Financial Frictions and Startup Antitrust

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Abstract

I model the welfare effects of blocking startup acquisitions when startups face financial frictions caused by asymmetric information. In the model, startups self select into acquisitions when they have unobservably bad future investment opportunities. Blocking acquisitions causes low type startups to instead seek equity financing as standalone firms, exacerbating adverse selection in equity issuance and causing underinvestment. The decrease in investment from financial frictions can overwhelm the effect of greater competition. My channel differs substantially from existing defenses of anticompetitive startup acquisitions based on technological synergies or ex-ante entry.

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1 Introduction

Antitrust regulators are increasing scrutiny of incumbent acquisitions of startup firms. In February 2020, the FTC announced that it would be investigating startup acquisitions made by Amazon, Apple, Facebook, Google, and Microsoft over the past decade. In the same month Chinese antitrust authorities also proposed to expand antitrust scrutiny over small acquisitions that could potentially eliminate innovative competitors. Concerns over startup acquisitions have been especially prominent in the life sciences. For example, Roche's 2019 acquisition of Spark Therapeutics, a gene therapy startup, was held up over concerns that the merger would have reduced Roche's incentives to develop Spark's early stage treatments for hemophilia.

This paper analyzes the welfare effects of blocking startup acquisitions when startups face financial frictions stemming from asymmetric information. Asymmetric information is a natural friction startups face because they are commercializing new technologies while relying on external finance. Traditional innovation analyses of mergers assess the effect of the merger on the incentives of the merging parties to innovate, otherwise known as unilateral effects analysis. Implicit is an assumption that the parties to the merger are the primary firms affected by merger policy. This paper shows how merger policy can be transmitted to non-merging firms through financial markets. 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.

I construct a simple two period model to illustrate this friction. Inspired by past empirical work, I focus primarily on the biotech industry, although my results can generalize to other settings. In the model, a biotech 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. Adverse selection means that low type firms sell in an acquisition, medium type firms issue equity to invest, and high type firms choose not to invest.

In this environment, stricter antitrust enforcement shrinks the set of firms who choose to merge and induces marginal firms to instead operate as standalone firms and issue equity. Because the firms that choose to sell out are lower type firms on average, firms that switch from acquisition to standalone lower the market's inference of all inframarginal equity issuers. These types now face more severe mispricing when they issue equity.

The higher cost of equity finance pushes some firms to not undertake the first period investment opportunity, creating an ex-post welfare loss.

I contribute mainly 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. 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 ex-post welfare even in the absence of technological synergies and when there are no ex-ante incentives for entry. This novel cost of antitrust is important because past empirical work suggests that the standard arguments for permissive antitrust – technological synergies and entry – may not apply in the startup setting.

Second, I contribute to a corporate finance literature on the consequences of asymmetric information. My main contribution is to illustrate how basic corporate finance concepts can offer new insight into 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. Regulation that changes the payoffs of those choices therefore changes the information signalled by those choices, further affecting financing and investment behavior. I survey the papers in these areas in more detail in section 4.

2 Theory

I will focus on a young biotech firm as my canonical startup operating in an industry with competing incumbent products. There are three reasons for focusing on biotech. First, as the pandemic has illustrated, its products are economically important. Second, the firms in this industry fit the mold of trying to commercialize novel technologies while also relying on a substantial amount of external finance. The requirement for sustained, substantial amounts of external finance make it more appropriate than software, where firms may be able to rely more on internal funds. Third, there is already empirical work documenting that anticompetitive acquisitions happen in the industry (Cunningham et al., 2020). Therefore understanding the welfare effects of restricting acquisitions in this industry is policy relevant.

2.1 Baseline Model

A simple model based on Myers and Majluf (1984) illustrates the effects of antitrust on financial frictions. There are two periods $t = 1,2$. At $t = 1$ an entrepreneur is born with knowledge that at $t = 2$, her technology platform will be worth b with probability p and 0 otherwise. The market and potential acquirors do not know p, but know that $p \sim F$, with F supported $\left[\underline{\rho}, \overline{\rho}\right]$. The value of b is public information. At the same time, an opportunity to invest in a drug candidate with NPV a and cost I arrives. Again, both a and I are public information. After the first period investment opportunity arrives, the entrepreneur has three options: she can sell the firm to an incumbent pharma, she can finance the investment by raising equity, or she can choose not to invest. The entrepreneur announces her action, the market makes inferences based on the action, and then payoffs are realized, potentially depending on the market's inference. Last, at $t = 2$, the second investment opportunity arrives with probability p.

I next outline the payoffs from the entrepreneur's actions. In the second period, the platform is worth b. Then if the entrepreneur does not invest in the first period, her payoff derives entirely from the platform value. Define $N \subset \left[\underline{\rho}, \overline{\rho}\right]$ to be the set of entrepreneurs who do not invest. Define the value of not investing as V^n; it is equal to

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

Alternatively, she can issue equity. Define $E \subset \left[\underline{\rho}, \overline{\rho}\right]$ as the equilibrium subset of firms that issue equity, indexed by the probability of a second period investment opportunity p. I assume financial markets are competitive. Then she will raise equity at a pre-money valuation of

$$R = a + b\mathbb{E}\left[p \middle| p \in E\right]$$

After issuing equity she has a payoff of

$$V^e(p) = \frac{R}{R+I}(a + I + pb)$$

Last, she can decide to sell the firm to an incumbent. Let $A \subset S$ be the equilibrium subset of entrepreneurs who decide to be acquired. I assume the entrepreneur has all the bargaining power. Her value from an acquisition is

$$V^a(p) = a + b\mathbb{E}\left[p \middle| p \in A\right] + \sigma$$

where $\sigma \geq 0$ reflects the net value created by technological synergies and the prospect of

reduced competition. For the remainder of this paper, I will refer to σ as the synergy, while recognizing that it may reflect either a socially beneficial technological synergy or a socially harmful loss of competition.

In the model, the value of the technology platform is private information but the value of the drug candidate is common knowledge. For example, Moderna, one of the biotechs with a leading candidate for a COVID-19 vaccine, was founded to commercialize the technology platform of mRNA vaccines. The 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 a while there is asymmetric information over p 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 a new technology.

In a Perfect Bayesian Equilibrium, it must be that for all p, the entrepreneur takes the optimal action, and that the market inference is consistent. I formalize this in the following definition.

Definition 1. A Perfect Bayesian Equilibrium is defined by

1. (Three Pools) Three disjoint sets of acquired types A, investing types E, and no investing types N that cover $\left[\underline{\rho}, \overline{\rho}\right]$
2. (Market inference is consistent) Functions V^a, V^e, V^n defined by those sets
3. (Each type takes best action) Define $V(p) = \max_{i \in \{a,e,n\}} V^i(p)$. Then $\forall p \in A$, $V^a = V$, $\forall p \in E, V^e = V$, and $\forall p \in N$, $V = V^n$

In general there are multiple equilibria, and the sets A, E or N may be empty. For policy analysis, I will focus on equilibria in which there is some positive measure of firms being acquired, some issuing equity, and some choosing not to invest. In this situation we can get a tighter characterization of equilibrium. In particular, low types will sell in an acquisition, medium types will issue equity, and high types will fail to undertake the investment opportunity. I formalize this in the following proposition.

Theorem 1. *Fix three disjoint sets $A, E, N \subset \left[\underline{\rho}, \overline{\rho}\right]$. These three sets are consistent with an equilibrium if and only if they can be characterized by the form $A = \left[\underline{\rho}, \underline{p}\right]$, $E = \left(\underline{p}, \overline{p}\right)$, and*

$N = [\overline{p}, \overline{\rho}]$ *(up to switching endpoints), with the indifference conditions* $V^e\left(\underline{p}\right) = V^a\left(\underline{p}\right)$ *and* $V^e\left(\overline{p}\right) = V^n\left(\overline{p}\right)$.

Proof. All proofs are in Appendix A. □

Intuitively, this ordering happens because the payoffs from the three options satisfy single crossing. Being acquired leaves the biotech with no return to the second period platform value pb, issuing equity leaves the biotech with a partial return, while not investing leaves the biotech with the full value of pb. Therefore it is relatively more costly for firms with unobservably high p to be acquired or to issue equity.

Given that the equilibrium can be characterized by these cutoffs, I will write the equity and acquisition payoff functions to include these cutoffs. Let $V^e\left(p, \underline{p}, \overline{p}\right)$ be the payoff for an entrepreneur of type p who issues when the equilibrium cutoffs are $\underline{p}, \overline{p}$, and $V^a\left(\underline{p}, \sigma\right)$ is the payoff to an acquisition when the lower cutoff is $\underline{p}$ and the synergy level is σ. Note that the private type does not enter into the payoff from an acquisition.

2.2 Comparative Static of Changing Antitrust

I model antitrust as changing the net value σ of the technological synergies and potential anticompetitive effects. The easiest interpretation is to suppose that the startup has a continuum of potential acquirors with differing levels of potential anticompetitive incentives to acquire the startup. By ruling out certain anticompetitive deals, the regulator rules out high values of σ that the biotech could have extracted. Moreover, studying the effects of small changes in σ is a convenient mathematical tool, since a discrete change in σ from a high level to zero (i.e. going from allowing to banning acquisitions), can be evaluated by calculating the derivative of welfare with respect to σ at many intermediate values.

The comparative statics depend on equilibrium selection. I will restrict attention to equilibria that are self correcting. Formally, a self correcting equilibrium can be defined as follows:

Definition 2. Define the functions

$$g\left(c, \overline{p}, \sigma\right) = V^e\left(c, c, \overline{p}\right) - V^a\left(c, \sigma\right)$$
$$h\left(\underline{p}, c\right) = V^n\left(c\right) - V^e\left(c, \underline{p}, c\right)$$

An equilibrium set of cutoffs $\underline{p}^*, \overline{p}^*$ features *self correcting beliefs* provided that

$$\left.\frac{\partial g}{\partial c}\right|_{c=\underline{p}^*} \times \left.\frac{\partial h}{\partial c}\right|_{c=\overline{p}^*} + \frac{\partial V^e}{\partial \underline{p}} \frac{\partial V^e}{\partial \overline{p}} > 0$$

While the expression may not be immediately intuitive, in Appendix B I show how this restriction implies that the equilibrium beliefs can be interpreted as the outcome of an iterative process of learning so that if the market has beliefs that are close to the true values $\left(\underline{p}^*, \overline{p}^*\right)$, the learning process would converge on the true beliefs.

The main comparative static of the model is to consider how the equilibrium changes as σ changes. Reducing σ shrinks the set of firms acquired and expands the set of firms who do not invest. Figure 1 illustrates this intuition. There is first a direct effect from inducing marginal firms to shift from issuing equity to being acquired. This has follow on effects because it lowers both the average inferred type of the acquired and issuing firms. The lower inferred type for all equity issuing firms then means that some high type firms that issued equity under the old equilibrium no longer issue equity and invest. I formalize the intuition in proposition 2.

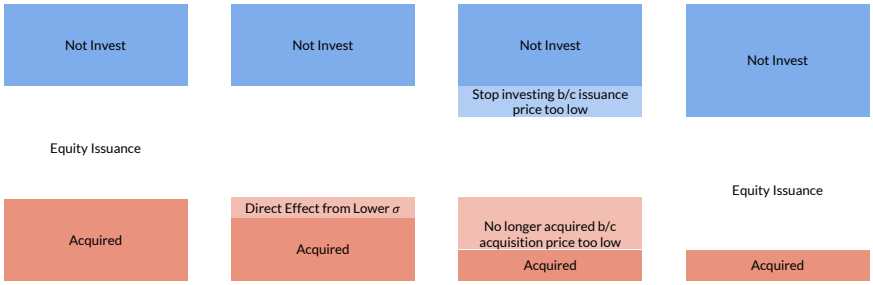
Theorem 2. *If there is an equilibria with self correcting inferences at a given level of σ, then there is a neighborhood U of σ such that there exist functions $\underline{p}(\sigma), \overline{p}(\sigma)$ with $\overline{p}$ increasing on U such that $\forall \sigma \in U$, the sets $A(\sigma) = \left[\underline{\rho}, \underline{p}(\sigma)\right]$, $E(\sigma) = \left(\underline{p}(\sigma), \overline{p}(\sigma)\right)$, and $N(\sigma) = [\overline{p}(\sigma), \overline{\rho}]$ form a PBE.*

2.3 Optimal Antitrust

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 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 anticompetitive effects with the assumption that a fraction $\kappa(\sigma) \in (0,1)$ of the acquired projects and platforms are discontinued, where the fraction of discontinued projects is increasing in the size of allowed merger synergies. The justification

Figure 1: Intuition behind proposition 2 on how the cutoff types $\underline{p}, \overline{p}$ change as the amount of synergy σ changes. The first panel on the left illustrates the initial equilibrium. The second panel from the left illustrates how a lower σ causes a direct effect by causing the marginal firms between issuance and acquisition to switch into being 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.



for $\kappa^{'} > 0$ is that if the regulator allows more anticompetitive mergers, then on average the mergers approved will have anticompetitive effects (so that σ is higher) while also having a higher probability of the acquired drug candidate being killed by the acquiror (and so κ is higher).

With these assumptions I derive an expression for consumer surplus and a directional test for optimal antitrust. Let the drug candidate generate $\alpha_I(\sigma)$ dollars of consumer surplus if developed by the incumbent and α_S dollars of consumer surplus if developed by the startup. Generically $0 < \alpha_I < \alpha_S$ because of the incentive of the incumbent's multi-product pricing incentives to price both drugs higher and reduce cannibalization, otherwise known as unilateral price effects. The surplus value if the incumbent invests is also a decreasing function of σ, as the incumbent has a weaker incentive to price aggressively if the startup's drug features more overlap. Let the platform, if realized, create β dollars of consumer surplus. Then consumer surplus is equal to

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

Where the effective killing rate κ^* is defined as

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

and P_A, P_E, P_N are the measures of the acquisition, issuance, and non-investment sets with respect to the measure F. 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 $\left(\frac{\alpha_I}{\alpha_S} < 1\right)$. Both factors contribute to a positive effective killing rate.

Differentiating the welfare expression with respect to σ and dropping proportionality terms highlights the key forces behind the optimal extent of antitrust enforcement

$$\frac{\mathrm{d}W}{\mathrm{d}\sigma} \propto \underbrace{\left[-\frac{\mathrm{d}\kappa^*}{\mathrm{d}\sigma}P_A - \kappa^*\frac{\mathrm{d}P_A}{\mathrm{d}\sigma}\right]}_{<0\text{, more killed projects}} - \underbrace{\frac{\mathrm{d}P_N}{\mathrm{d}\sigma}}_{>0\text{, more investment}} \tag{1}$$

The first terms in equation 1 represents the typical losses from mergers, reflecting a combination of unilateral price and innovation effects. The last term is the novel force under asymmetric information, namely that allowing more mergers may reduce underinvestment by high type firms. Antitrust should allow more mergers provided that the underinvestment effect outweighs the competition effect. In general there are no simple numerical conditions that determine which effect, reduced competition or underinvestment, will be stronger in the data. Below, I construct an example in which the underinvestment effect is stronger.

2.4 A Numerical Example

In this section I illustrate the model mechanisms 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:

$$
\begin{aligned}
\underline{p} &= \frac{2(\sigma - a)}{b} \\
\overline{p} &= \frac{2\sigma(I + a)}{b(I - a)}
\end{aligned}
$$

Assume for now that $\sigma > a$ and $I > a$ so that we're in an interior equilibrium with a positive measure of firms being acquired, issuing equity, and not investing. Then

$$
\begin{aligned}
\frac{\mathrm{d}\underline{p}}{\mathrm{d}\sigma} &= \frac{2}{b} \\
\frac{\mathrm{d}\overline{p}}{\mathrm{d}\sigma} &= \frac{2}{b}\frac{I + a}{I - a}
\end{aligned}
$$

Under this numerical parameterization, changing σ has a two for one effect on the lower cutoff, and then an even larger effect on the upper cutoff. This particular example highlights how slight changes in antitrust policy that affect the merging decisions of low type firms can have large effects on the investment decisions of high type firms.

Consider an extreme case of $\kappa = 1$ and $\kappa' = 0$, so that all acquired projects are killed. Under this parameterization, $\kappa^* = 1$ as well. Then the derivative of welfare with respect to σ is proportional to

$$
\begin{aligned}
\frac{\mathrm{d}W}{\mathrm{d}\sigma} &\propto -\kappa^* \frac{\mathrm{d}P_A}{\mathrm{d}\sigma} - \frac{\mathrm{d}P_N}{\mathrm{d}\sigma} \\
&= \frac{2}{b}\left(-1 + \frac{I + a}{I - a}\right) \\
&> 0
\end{aligned}
$$

Marginally tighter antitrust leads to $\frac{2}{b}$ fewer anticompetitive acquisitions, but $\frac{I+a}{I-a} \times \frac{2}{b}$ more firms who opt to not invest. In this particular parametric example, the effect of

antitrust on underinvestment is so large that optimal antitrust seeks to stop all underinvestment even at the cost of additional anticompetitive acquisitions.

3 Discussion

3.1 Modeling Assumptions

My model implicitly assumes 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 entrepreneur and outside investors. First, in the real world there are likely a long tail of negative NPV projects that I assume have already been screened out by investors. Therefore being acquired means that the firm is not in that long tail, which can be interpreted as a modestly successful outcome. Even among the group of firms with positive value, my model only argues that firms with unobservably worse future investment opportunities are more likely to sell out. Therefore I do not rule out that acquired firms may have had many successful products in the past. Anecdotally, Mark Zuckerberg had to turn down very large attractive acquisition offers when Facebook was very young. One plausible reason he turned them down was because he thought that Facebook still had substantial growth opportunities that were being undervalued by acquirors.

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 cancel the platform. 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 acquiror is buying the startup in order 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.

A key feature of the numerical example is that the masses of non-investing and acquired firms are highly responsive to the level of the synergy parameter σ. This may be counterfactual and limit the empirical relevance of my theory. This high elasticity is the consequence of firms payoffs being highly sensitive to the market's inference of type. In alternative models where biotechs may have hidden idiosyncratic tastes for selling out or staying standalone, actions may reveal less information about type and so the underinvestment effect that I conjecture is smaller. Nonetheless, the theoretical mechanism I outline would still apply. By changing the incentives to merge, that changes the composition of firms who issue equity, and can thereby cause underinvestment.

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.

I also assume that entrepreneurs are risk neutral and have the same discount rate as the market. These assumptions are not necessary for my results. Incorporating these elements would mean that there are additional gains from trade from selling the firm or issuing equity. In that more realistic model, blocking startup acquisitions would be additionally costly because it would reduce the gains from trade realized by selling equity or selling in an acquisition. In a richer model with entry, the reduction in gains from trade can lead to an even larger ex-ante welfare loss as fewer entrepreneurs enter.

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.

While in the paper I model the synergy as additive, this can be generalized to a multiplicative synergy as well. The only loss is that a different synergy can affect the existence of equilibria under different distributions. For example, a multiplicative synergy will not admit an equilibrium with acquired, issuing, and non-investing firms in the case of a uniform distribution.

My model also assumes that the NPV of the $t = 1$ project is known. This assumption can be relaxed so long as high type firms remain less likely to issue equity. For example, if the mean of a is increasing too fast in p, then all types would be forced to pool and the comparative statics of my model would break down.

3.2 Implications for Antitrust and Entrepreneurship Policy

My model implies that blocking startup acquisitions can affect non-merging firms' financing costs. This tradeoff is novel to the antitrust literature because the firms that are affected by antitrust policy in this world do not necessarily 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 other platform companies, such as cell therapy, mRNA, or CRISPR companies. By signaling that acquisitions by acquirors with overlapping product portfolios were off the table, then other platform companies would have fewer options to get acquired, 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, which makes 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. Crucially, my model outlines how blocking acquisitions can actually lower investment activity, even accounting for the impact of incumbents' incentives to kill acquired projects.

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 given Novartis is 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 Other Defenses of Anticompetitive Mergers

My model shows how stringent antitrust can be harmful even in the absence of technological synergies or entry. This is important because the theory and evidence in Cunningham et al. (2020) emphasizes that these traditional defenses of anticompetitive mergers likely do not apply in the pharmaceutical industry.

One defense of mergers is that they create technological synergies which spur innovation (Bena and Li, 2014). Cunningham et al. (2020) 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. However, 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 bad quality. Second, the traditional technological synergy appears at the merging firms, while the benefit of relaxing financial constraints can occur at completely unrelated firms. In contrast to the measurement of technological synergies, the measurement of the effect of antitrust on financial constraints cannot be done at the firm level.

Another argument for more permissive merger policy in innovation markets is that allowing anticompetitive mergers creates ex-ante benefits on startup entry that overwhelm the ex-post loss in competition (Phillips and Zhdanov, 2013). Cunningham et al. (2020) argue that the positive effect of entry is unlikely to offset the cost of lost competition because anticompetitive startup acquisitions are most likely to occur when there are few prospects of new entrants. However, 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 Relation to Literature

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. 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. Kamepalli et al. (2020); Katz (2020) explore models of how acquisitions of nascent competitors by incumbent firms when there are significant network effects can affect consumers and even the startup themselves. Missing from these theories and practical guidance is a discussion of how antitrust policy affects the ability of firms' 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.

Empirically, Cunningham et al. (2020) document 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. (2020) 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.

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. 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 Main Propositions

Proof of Proposition 1. For the if direction, it suffices to show that each type is taking the best action. Note that after we fix the sets A, E, we have that

$$0 = \frac{\partial V^a}{\partial p} < \frac{\partial V^e}{\partial p} = \frac{R}{R+I} < \frac{\partial V^n}{\partial p} = b$$

By integrating and combining with the indifference conditions, we then have that $V^n(p) > V^e(p)$ for all $p > \overline{p}$, $V^n < V^e(p)$ for all $p < p$, $V^e(p) > V^a(p)$ for all $p \geq \underline{p}$, and $V^e(p) < V^a(p)$ for all $p < \underline{p}$. Let $V(p) = \max_{i \in \{a,e,n\}} V^i(p)$. Combining inequalities gives that $V^a = V$ for all $p \leq \underline{p}$, $V^e = V$ for all $p \in \left[\underline{p}, \overline{p}\right]$, and $V^n = V$ for all $p \geq \overline{p}$.

For the only if direction, fix the three sets. Because $\frac{\partial}{\partial p}(V^e - V^a) > 0$, then if any type prefers issuing equity to acquisitions all higher types will also share the preference. Similarly, $\frac{\partial}{\partial p}(V^n - V^e) > 0$ implies that if any type prefers not investing to issuing equity, then so will all higher types. Therefore $\forall a \in A, e \in E, n \in N$, $a \leq e \leq n$. This gives the interval representation, up to the choice of endpoints.

For the indifference conditions on the acquisition/issuance boundary, suppose by contradiction that $V^e\left(\underline{p}\right) > V^a\left(\underline{p}\right)$. Then by continuity, there is some ϵ such that the inequality is still true on $\left(\underline{p} - \epsilon, \underline{p}\right)$. But all such points are in E, a contradiction to the definition of equilibrium. Similar logic for the less than case and for the other indifference condition establish the indifference conditions in the general case. □

Proof of Proposition 2. Define

$$\begin{aligned} g(c, \overline{p}, \sigma) &= V^e(c, c, \overline{p}) - V^a(c, \sigma) \\ h\left(\underline{p}, c\right) &= V^n(c) - V^e\left(c, \underline{p}, c\right) \\ H\left(\underline{p}, \overline{p}, \sigma\right) &= \begin{pmatrix} g\left(\underline{p}, \overline{p}, \sigma\right) \\ h\left(\underline{p}, \overline{p}\right) \end{pmatrix} \end{aligned}$$

Then an equilibrium is a point where $H = \mathbf{0}$. By the implicit function theorem, for a fixed synergy σ^*, there is a neighborhood U of σ^* such that there exist functions $\underline{p}(\sigma), \overline{p}(\sigma)$

such that $H\left(\underline{p}(\sigma),\overline{p}(\sigma),\sigma\right)=0$. The derivatives can be expressed as

$$\begin{aligned}
\begin{pmatrix} \frac{\partial \underline{p}}{\partial \sigma} \\ \frac{\partial \overline{p}}{\partial \sigma} \end{pmatrix} &= \begin{pmatrix} \frac{\partial g}{\partial c} & \frac{\partial g}{\partial \overline{p}} \\ \frac{\partial h}{\partial \underline{p}} & \frac{\partial h}{\partial c} \end{pmatrix}^{-1} \begin{pmatrix} \frac{\partial g}{\partial \sigma} \\ \frac{\partial h}{\partial \sigma} \end{pmatrix} \\
&= \begin{pmatrix} \frac{\partial g}{\partial c}\Big|_{c=\underline{p}} & \frac{\partial V^e}{\partial \overline{p}} \\ -\frac{\partial V^e}{\partial \underline{p}} & \frac{\partial h}{\partial c}\Big|_{c=\overline{p}} \end{pmatrix}^{-1} \begin{pmatrix} 1 \\ 0 \end{pmatrix} \\
&= \frac{1}{D} \begin{pmatrix} \frac{\partial h}{\partial c}\Big|_{c=\overline{p}} \\ \frac{\partial V^e}{\partial \underline{p}} \end{pmatrix}
\end{aligned}$$

Where

$$\begin{aligned}
D &= \det \begin{pmatrix} \frac{\partial g}{\partial c}\Big|_{c=\underline{p}} & \frac{\partial V^e}{\partial \overline{p}} \\ -\frac{\partial V^e}{\partial \underline{p}} & \frac{\partial h}{\partial c}\Big|_{c=\overline{p}} \end{pmatrix} \\
&= \frac{\partial g}{\partial c}\Big|_{c=\underline{p}} \times \frac{\partial h}{\partial c}\Big|_{c=\overline{p}} + \frac{\partial V^e}{\partial \underline{p}} \frac{\partial V^e}{\partial \overline{p}} > 0
\end{aligned}$$

Note the last line holds by the definition of self correcting beliefs. □

B Connecting Self Correcting Beliefs to a Model of Learning

The goal of this section is to show how the self correcting beliefs definition arises naturally from restricting to the set of beliefs that can be attained from a process of learning. I prove the following theorem:

Theorem 3. *A set of equilibrium cutoffs $\underline{p}^*, \overline{p}^*$ satisfies the self correcting beliefs assumption if and only if $\left(\underline{p}^*, \overline{p}^*\right)$ is a stable sink of the system of differential equations*

$$\underline{p}^{'}(t) = -g\left(\underline{p}(t), \overline{p}(t), \sigma\right)$$
$$\overline{p}^{'}(t) = -h\left(\underline{p}(t), \overline{p}(t)\right)$$

To understand the differential equation at the heart of this theorem, recall the definitions of g and h:

$$g(c, \overline{p}, \sigma) = V^e(c, c, \overline{p}) - V^a(c, c, \sigma)$$
$$h\left(\underline{p}, c\right) = V^n(c) - V^e\left(c, \underline{p}, c\right)$$

The function $g(c, \overline{p}, \sigma)$ gives the relative value of issuing versus being acquired for the marginal firm who gets acquired, assuming that the marginal firm is of type c and the marginal firm between issuance and not investing is of type $\overline{p}$. The function $h\left(\underline{p}, c\right)$ represents the relative value of not investing versus issuing equity for the marginal biotech who decides to not invest, assuming that the marginal firm deciding between issuance and not investing is of type c and the marginal firm deciding between acquisition and issuance is of type $\underline{p}$. Note that in equilibrium, the indifference conditions give $g\left(\underline{p}^*, \overline{p}^*, \sigma\right) = h\left(\underline{p}^*, \overline{p}^*\right) = 0$.

The system of differential equation specifies a natural learning process by which the market can start with some initial beliefs about $\underline{p}^*, \overline{p}^*$, and revise them based on the violations of the indifference conditions g and h. The first equation in the system says that if the type at the conjectured lower cutoff $\underline{p}(t)$ strictly prefers the issuance option (i.e. $g > 0$), then the market revises its beliefs to expand the set of firms who issue by lowering $\underline{p}(t)$. Similarly, if the type at the conjectured upper cutoff $\overline{p}(t)$ strictly prefers not investing, then the market revises its beliefs to expand the set of firms who do not invest by lowering $\overline{p}(t)$. Therefore the system of differential equations has the market

revise its beliefs of the cutoffs $\underline{p}(t), \overline{p}(t)$ over time until the equilibrium conditions are satisfied.

Given the theorem, then the assumption of self correcting beliefs restricts to equilibria in which the market could converge to those beliefs from the specified learning process. This is a natural restriction because we cannot expect the market to know the values of $\underline{p}^*, \overline{p}^*$. Next we prove the theorem.

Proof of Theorem 3. By the indifference conditions, we know that $g\left(\underline{p}^*, \overline{p}^*, \sigma\right) = h\left(\underline{p}^*, \overline{p}^*\right) = 0$ and so $\left(\underline{p}^*, \overline{p}^*\right)$ are an equilibrium to the system of differential equations. It suffices to show that it is a sink if and only if the self correcting belief holds. From the theory of differential equations, we know that it is a local sink only if the determinant of the Jacobian of the system is negative at the equilibrium value. The determinant is precisely

$$-\left(\left.\frac{\partial g}{\partial c}\right|_{c=\underline{p}^*}\left.\frac{\partial h}{\partial c}\right|_{c=\overline{p}^*} + \frac{\partial V^e}{\partial \overline{p}}\frac{\partial V^e}{\partial \underline{p}}\right) < 0$$

By the self correcting beliefs assumption. □