I+b\mathbb{E}[p|p\in S_e]}$. Otherwise, $\phi = \frac{I}{a+I+b\mathbb{E}[\tilde{p}|\tilde{p}\in S]}$ for some set $S \subset \mathcal{P}$.
3. (Acquisition prices are consistent and competitive) If $P(\tilde{p} \in S_a) > 0$, then the acquisition price R is equal to $a + b\mathbb{E}[\tilde{p}\,|\tilde{p} \in S_a] + \sigma$. Otherwise $R = a + b\mathbb{E}[\tilde{p}\,|\tilde{p} \in S] + \sigma$ for some set $S \subset \mathcal{P}$.

The first condition requires that firms of each type are taking their best action, accounting for the fact that their action affects the market's inference. The second condition requires that if firms issue in equilibrium, then the share of the firm that is sold is consistent with competitive bidding for the equity of the issuing firms. The third condition requires that if firms choose to be acquired in equilibrium, then the acquisition price is consistent with competitive bidding for the assets of the acquired firms. Both the second and third conditions require that if issuance or acquisitions, respectively, do not happen in equilibrium, then the share of the firm that has to be sold or the acquisition price are consistent with some beliefs about the types who take the off equilibrium actions.

2.2 Equilibrium Characterization

In this section I characterize the equilibria of the model. An important lemma is that in any equilibrium, the types who sell in an acquisition are lower types than those who issue equity, who are in turn lower than the types who do not invest. Intuitively, this ordering happens because the payoffs from the three options satisfy single crossing. It is relatively more costly for biotechs with unobservably high success probabilities p to be acquired or to issue equity. I discuss the realism of this simple result in section 3.1. I formalize this in the following lemma

Lemma 1. *In any PBE, $\forall p_a \in S_a, p_e \in S_e, p_n \in S_n$,*

$$p_a \leq p_e \leq p_n$$

Proof. All proofs are in Appendix A. □

I focus on equilibria that survive the D1 refinement of Cho and Kreps (1987) on off equilibrium path beliefs. This refinement has been previously used in the literature on security design under asymmetric information (Nachman and Noe, 1994). Theorem 2 then characterizes the equilibria that remain.

Lemma 2. *Any PBE that satisfies the D1 refinement must be one of the five following forms*

1. *All types are acquired*
2. *All types issue equity*
3. *Low types are acquired and high types issue equity. There is a cutoff type $\underline{p}$ such that all types $p < \underline{p}$ are acquired, all types $p > \underline{p}$ issue equity, and the cutoff type $\underline{p}$ can do either action.*
4. *Low types issue equity and high types do not invest. There is a cutoff type $\overline{p}$ such that all types $p < \overline{p}$ issue equity, all types $p > \overline{p}$ do not invest, and the cutoff type $\underline{p}$ can do either action.*
5. *Low types are acquired, medium types issue equity, and high types do not invest. There are two cutoffs $\underline{p} < \overline{p}$ such that all types $p < \underline{p}$ are acquired, types $p \in \left(\underline{p}, \overline{p}\right)$ issue equity, and types $p > \overline{p}$ do not invest. The lower cutoff type $\underline{p}$ can either be acquired or issue equity, and the upper cutoff type $\overline{p}$ can either issue equity or not invest.*

The five kinds of equilibria in lemma 2 are convenient to work with because whether or not an equilibrium of a given type exists can be reduced to checking conditions on a set of nonlinear functions that depend only on the primitives of the model.

Theorem 1. *Define the functions*

$$g\left(c,\overline{p}\right)=\frac{a+b\mathbb{E}\left[p|\,c\leq p\leq\overline{p}\right]}{a+b\mathbb{E}\left[p|\,c\leq p\leq\overline{p}\right]+I}\left(a+bc+I\right)-\left(a+b\mathbb{E}\left[p|\,p\leq\overline{p}\right]+\sigma\right)$$
$$h\left(\underline{p},c\right)=bc-\frac{a+b\mathbb{E}\left[p|\,\underline{p}\leq p\leq c\right]}{a+b\mathbb{E}\left[p|\,\underline{p}\leq p\leq c\right]+I}\left(a+bc+I\right)$$

The function g represents the difference between the payoff from issuing equity and being acquired for a type c, assuming that all firms of type less than c are acquired and all firms of types between c and $\overline{p}$ issue equity. The function h represents the payoff from not investing and issuing equity for a type c firm when all firms of types between $\underline{p}$ and c issue equity and all firms of type c and above do not invest.

There exists a PBE that survives the D1 refinement of each of the following forms provided that the corresponding restrictions on g and h hold:

1. *All firms are acquired iff $g\left(\overline{\rho},\overline{\rho}\right)\leq 0$*
2. *All firms issue equity iff $g\left(\underline{\rho},\overline{\rho}\right)\geq 0$ and $h\left(\underline{\rho},\overline{\rho}\right)\leq 0$*
3. *Low types are acquired and high types issue equity iff there is cutoff $\underline{p}$ satisfying $g\left(\underline{p},\overline{\rho}\right)=0$ and $h\left(\underline{p},\overline{\rho}\right)\leq 0$.*
4. *Low types issue equity and high types do not invest iff there is a cutoff $\overline{p}$ satisfying $g\left(\underline{\rho},\overline{p}\right)\geq 0$ and $h\left(\underline{\rho},\overline{p}\right)=0$.*
5. *Low types are acquired, medium types issue equity, and high types do not invest iff there are two cutoffs $\underline{p}<\overline{p}$ such that $g\left(\underline{p},\overline{p}\right)=0$ and $h\left(\underline{p},\overline{p}\right)=0$*

2.3 The Effects of Blocking Mergers on the Market Equilibrium

In this section I show how blocking mergers increases underinvestment. I assume for now that all three actions take place in equilibrium. Appendix B derives the pertinent regularity conditions. I operationalize the idea of blocking acquisitions by setting $\sigma=0$. This can be interpreted as changing the option of selling out to an acquiror to instead selling all shares of the firm in a competitive equity market. Such a sale does not generate any "synergy" value, hence $\sigma=0$. Moreover, any equilibrium with $\sigma=0$ features no acquisitions. Intuitively, selling the entire firm bears strictly higher adverse selection costs with no offsetting benefit, and so no firm would sell all the shares.

Lemma 3. *Let $\sigma = 0$. Then in any equilibrium $S_a = \emptyset$.*

I can now prove the main result that blocking acquisition causes more underinvestment. In general, there can be a multiplicity of equilibria in models of incomplete information. However, I am able to show that for each equilibrium with acquisitions, there exists a corresponding equilibrium without acquisitions that features more underinvestment.

Theorem 2. *Given a set of primitives, suppose there exists an equilibrium in which all three actions are taken. Define $S_a = \left[\underline{\rho}, \underline{p}^*\right)$, $S_e = \left[\underline{p}^*, \overline{p}^*\right]$, and $S_n = (\overline{p}^*, \overline{\rho}]$, and by assumption $\underline{\rho} < \underline{p}^* < \overline{p}^* < \overline{\rho}$. Then if σ is changed to 0, there exists an equilibrium cutoff $\overline{p}'$ with $\overline{p}' < \underline{p}^*$ such that $S_a = \emptyset$, $S_e = \left[\underline{\rho}, \overline{p}'\right]$, and $S_n = \left(\overline{p}', \overline{\rho}\right]$ is a PBE.*

Figure 2 illustrates the intuition for the result. If acquisitions are blocked, firms that would have been acquired will instead issue equity. This lowers the average inference of equity issuing firms. As a result, the highest type firms that issue equity in the original equilibrium will drop out and instead choose to not invest. In the final equilibrium, there are no acquisitions but there is also more underinvestment.

One way to interpret theorem 2 is that acquisitions serve a useful role by allowing low type firms to self select out of equity issuance. Acquisitions lower financing frictions and increase investment by high type firms by allowing for more separation between types. In contrast, when acquisitions are banned then low and medium types have to pool, and some high type firms opt not to invest. This benefit exists regardless of whether or not the acquisitions result in reduced competition.

2.4 Optimal Policy

In this section I show how incorporating the effect of antitrust on financial frictions argues for more permissive antitrust thresholds. The key idea is that antitrust should weigh the net effect of killed projects at acquired firms against underinvestment at standalone firms. To formalize this tradeoff, assume that the technology platform generates the same consumer surplus β no matter whether it's owned by the incumbent or the biotech. This assumption requires that the platform is sufficiently flexible that the incumbent is able to redirect it to develop drugs in areas that do not compete with its own products but that also generate the same amount of consumer surplus.

I incorporate the incentive for the incumbent to kill the startup's project with the assumption that a fraction κ of the acquired projects and platforms are discontinued. I capture the potential for synergies by allowing $\kappa < 0$, in which case the incumbent is more likely to complete the project than the startup. I also allow for the possibility that conditional on the incumbent developing

Figure 2: Intuition behind theorem 2 on how the equilibrium changes as fewer firms are acquired. The first panel on the left illustrates the initial equilibrium. The second panel illustrates the direct effect of shrinking the set of firms who are acquired. The third panel then illustrates the additional informational effects that arise due to the shift in composition of firms issuing equity. The fourth panel then illustrates how in the final equilibrium, fewer firms are acquired and the mass of not investing firms increases.

the project, the project generates less consumer surplus when it's under the incumbent's control because the incumbent will price the drug higher to avoid cannibalization of its existing product. Formally, let the drug candidate generate α_I dollars of consumer surplus if developed by the incumbent and α_S dollars of consumer surplus if developed by the startup. By assumption, $0 < \alpha_I < \alpha_S$ because the incumbent has a weaker incentive to price aggressively if the startup's drug features more overlap.

With these assumptions I derive an expression for consumer surplus. Let P_A, P_E, P_N be the measures of the acquisition, issuance, and non-investment sets with respect to the measure F. Consumer surplus is equal to

$$\begin{aligned} W &= (1-\kappa)\,\alpha_I P_A + \alpha_S P_E + \beta \mathbb{E}\left[p\right] \\ &= \alpha_S\left(P_A + P_E + P_N - P_N\right) + \alpha_S P_A\left((1-\kappa)\frac{\alpha_I}{\alpha_S} - 1\right) + \beta \mathbb{E}\left[p\right] \\ &= \underbrace{\alpha_S\left[1 - \kappa^* P_A - P_N\right]}_{\text{Surplus from Drug Candidate}} + \underbrace{\beta \mathbb{E}\left[p\right]}_{\text{CS from Platform}} \end{aligned}$$

Where the effective killing rate κ^* is defined as

$$\kappa^* = 1 - (1-\kappa)\frac{\alpha_I}{\alpha_S} \in (0,1)$$

The expression for the effective killing rate captures two sources of ex-post efficiency loss from the incumbent's ownership of the drug. First, the incumbent may kill the project before it reaches market ($\kappa < 1$), which Federico et al. (2019) term unilateral innovation effects. Second, even if the incumbent develops the new drug candidate it will charge a higher price for the new candidate in order to not cannibalize its existing product, known as unilateral price effects. This will result in less consumer surplus if the incumbent develops the candidate, even conditional on making it to market. Both factors contribute to a positive effective killing rate.

The above welfare expression provides a foundation for optimal antitrust. In a counterfactual world without acquisitions, $P_A = 0$, but the share of firms who do not invest rises to some $P_N^{'}$. The change in welfare is then proportional to

$$\Delta W \propto \kappa^* P_A - \left(P_N^{'} - P_N\right)$$

The first term is the standard benefit from blocking anticompetitive acquisitions. The second term is novel and reflects the loss from lower investment caused by financial frictions. A regulator who ignored financial constraints would always block mergers provided that acquired firms produced less consumer surplus, whether through unilateral innovation or price effects. However, in the presence of financial constraints the regulator also has to weigh the effect of blocking acquisitions on underinvestment at high type firms.

2.5 Parametric Example

In this section I illustrate the model mechanism with a numerical example. Assume $p \sim \text{Uniform}[0,1]$. Given equilibrium cutoffs $\underline{p}, \overline{p}$, then the payoffs from the three options are

$$\begin{aligned}
V^n(p) &= pb \\
V^e(p) &= \frac{a + \frac{b}{2}\left(\overline{p} + \underline{p}\right)}{a + I + \frac{b}{2}\left(\overline{p} + \underline{p}\right)}(a + I + bp) \\
V^a(p) &= a + \frac{b}{2}\underline{p} + \sigma
\end{aligned}$$

By using the indifference conditions at the cutoffs $\underline{p}, \overline{p}$, we can solve for the equilibrium cutoffs:

$$\underline{p}^* = \frac{2(\sigma - a)}{b}$$
$$\overline{p}^* = \frac{2\sigma(I + a)}{b(I - a)}$$

Assume for now that $a < \sigma < \frac{b}{2(I+a)}$ and $I > a$ so that we're in an interior equilibrium with a positive measure of firms each being acquired, issuing equity, and not investing.

Suppose the regulator now bans acquisitions. Then the new upper boundary between issuance and not investing becomes

$$\overline{p}' = \frac{2a(I + a)}{b(I - a)}$$

Therefore the change in the mass of firms not investing is

$$\begin{aligned} P_E - P_E' &= \overline{p}^* - \overline{p}' \\ &= \frac{2(\sigma - a)}{b} \times \frac{I + a}{I - a} \end{aligned}$$

Suppose all acquired projects are killed, with $\kappa^* = 1$. Then the change in consumer surplus from blocking acquisitions is proportional to

$$\begin{aligned} \Delta W &\propto P_A - \left(P_E - P_E'\right) \\ &= -\frac{2a}{I - a}\frac{2(\sigma - a)}{b} < 0 \end{aligned}$$

Therefore even if an antitrust regulator knew that all acquisitions would result in the drug candidate being killed, she would still want to commit to allowing acquisitions to occur.

The stark result arises because blocking acquisitions has a large effect on equity valuations. When low types decide to issue instead of becoming acquired, that lowers the valuation of all equity issuers. Some high types then switch from issuing to not investing. The equity market recognizes that some high types will exit the market, and then lowers the valuation of equity issuers even further.

3 Discussion

3.1 Modeling Assumptions

A simple consequence of my model is that the startups that sell out are worse type firms. This may seem counterfactual given that many acquisitions are seen as successful outcomes for both the startup and outside investors. This is nonetheless consistent with my model because the asymmetric information is over future investment opportunities, not past products or the quality of the drug candidate a. Facebook CEO Mark Zuckerberg had to turn down very large acquisition offers as an early stage firm. One plausible reason he was willing to turn them down was because he thought that Facebook still had substantial growth opportunities that were being undervalued by acquirors. Similarly, after the use of digital finance exploded during the COVID-19 pandemic, Plaid's future as a platform for fintech data became much brighter. Plaid then opted to walk away from a $5.3 billion offer from Visa and instead chose to raise another round of private equity finance at a valuation of $13.4 billion.

One could also object to the result that high type firms are the ones who are underinvesting given that many good firms in the economy do a large amount of investment. This result is more natural if underinvestment is interpreted as meaning underinvestment *at the margin*. There are many startups who are known by all investors to be very valuable and therefore are able to raise substantial amounts of equity finance. But among observably similar startups, the unobservably worse startups will want to sell more of the firm on the margin. It is precisely this inference that prevents unobservably better startups from issuing at first best levels.

I ignore the possibility of signaling information via capital structure. In particular one could imagine firms could signal type with debt contracts. However, debt is unlikely to be valuable in my environment. The platform value b should be interpreted as an expected value, not a deterministic cash flow if the platform succeeds. Given the lack of stable cash flows or collateral, debt financing would be highly risky and require a high face value to promise upside to the investors. Such a contract would look similar to the equity contract modeled.

In my welfare analysis I assume that the acquiror does not kill the platform b. This may be appropriate for a setting such as the pharmaceutical industry, where even if the acquiror can have an incentive to cancel existing projects that overlap with the acquiror's portfolio (represented by a), it may still be willing to use the target's technology platform (e.g. mRNA vaccines, cell therapy) to attack other diseases. This is less appropriate for certain acquisitions, such as Visa's acquisition of Plaid, where the concern was that the acquiror is buying the startup to stop it from launching a technological platform that would displace the incumbent's platform. Incorporating the possibility that the biotech's platform b could be canceled in an acquisition would not change the qualitative results, but could have a significant impact on the optimal antitrust thresholds.

I do not model entry. Were I to incorporate entry, then that would introduce an additional reason to tolerate anticompetitive mergers, as the prospect of higher payoffs may encourage more entry. However, because the information channel does not have a large first order effect on this additional channel, I do not model it here.

The assumption that the biotech has all the bargaining power in the acquisition is not essential to the results. Any losses due to lower bargaining power can be incorporated with a smaller σ. The essential assumption is that the acquisition price does not depend on the startup's private type.

I model the synergy as additive as independent of the private type p. This makes sense if the synergy primarily comes from the incentive to kill the current drug candidate and not the future technology platform. Because the characteristics of the current drug candidate are common knowledge, the synergy should not depend on the private type p. If one were to instead model the synergy as depending on the private type p, the main challenge would be that it might no longer be the case that low type firms are acquired.

3.2 Implications for Antitrust and Entrepreneurship Policy

My model implies that blocking startup acquisitions can raise financing costs for observationally equivalent firms who choose not to be acquired. This tradeoff is novel to the antitrust literature because the firms that are affected by antitrust policy in this world might not yet have any potential product market interaction with the firms whose mergers are blocked. In the context of the Roche/Spark acquisition, conventional analysis would have focused on how the acquisition would reduce the incentives of the combined entity to continue investing in Spark's hemophilia gene therapies. My framework would predict that blocking the acquisition could have a chilling effect on investment activity at all biotech companies by tightening financial constraints. Blocking the merger would have signalled that acquisitions by acquirors with overlapping product portfolios were off the table. This would have limited other biotech companies' acquisitions, lowering the average type of equity issuers and worsening underinvestment.

The underinvestment channel I identify goes beyond the simple argument that blocking acquisitions lowers startup valuations, making it harder for startups to raise capital. Lower valuations from blocking acquisitions is not bad for welfare per se because part of the decrease in valuations may represent a decrease in socially harmful rents from softer competition. However, part of the decrease in startup valuations in my model comes from reduced investment activity caused by underinvestment. Therefore my model mechanism goes beyond the simple argument focused on valuations.

My model suggests that regulators should be less concerned about startup acquisitions that buy out the entire company, but more concerned with naked asset transfers that increase concentration. For example, one acquisition discussed in Federico et al. (2019) was an acquisition by Questcor of the rights to a competitor drug from Novartis. Questcor, a manufacturer of the hormone Acthar, acquired the rights to a synthetic version from Novartis. Incorporating my model's effects would likely still lead regulators to block the acquisition. First, because Novartis was selling an asset backed by one product, not the company itself, such an acquisition does not signal Novartis' future investment opportunities. Therefore blocking the merger would not change the markets' inference about the types of equity issuers. Second, even if cash could relieve financial constraints, it's unlikely to have been relevant for Novartis, given it's a mature company with ample internal funds.

My framework is also relevant for proposals in Lemley and McCreary (2020) to use the tax code to incentivize firms to stay standalone and not sell out in acquisitions. Reducing the tax benefits of acquisition, for example, would be the same as reducing σ and would have the potential for reducing investment. At the same time, my framework would predict that their proposal to subsidize equity finance would have knock on effects from changing the composition of equity issuers. The precise welfare effects of such a policy would however also need to account for the deadweight loss of funding negative NPV investments, which are not present in the above model.

3.3 Comparison with Past Defenses of Anticompetitive Mergers

My model generates a new channel by which stringent antitrust can be harmful. This is important because the theory and evidence in Cunningham et al. (2021) emphasizes that traditional defenses of anticompetitive mergers based on technological synergies or entry may not apply in important empirical settings such as the biotech sector.

One defense of mergers is that they create technological synergies which spur innovation (Bena and Li, 2014). Cunningham et al. (2021) argue that this is unlikely to be relevant in the pharmaceutical sector because they document the net effect of synergies and reduced competition is that incumbents are still more likely to kill acquired projects that overlap with the incumbent's product portfolio.

The financial frictions channel that I identify is distinct in two ways. First, the financial frictions channel applies even if there are no technological synergies from the acquisition. I only require that acquired firms are of unobservably low quality. Second, while the traditional technological synergy appears at the merging firms, the benefit of relaxing financial constraints can occur at non-merging firms. Therefore the net effect of permitting acquisitions in my model cannot be measured by the analysis conducted in Cunningham et al. (2021), since they focus on what happens to investment in the target firm's projects.

Another argument for more permissive antitrust in innovation markets is that allowing anticompetitive mergers creates ex-ante benefits on startup entry that overwhelm the ex-post loss in competition (Rasmusen, 1988; Phillips and Zhdanov, 2013; Letina et al., 2020). Cunningham et al. (2021) argue that this argument ignores the private incentives of the incumbent. For an anticompetitive acquisition to be profitable, it must be that there are few prospects of new entrants. Therefore entry is unlikely to be a solution to anticompetitive startup acquisitions. Cunningham et al. (2021) also show that the anticompetitive startup acquisitions are most likely to occur in areas where there are few other competitors offering similar products. If the number of existing products is used as a proxy for the ease of entry, then this is additional evidence that anticompetitive acquisistions are unlikely to happen where there is likely to be entry.

The relative importance of the underinvestment channel I identify does not depend on whether there are future entrants. In the above model there is no entry, but allowing acquisitions can nevertheless raise ex-post welfare. Intuitively, if new drug ideas are rare, then it becomes more important that firms invest whenever the opportunity arrives. My model shows that strict antitrust can cause these firms to pass up these opportunities due to financial frictions.

4 Literature Review

My paper is related to several strands of the literature. It is most directly related to a literature on the relationship between antitrust and innovation, and in particular on how to regulate acquisitions of nascent competitors. Rasmusen (1988) was among the first to point out how the prospect of an acquisition can change the incentive to enter a market. Shapiro (2012); Federico et al. (2019) offer a set of guiding principles on how to think about how mergers can affect the pace and direction of innovation. A recent theory literature studies how acquisitions of nascent competitors by incumbent firms can reduce the creation of new networks (Kamepalli et al., 2020; Katz, 2020) and change the direction of innovation (Callander and Matouschek, 2020; Bryan and Hovenkamp, 2020; Letina et al., 2020). With the exception of Fumagalli et al. (2020), these papers ignore how antitrust policy can affect firms' ability to obtain financing. My paper shows that incorporating financing frictions has the potential to change policy conclusions. The main cost of incorporating corporate finance is that I neglect the strategic consequences of acquisitions covered in the other papers.

Fumagalli et al. (2020) also theoretically study how financial constraints interact with antitrust policy. In their model, startups with insufficient internal funds are unable to raise funds from perfectly informed investors due to a moral hazard constraint, as in Holmstrom and Tirole (1997). Our papers both share the common idea that underinvestment can occur due to both market power and financial constraints, and therefore the regulation of startup acquisitions should account for the way antitrust policy can affect financing conditions. However, our papers offer different predictions about when antitrust policy should be more stringent or lax. In Fumagalli et al. (2020), the regulator should block all acquisitions in which the incumbent cancels the project while the biotech would have invested in the project. In contrast, my model predicts that the regulator should allow some amount of "killer acquisitions" because doing so increases investment at standalone startups. This effect emerges in my model because the valuation that equity issuers receive depends on the set of startups who self select into an acquisition. In contrast, because Fumagalli et al. (2020) focus on the case of perfect information between investors and the startup, blocking some early stage startup acquisitions does not affect the investment decisions of other early stage startups.

Cunningham et al. (2021) document empirically that in the pharmaceutical industry, acquired products that overlap with the acquiror's product portfolio are more likely to be terminated. They call these acquisitions "killer acquisitions". My theory explains how permitting killer acquisitions can nevertheless increase expected investment. The key insight is that, under asymmetric information, the benefits of allowing acquisitions can show up at non-acquired firms. Because Cunningham et al. (2021) focus on development activity at the merging firms, they are unable to estimate the size of the offsetting underinvestment channel that I hypothesize.

The tools of the paper come from a corporate finance literature on the implications of asymmetric information for firm financing and government policy. Myers and Majluf (1984) were the first to argue that because managers are more likely to issue equity when shares are overvalued, then equity pricing is both subject to adverse selection and can be the cause of underinvestment. Philippon and Skřeta (2012) use a Myers-Majluf model to study how asymmetric information affects the ability of the government to support investment in a financial crisis. While the policy setting is different, my model setting shares the common feature that changing government policy towards one set of firms can affect market inferences about other firms.

The model also draws on evidence that entrepreneurial firms are financially constrained. For example, Howell (2017) shows that relatively small grants to startups through the Department of Energy's SBIR program enable the startups to build new prototypes, substantially increasing future revenue and patenting activity. Krieger et al. (2021) show that even large pharmaceutical firms invest as if they are financially constrained. After the expansion of Medicare Part D, firms who experienced a larger increase in expected cash flows substantially increased their investment in novel drug candidates even in therapeutic areas that did not experience a direct demand shock stemming from Medicare Part D.

More broadly, my paper contributes to an older literature on the connections between corporate finance and industrial organization (Brander and Lewis, 1986; Bolton and Scharfstein, 1990; Chevalier, 1995). However, these papers focused more on the interaction of creditor-debtor disagreement, agency problems, and product market competition. I instead focus on the impact of asymmetric information on the ability to raise financing and the effects of antitrust on asymmetric information frictions. This latter channel is more relevant for startup firms who have very little debt on their balance sheet.

5 Conclusion

I identify a novel tradeoff for antitrust in a startup context. I incorporate acquisitions and antitrust into a Myers and Majluf (1984) model of financing under asymmetric information. In the model, antitrust changes the composition of types who issue equity, which affects equity valuations and investment behavior. Optimal antitrust balances anticompetitive effects of mergers against the positive effects of mergers in spurring investment. Future work can explore the quantitative magnitude of this corporate finance effect in innovation markets featuring startups and incumbent acquisitions, and how to translate these estimates into practical policy guidance.

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A Proofs of Statements in Main Text

Proof of Lemma 1. Note that

$$\frac{\partial V^a}{\partial p} = 0$$
$$\frac{\partial V^e}{\partial p} = (1-\phi)\, b$$
$$\frac{\partial V^n}{\partial p} = b$$

Hence $\frac{\partial V^a}{\partial p} < \frac{\partial V^e}{\partial p} < \frac{\partial V^n}{\partial p}$. Therefore if $V^e(p) \geq V^a(p)$ for some p, then $V^e\left(p^{'}\right) > V^a\left(p^{'}\right)$ for all $p > p^{'}$. Therefore all acquired types must be below all issuing types. A similar argument establishes that all acquired types must be below all non-investing types, and all issuing types must be below all non-investing types. □

Proof of Lemma 2. By lemma 1, the set of acquired types is always less than the set of issuing types, which in turn is less than the set of non-investing types. Each set can either be empty or not, and at least one set must be non-empty. Therefore there are at most 7 possible equilibria corresponding to different choices of whether the sets S_a, S_e, S_n are empty or not.

There is no PBE in which all firms do not invest. The lowest type $p = \underline{\rho}$ could deviate to being acquired. Regardless of the market's inference of the deviator's type, it would be better off. For any belief $S \subset \mathcal{P}$,

$$V^a\left(\underline{\rho}\right) = \sigma + a + b\mathbb{E}\left[\tilde{p}\,|\,\tilde{p} \in S\right] > b\underline{\rho} = V^n\left(\underline{\rho}\right)$$

There is no PBE that survives D1 in which low types are acquired, high types do not invest, and nobody issues. In a putative equilibrium, there would exist some cutoff $p^* \in \left(\underline{\rho}, \overline{\rho}\right)$ such that $\left[\underline{\rho}, p^*\right) \subset S_a$ and $(p^*, \overline{\rho}] \subset S_n$. Moreover, because all payoff functions V^a, V^n are continuous in the private type p, the critical type p^* must be indifferent between being acquired or not investing.

I claim that under the D1 refinement, investors believe that if a firm issues equity, then it is of type p^*. For any type $p \in S_a$, the difference in payoffs from issuing equity instead of being acquired is given by

$$V^e(p) - V^a(p) = (1-\phi)(a + I + bp) - \left(a + \mathbb{E}\left[\tilde{p}\,|\,\tilde{p} \in S_a\right] + \sigma\right)$$

Let $\phi_a(p)$ denote the maximum share of the firm that could be sold and still make an acquired firm with type p weakly better off from issuing equity. By setting the above equation to be less than zero, we have that

$$\phi_a(p) = 1 - \frac{a + \mathbb{E}[\tilde{p}|\tilde{p} \in S_a] + \sigma}{a + I + bp}$$

Since $\phi_a(p)$ is increasing in p, then the set of best responses under which a type p is weakly better off by issuing equity is strictly increasing in p. Therefore the D1 criterion strikes all types $p < p^*$.

For any type $p \in S_n$, the difference in payoffs from issuing equity instead of not investing is given by

$$V^e(p) - V^n(p) = (1 - \phi)(a + I + bp) - bp$$

Let $\phi_n(p)$ the maximum share of the firm that could be sold and still make a noninvesting type p better off from issuing equity. By setting the above equation to be less than zero, we have that

$$\phi_n(p) = \frac{a + I}{a + I + bp}$$

This share is decreasing in p. The set of best responses that make a non-investing firm weakly better off is strictly decreasing in p and therefore the D1 criterion strikes all types $p > p^*$.

Therefore if a firm issues equity, D1 selects the belief that $S_e = \{p^*\}$. The payoff from the type p^* firm from issuing equity is then

$$V^e(p^*) = a + bp^*$$

By inspection, this is greater than $V^n(p^*) = V^a(p^*)$. Therefore the type p^* firm would deviate, and there cannot be an equilibrium with only acquired and non-investing firms that survives the D1 refinement. □

Proof of Theorem 1. **All Acquired:** By the D1 arguments used in theorem 2, if a type deviates to issuing equity it would be inferred to be the highest type $\overline{\rho}$. Therefore for the highest type $\overline{\rho}$ to not want to deviate to issuing equity, it must be that $g(\overline{\rho},\overline{\rho}) \leq 0$.

Now suppose $g(\overline{\rho},\overline{\rho}) \leq 0$. I now claim that all firms choosing to be acquired and an issuer or non-investor is inferred to be type $\overline{\rho}$ is a PBE that survives D1. By the same D1 argument, a sufficient condition for no type to want to deviate to issuing equity is if the type $\overline{\rho}$ firm does not want to deviate. This is given by $g(\overline{\rho},\overline{\rho}) \leq 0$. To show that no type would want to deviate to not investing, it is sufficient for the type $\overline{\rho}$ firm to not want to deviate. This is guaranteed because issuing leads to a payoff of $a + b\overline{\rho}$ under the D1 refinement, whereas not investing leads to a payoff of $b\overline{\rho}$.

All Issue: To rule out deviations to not investing, it is again sufficient to rule out a deviation to not investing by the highest type. In that case we must have $h\left(\underline{\rho},\overline{\rho}\right) \leq 0$. Now suppose a firm chooses to deviate by being acquired. Then the set of acquisition prices R such that this would achieve a higher payoff for a type p is

$$R \geq \frac{a + b\mathbb{E}\left[\tilde{p}\right]}{a + b\mathbb{E}\left[\tilde{p}\right] + I}\left(a + bp + I\right)$$

Therefore the set of acquisition prices that would cause a type p^* to deviate is decreasing in p. Therefore the lowest type benefits the most from deviating to an acquisition, and so the market infers that it is the lowest type that deviates. For the lowest type $\underline{\rho}$ to not want to deviate, then it must be that $g\left(\underline{\rho},\overline{\rho}\right) \geq 0$.

Going the other direction, suppose that $g\left(\underline{\rho},\overline{\rho}\right) \geq 0$ and $h\left(\underline{\rho},\overline{\rho}\right) \leq 0$. Then I claim that all firms choosing to issue equity, acquired firms being inferred to be $\underline{\rho}$, and non-investing firms inferred to be $\overline{\rho}$ is a PBE that survives D1. By the same D1 argument as in the forward direction, the lowest type firm stands to gain the most from deviating to an acquisition, and such a deviation is not profitable because $g\left(\underline{\rho},\overline{\rho}\right) \geq 0$. The highest type firm stands to gain the most from deviating to not investing, and such a deviation is not profitable because $h\left(\underline{\rho},\overline{\rho}\right) \leq 0$.

Low Types Acquired, High Types Issue: In a putative equilibrium, there would be a cutoff $\underline{p}$ such that all firms with $p < \underline{p}$ are acquired, firms of type $p > \underline{p}$ issue. I now claim that the type $\underline{p}$ firm must be indifferent, i.e. that $g\left(\underline{p},\overline{\rho}\right) = 0$. Note that by construction $g\left(\underline{p},\overline{\rho}\right) = V^e\left(\underline{p}\right) - V^a\left(\underline{p}\right)$, where V^a, V^e are calculated with the equilibrium inferences. Since each type is taking the weakly optimal action, $V^a\left(p\right) \geq V^e\left(p\right)$ for all $p < \underline{p}$ and $V^e\left(p\right) \geq V^a\left(p\right)$ for all $p > \underline{p}$. By continuity, $V^e\left(\underline{p}\right) = V^a\left(\underline{p}\right)$. To rule out a firm deviating to not investing, it is sufficient to show that the type $\overline{\rho}$ firm must not want to deviate to not investing. But for this to be the case, a necessary condition is that $h\left(\underline{p},\overline{\rho}\right) \leq 0$.

Going the other direction, suppose that there is some cutoff $\underline{p}$ such that $g\left(\underline{p},\overline{\rho}\right) = 0$ and $h\left(\underline{p},\overline{\rho}\right) \leq 0$. I then claim that types $p < \underline{p}$ choosing acquisition and types $p \geq \underline{p}$ choosing to issue, with non-investing firms inferred to be $\overline{\rho}$ is a PBE that survives D1. By single crossing, since $V^e\left(\underline{p}\right) = V^a\left(\underline{p}\right)$, then $V^e\left(p\right) > V^a\left(p\right)$ for all $p > \underline{p}$, and $V^e\left(p\right) < V^a\left(p\right)$ for all $p < \underline{p}$. Therefore the firms of type $p > \underline{p}$ would not gain from deviating to being acquired, and firms of type $p < \underline{p}$ would not deviate to issuance. To show nobody would deviate to not investing, it suffices to show this is true for the highest type. Because $h\left(\underline{p},\overline{\rho}\right) \leq 0$, the highest type $\overline{\rho}$ would not gain from deviating to not investing.

Low Types Issue, High Types Do Not Invest: In a putative equilibrium, there would be a cutoff $\overline{p}$ such that all firms $p < \overline{p}$ issue, and all firms of type $p > \overline{p}$ do not invest. By a similar argument to the acquisition/issuance case, we have that $h\left(\underline{\rho}, \overline{p}\right) = 0$. By the same D1 argument as in the all issue case above, the lowest type $\underline{\rho}$ has the strongest incentive to be acquired. Therefore to rule out any player deviating to an acquisition, it is necessary to rule out a deviation from $\underline{\rho}$ in which the type $\underline{\rho}$ firm will be inferred to be a type $\underline{\rho}$ firm. Hence it is necessary that $g\left(\underline{\rho}, \overline{p}\right) \geq 0$.

Going in the other direction, suppose that there is some cutoff $\overline{p}$ such that $g\left(\underline{\rho}, \overline{p}\right) \geq 0$ and $h\left(\underline{\rho}, \overline{p}\right) = 0$. I then claim that if types $p \leq \overline{p}$ choose issuance, types $p > \overline{p}$ do not invest, and acquired firms would be inferred to be $\underline{\rho}$ is a PBE that survives D1. Since $V^n(p) - V^e(p)$ is strictly increasing in p, and $V^n(\overline{p}) - V^e(\overline{p}) = h\left(\underline{\rho}, \overline{p}\right)$, then no firm of type $p \leq \overline{p}$ would want to deviate to not investing, nor would any firm of type $p > \overline{p}$ want to deviate to issuance. The type that stands the most from deviating to an acquisition is $\underline{\rho}$, and such a deviation is ruled out by $g\left(\underline{\rho}, \overline{p}\right) \geq 0$.

Low Types Acquired, Medium Types Issue, and High Types Do Not Invest: In a putative equilibrium, there would be two cutoffs $\underline{p}, \overline{p}$ such that firms of type $p < \underline{p}$ are acquired, firms of type $p \in \left(\underline{p}, \overline{p}\right)$ issue, and firms of type $p > \overline{p}$ do not invest. By similar continuity arguments as in the last two cases, the firms at the cutoff must be indifferent. Hence $g\left(\underline{p}, \overline{p}\right) = h\left(\underline{p}, \overline{p}\right) = 0$.

Now suppose we have two cutoffs $\underline{p}, \overline{p}$ such that $g\left(\underline{p}, \overline{p}\right) = h\left(\underline{p}, \overline{p}\right) = 0$. Then I claim that if types $p < \underline{p}$ get acquired, types $p \in \left[\underline{p}, \overline{p}\right]$ issue, and types $p > \overline{p}$ do not invest, that is a PBE. Note D1 has no bite since there are no off equilibrium actions. Note

$$V^n(\overline{p}) - V^e(\overline{p}) = 0$$
$$V^e\left(\underline{p}\right) - V^a\left(\underline{p}\right) = 0$$

By the proof of lemma 1, we have that $V^n - V^e$ and $V^e - V^a$ are both increasing in type p. Hence all types $p > \overline{p}$ find non-investment optimal, all types $p \in \left[\underline{p}, \overline{p}\right]$ find issuance optimal, and all types $p < \underline{p}$ prefer acquistion. □

Proof of Lemma 3. We show that if $\sigma = 0$, there can be no equilibrium in which all firms are acquired or an equilibrium in which some firms are acquired and others issue equity. To rule out the first case, it is sufficient to show that $g(\overline{\rho}, \overline{\rho}) > 0$. This follows as

$$g(\overline{\rho}, \overline{\rho}) = a + b\overline{\rho} - (a + b\mathbb{E}[\tilde{p}]) = b(\overline{\rho} - \mathbb{E}[\tilde{p}]) > 0$$

To rule out the second case, suppose $\underline{p} > \underline{\rho}$ is the boundary point that separates acquired firms from issuing firms, and $\overline{p}$ is the boundary that separates issuing and non-investing firms. In the case that all firms with type $p > \underline{p}$ issue, then set the upper boundary $\overline{p} = \overline{\rho}$. In both cases, $\underline{p} < \overline{p}$. As a result, the the payoff from issuing equity for the putative firm indifferent between issuance and acquisition is

$$\begin{aligned}
\frac{a + b\mathbb{E}\left[\tilde{p}\middle|\underline{p} \leq \tilde{p} \leq \overline{p}\right]}{a + b\mathbb{E}\left[\tilde{p}\middle|\underline{p} \leq \tilde{p} \leq \overline{p}\right] + I}\left(a + b\underline{p} + I\right) &= a + b\underline{p} + I\left(1 - \frac{a + b\underline{p} + I}{a + b\mathbb{E}\left[\tilde{p}\middle|\underline{p} \leq \tilde{p} \leq \overline{p}\right] + I}\right) \\
&> a + b\underline{p}
\end{aligned}$$

This simply restates that the lowest type equity issuer gets a higher payoff than the full information valuation because she obtains a cross subsidy from higher type equity issuers. But then the value of issuance relative to acquisition g is:

$$\begin{aligned}
g\left(\underline{p}, \overline{p}\right) &= \frac{a + b\mathbb{E}\left[\tilde{p}\middle|\underline{p} \leq \tilde{p} \leq \overline{p}\right]}{a + b\mathbb{E}\left[\tilde{p}\middle|\underline{p} \leq \tilde{p} \leq \overline{p}\right] + I}\left(a + b\underline{p} + I\right) - \left(a + b\mathbb{E}\left[\tilde{p}\middle|p \leq \underline{p}\right]\right) \\
&> a + b\underline{p} - \left(a + b\mathbb{E}\left[\tilde{p}\middle|p \leq \underline{p}\right]\right) \\
&> 0
\end{aligned}$$

□

Proof of Theorem 2. By the characterization of equilibria in theorem 1, we have that $h\left(\underline{p}^*, \overline{p}^*\right) = 0$. If there are no acquisitions, then by theorem 1 a PBE with equity issuance and underinvestment can be found by solving for a $\overline{p}^{'}$ such that $h\left(\underline{\rho}, \overline{p}^{'}\right) = 0$. By inspection, h is decreasing in the first argument, as the payoff from issuing equity goes down when lower types are added to the pool of equity issuers. Therefore $h\left(\underline{\rho}, \overline{p}^*\right) > 0$. We also have that

$$\begin{aligned}
h\left(\underline{\rho}, \underline{\rho}\right) &= \underline{\rho} b - \left(\underline{\rho} b + a\right) \\
&= -a < 0
\end{aligned}$$

By the intermediate value theorem, there exists a value $\overline{p}^{'} < \overline{p}^*$ such that $h\left(\underline{\rho}, \overline{p}^{'}\right) = 0$. □

B Conditions for Equilibria with Acquisitions, Issuance, and Underinvestment

This appendix characterize conditions under which the resulting equilibrium features types taking all three actions. While these conditions are not always necessary, they provide helpful economic intuition for the motivation for firms to take the different actions. The synergy σ must be large enough to make acquisitions attractive (lemma 4), but cannot be too large or else all firms would be acquired (lemma 5). The platform value b must also be large enough such that the cost of adverse selection is large enough relative to the benefits of investing in the drug candidate (lemma 6)

Lemma 4. *Let*

$$\sigma > \frac{b\left(\mathbb{E}\left[p\right]-\underline{\rho}\right)}{a+b\mathbb{E}\left[p\right]+I}$$

Then in equilibrium $S_a \neq \emptyset$.

Proof. By theorem 1, the only two classes of equilibria without acquisition are the equilibria in which all agents issue equity, or that low types issue equity and high types do not invest. In the first class of equilibria, we need that $g\left(\underline{\rho},\overline{\rho}\right) \geq 0$ and in the second class, $g\left(\underline{\rho},\overline{p}\right) \geq 0$ for the equilibrium cutoff $\overline{p}$. By inspection, g is increasing in its second argument. Therefore a sufficient condition to ensure that the resulting equilibrium features acquisitions is for $g\left(\underline{\rho},\overline{\rho}\right) < 0$. Using the definition of g we then have that

$$\underbrace{\frac{a+b\mathbb{E}\left[p\right]}{a+b\mathbb{E}\left[p\right]+I}\left(a+b\underline{\rho}+I\right)}_{\text{Value of Equity Issuance}} < \underbrace{a+b\underline{\rho}+\sigma}_{\text{Value of Acquisition}}$$

This condition is equivalent to

$$\begin{aligned}
\sigma &> \frac{a+b\mathbb{E}\left[p\right]}{a+b\mathbb{E}\left[p\right]+I}\left(a+b\underline{\rho}+I\right)-\left(a+b\underline{\rho}\right)\\
&= -\frac{I}{a+b\mathbb{E}\left[p\right]+I}\left(a+b\underline{\rho}\right)+\frac{I\left(a+b\mathbb{E}\left[p\right]\right)}{a+b\mathbb{E}\left[p\right]+I}\\
&= \frac{b\left(\mathbb{E}\left[p\right]-\underline{\rho}\right)}{a+b\mathbb{E}\left[p\right]+I}I
\end{aligned}$$

$\square$

The condition in lemma 4 requires that the synergy parameter σ is large relative to the amount of benefit from issuing mispriced equity. Recall that the equity price depends on the average type of all issuers, and so the lowest type equity issuer is subsidized in equilibrium by higher types. For there to be a guarantee that acquisitions occur in equilibrium, σ must be larger than the maximal amount of subsidy that can be obtained by the lowest type, which occurs when all types issue equity.

Lemma 5 says that if σ is smaller than the cost of selling out at a low acquisition price for the highest type, then not all firms will choose to get acquired.

Lemma 5. *If*

$$\sigma < b\left(\overline{\rho} - \mathbb{E}\left[p\right]\right)$$

Then not all firms are acquired in equilibrium.

Proof. By theorem 1, for all firms to be acquired we must have that $g\left(\overline{\rho},\overline{\rho}\right) \leq 0$. But if $\sigma < b\left(\overline{\rho} - \mathbb{E}\left[p\right]\right)$, we have that

$$\begin{aligned} g\left(\overline{\rho},\overline{\rho}\right) &= a + b\overline{\rho} - \left(a + b\mathbb{E}\left[p\right] + \sigma\right) \\ &= b\left(\overline{\rho} - \mathbb{E}\left[p\right]\right) - \sigma > 0 \end{aligned}$$

□

Lemma 6 additionally says that a sufficient condition for some firms to not invest is for the value of the technology platform must be sufficiently large relative to the value of the drug candidate so that equity issuance is sufficiently costly.

Lemma 6. *Define $\underline{p}'$ as the maximal solution to the equation*

$$g\left(\underline{p}',\overline{\rho}\right) = 0$$

Then provided that

$$\begin{aligned} \frac{b\left(\mathbb{E}\left[p\right] - \underline{\rho}\right)}{a + b\mathbb{E}\left[p\right] + I} I < \sigma &< b\left(\overline{\rho} - \mathbb{E}\left[p\right]\right) \\ \overline{\rho} &> \left(1 + \frac{a}{I}\right)\mathbb{E}\left[p \middle| \underline{p}' < p < \overline{\rho}\right] \\ b &> \frac{a}{\frac{I}{a+I}\overline{\rho} - \mathbb{E}\left[p \middle| \underline{p}' < p < \overline{\rho}\right]} \end{aligned}$$

We have that S_a, S_e, S_n are all non-empty.

Proof. The first two assumptions satisfy the conditions of lemmas 4 and 5, and so some but not all firms are acquired, i.e. $S_a \neq \emptyset$ and $S_a \neq \mathcal{P}$. But by theorem 1, in any equilibrium in which some but not all types are acquired, we have $S_e \neq \emptyset$. Therefore it remains to show that $S_n \neq \emptyset$. To rule out the possibility of $S_n = \emptyset$, it suffices to rule out the possibility that there exists some lower cutoff $\underline{p}$ such that $g\left(\underline{p}, \overline{\rho}\right) = 0$ and $h\left(\underline{p}, \overline{\rho}\right) \leq 0$. In particular I will show that under the assumptions of the lemma, for any lower cutoff $\underline{p}$ satisfying $g\left(\underline{p}, \overline{\rho}\right) = 0$, we will have $h\left(\underline{p}, \overline{\rho}\right) > 0$.

By inspection, h is decreasing in $\underline{p}$. Therefore it suffices to show h satisfies that condition for a maximal cutoff $\underline{p}$ with $g\left(\underline{p}, \overline{\rho}\right) = 0$. Let $P = \left\{\underline{p} \in \left[\underline{\rho}, \overline{\rho}\right] : g\left(\underline{p}, \overline{\rho}\right) = 0\right\}$. The assumptions on σ imply that $g\left(\underline{\rho}, \overline{\rho}\right) < 0$ and $g\left(\overline{\rho}, \overline{\rho}\right) > 0$. The function g is continuous by the assumption that f admits a density. Therefore by the intermediate value theorem, we have that P is non-empty. The set of roots of a continuous function is closed. Therefore define $\underline{p}^{'} = \max P$ to be the maximal such root. Using the definition of h, the condition that $h\left(\underline{p}^{'}, \overline{\rho}\right) > 0$ is equivalent to.

$$
\begin{aligned}
b\overline{\rho} &> \frac{a + b\mathbb{E}\left[p \,\middle|\, \underline{p}^{'} < p < \overline{\rho}\right]}{a + b\mathbb{E}\left[p \,\middle|\, \underline{p}^{'} < p < \overline{\rho}\right] + I}\left(a + b\overline{\rho} + I\right) \\
b\overline{\rho}I &> \left(a + b\mathbb{E}\left[p \,\middle|\, \underline{p}^{'} < p < \overline{\rho}\right]\right)\left(a + I\right) \\
\implies b\left(\overline{\rho}\frac{I}{a+I} - \mathbb{E}\left[p \,\middle|\, \underline{p}^{'} < p < \overline{\rho}\right]\right) &> a
\end{aligned}
$$

The expression inside the parentheses is positive by assumption. Then we can divide to obtain that the condition is equivalent to

$$
b > \frac{a}{\frac{I}{a+I}\overline{\rho} - \mathbb{E}\left[p \,\middle|\, \underline{p}^{'} < p < \overline{\rho}\right]}
$$

Which is also satisfied by assumption. Hence $h\left(\underline{p}^{'}, \overline{\rho}\right) > 0$, and so $S_n \neq \emptyset$. □

As discussed above, these conditions are not necessary. For example, the lower bound on the synergy parameter in lemma 4 is strong enough to cause the lowest type to be acquired, even if all higher types were issuing. In practice, there may be some high types who decide to not invest, which lowers the return to issuing equity. In that case σ may not need to be as large as specified in lemma 4. However, the benefit of the above sufficient conditions is that they can be verified without computing the full equilibrium of the model while also providing economic intuition for the key forces.