

Financial Frictions and Startup Antitrust

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Abstract

Financial frictions can overturn conventional antitrust analysis of startup acquisitions. I extend Myers-Majluf to include the option to be acquired. Low types are acquired, medium types issue equity, and high types do not invest. Blocking acquisitions lowers the average type of equity issuers and raises the cost of capital for standalone startups. The welfare loss from lower investment can overwhelm the welfare gains from blocking anticompetitive acquisitions. A case study from the pharmaceutical industry suggests antitrust policy can have a large effect on the valuations of startups who are unlikely to be acquired for anticompetitive reasons.

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I have nothing to disclose.

1 Introduction

Antitrust authorities are increasing challenges of startup acquisitions by large incumbent firms. In 2019, the Federal Trade Commission (FTC) delayed the pharmaceutical company Roche's acquisition of Spark Therapeutics, a gene therapy startup. Because Roche had a drug on the market to treat hemophilia and Spark was developing a new treatment for hemophilia, the FTC was concerned that the acquisition would slow innovation in hemophilia treatments. In November 2020, the Department of Justice challenged Visa's proposed acquisition of Plaid, a financial data aggregator, arguing that the acquisition would have stifled nascent competition in online payments.

While there is a growing literature on when and whether startup acquisitions should be blocked, this literature has largely ignored the effects of antitrust policy on startups' ability to obtain financing. Even though industry lobbyists argue that acquisitions make investing in startups more lucrative, these arguments typically ignore the fact that consumers do not benefit if the acquisitions prevent innovative products from being introduced.

In this paper, I use corporate finance tools to study optimal antitrust policy towards startups. Startups differ from the firms traditionally studied in merger policy because they are more likely to face financial frictions stemming from asymmetric information. Innovation requires large upfront investments with an uncertain chance of success. In this environment, acquisitions relax financial frictions at startups who choose not to merge. Therefore even when acquisitions have anticompetitive effects, committing to allow such acquisitions can increase ex-ante consumer surplus.

The model extends a standard financing game under asymmetric information to incorporate acquisitions. In the model, a startup has a publicly observed first period investment opportunity and private information about the startup's future value. The investment opportunity represents a chance to invest in a product that would compete with a large incumbent firm. The startup has to make a decision between being acquired by the incumbent firm, financing the investment opportunity with equity, or not investing at all. In equilibrium, startups with bad private information sell in an acquisition, startups with intermediate private information issue equity to invest, and startups with good private information choose not to invest.

The model predicts that banning acquisitions reduces investment at standalone startups. When acquisitions are banned, startups with bad private information issue equity instead. Investors understand that the pool of equity issuers changes and offer lower valuations for all equity issuers. Lower valuations ultimately cause some startups with intermediate private information to no longer invest.

Optimal policy in the presence of financial frictions may allow for acquisitions with a direct anticompetitive effect. Optimal policy balances the positive effect of acquisitions in relaxing financial frictions at standalone startups against the potentially negative effect of acquisitions on competition between the merging parties. Under some conditions, allowing acquisitions can be good even if incumbents are guaranteed to not invest in the new product at the startup. The negative effect of acquisitions on competition between the merging parties overstates the harms of permissive antitrust by ignoring the positive effects on other standalone startups.

The narrative record of high growth startups supports the model's prediction that the startups who decide to sell have worse private information. Facebook considered accepting an acquisition offer from Yahoo, but turned it down after the successful roll out of Facebook beyond college campuses. Plaid, the financial data aggregator, accepted an acquisition offer from Visa, but walked away from the deal after demand from financial technology companies grew rapidly during the pandemic.

Incorporating entry, more sophisticated security design, or changing the bargaining power assumption does not significantly change the analysis. My model differs from standard defenses of acquisitions based on entry because it focuses on how regulators can best incentivize investment at the startups who have already chosen to enter. This makes my model a more robust defense of startup acquisitions. Although startups do not fund themselves with pure equity in practice, alternative securities do not eliminate the financial frictions associated with private information. While the baseline model assumes the startup has all of the bargaining power in an acquisition, as long as the acquisition price does not depend on the startup's private information the results still go through.

Roche's 2019 acquisition of Spark Therapeutics, a gene therapy startup, serves as a useful case study on the effects of strict antitrust on startups. While the acquisition offer was for \$4.8 billion, Spark nonetheless fits into the mold of a startup that is trying to commercialize a novel technology in the absence of internal funds. Much to the surprise

of market participants, the acquisition was delayed by the FTC. I use stock market event studies to show that, had regulators blocked the deal, all other gene therapy companies would have lost around 10% of their value, or \$5 billion. While the gene therapy startups with overlapping products with Roche would have been affected more, the majority of losses occurred at startups who were unlikely to quickly compete with any established pharmaceutical firm. While the event studies by themselves cannot speak to welfare, they do support the model's prediction that an active market for acquisitions is important even for standalone startups who are not acquired.

2 Literature Review

My paper 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.

Cunningham et al. (2021) document empirically that "killer acquisitions" occur in the pharmaceutical industry. By "killer acquisitions" the authors refer to cases where an incumbent acquires a startup in order to prevent the startup's competing products from entering the market. My theory explains how permitting killer acquisitions can nevertheless increase ex-ante consumer surplus. The key insight is that, under asymmetric information, the benefits of allowing acquisitions can show up at standalone startups. Because Cunningham et al. (2021) focus on development activity at the merging firms, they are unable to estimate the size of the offsetting benefits.

Fumagalli et al. (2020) also theoretically study how financial frictions interact with antitrust policy, but our papers differ in their conclusions for how killer acquisitions should be regulated. In their model, the regulator should block all acquisitions in which the incumbent would kill the startup's project while the startup 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 who would have otherwise chosen to not invest. 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 startup acquisitions does not affect the investment decisions of other startups.

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. Bond and Zhong (2016) extend the argument to a dynamic environment. 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 frictions arising from asymmetric information. This latter channel is more relevant for startup firms who have very little debt on their balance sheet.

3 Model

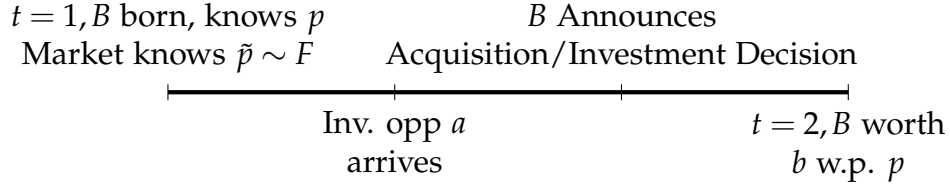
In this section I present a model of optimal regulation of startup acquisitions when startups face financial frictions stemming from asymmetric information. The model contains two main parts. First, I characterize the equilibria of a financing game in the spirit of Myers and Majluf (1984) in which startups can either sell themselves to an incumbent, raise equity to invest in a project that competes with the incumbent, or choose not to invest. Second, I study how antitrust policy changes equilibrium financing conditions and consumer surplus. I show that stringent antitrust decreases investment at standalone startups. Optimal policy weighs the benefits of relaxing financial frictions against the cost of lost competition.

3.1 The Financing Game

The structure of the game is very similar to Myers and Majluf (1984). Figure 1 illustrates the sequence of events in the model. There are two periods $t = 1, 2$. At $t = 1$ a startup 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 value of p is private to the startup. Investors and acquirors only know the distribution of p . Represent the private type as a random variable \tilde{p} distributed according to a distribution F , with F supported on $[\underline{\rho}, \bar{\rho}] \equiv \mathcal{P} \subset [0, 1]$ with a density f . Throughout I will at times refer to startups as types.

In the first period, the startup has a publicly observed opportunity to invest in developing a product to compete with the incumbent. The investment opportunity has NPV a and cost I . Both a and I are public information. After the investment opportunity arrives, the startup has three options: it can sell out to an incumbent who would otherwise

Figure 1: Sequence of events in the model



compete with the startup, it can finance the investment by raising equity, or it can choose not to invest. The startup 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 .

I make a crucial distinction between today's opportunity to invest in a competing product, 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. In the case of the Roche-Spark acquisition, Roche is the incumbent and Spark is the startup. The investment opportunity a represents a new treatment for hemophilia, b represents the value of gene therapy for treating other diseases, and p represents the probability that gene therapy will be useful in treating those other diseases. The assumption that there is perfect information over the investment opportunity 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 Spark, it's possible to evaluate the quality of its hemophilia cure using traditional clinical trials, while evaluating the quality of its broader gene therapy platform requires a deeper understanding of the technology.

The distinctions between current investment opportunities that will compete with incumbents and a future technology platform applies beyond biotech. Plaid is a financial data aggregator that powers many fintech apps. During the pandemic, Plaid played an important role in allowing financial service companies to provide more services online. Before the pandemic, Visa wanted to acquire Plaid for \$5.3 billion, and later Department of Justice filings showed that this was partially motivated by a concern that Plaid would compete with Visa in online debit payments. In this setting, the investment opportunity a reflects Plaid's opportunity to build a competing online debit network to compete

with Visa. The platform b represents the value of becoming a data aggregator for a new generation of financial service companies. The private information p is the probability Plaid will succeed. While Visa and the market can understand the likelihood Plaid can succeed in building a payments network to compete with Visa, Plaid has private information over whether fintech companies will grow enough for data aggregation to be a successful business.

Emphasizing asymmetric information over the value of the technology platform instead of asymmetric information over assets in place as in Myers and Majluf (1984) has two benefits. First, it helps to ground the assumption that the startup has better information than investors or incumbents. Many startups are founded on the basis of a new technology. It is natural to assume that the startup has a better understanding of the new technology than incumbents or investors. Second, the technological platform also provides a good reason why debt or more sophisticated security designs are not useful in this environment. The value of the startup is in its future growth potential, and any security to capture that must have a significant equity component.

I next outline the payoffs from the startup's actions. I assume that the startup, 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.

3.1.1 Underinvestment

If the startup does not invest in a , its payoff derives entirely from the second period platform value. Let n denote the action to not invest, and define $S_n \subset \mathcal{P}$ to be the set of startups 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 startup would undertake all positive NPV investments. Define the value of not investing as V^n ; it is equal to the expected value of the technological platform

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

3.1.2 Issuing Equity

The startup can also issue equity and invest in creating the competing product. Let e denote the action to issue equity, and let $S_e \subset \mathcal{P}$ index the equilibrium subset of types that issue equity. If the startup decides to issue equity, competitive investors offer to give I for a fraction ϕ of the startup. Therefore after issuing equity the original owners of the startup have a payoff of

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

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

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

This value of ϕ is pinned down by the fact that equity investors must earn zero expected profit on their investment.

3.1.3 Acquisition

Last, the startup can decide to sell itself to the incumbent. Let $S_a \subset \mathcal{P}$ be the equilibrium subset of startups who decide to be acquired. I assume that the startup has all the bargaining power in setting the acquisition price, and makes 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 investment opportunity as the startup, 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 investment opportunity than the startup would have obtained. It could capture efficiency gains from the incumbent's expertise in development or the difference between duopoly and monopoly profits that the incumbent captures by killing the startup's investment opportunity. 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 3.4.

3.1.4 Equilibrium Definition

Given the primitives $\{f, a, b, I, \sigma\}$ 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 startups of each type are taking their best action, accounting for the fact that the market's inference depends on each type's action. The second condition requires that if startups issue in equilibrium, then the share of the startup that is sold is consistent with competitive bidding for the equity of the issuing startups. The third condition requires that if startups choose to be acquired in equilibrium, then the acquisition price is consistent with competitive bidding for the assets of the acquired startups. Both the second and third conditions require that if issuance or acquisitions, respectively, do not happen in equilibrium, then the share of the startup that has to be sold or the acquisition price of the startup are consistent with some beliefs about the types who take the off equilibrium actions.

3.2 Characterizing Equilibria

In this section I characterize the equilibria of the model.

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 startups with unobservably high success probabilities p to be acquired or to issue equity. I discuss the realism of this simple result in section 4.1. I formalize the ordering in the following lemma

Lemma 1. *In any pure strategy PBE, the types of acquired startups are lower than the types of issuing startups, who in turn have lower types than non-investing startups. That is, $\forall p_a \in S_a, p_e \in S_e, p_n \in S_n, p_a \leq p_e \leq p_n$*

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 1 characterizes the equilibria that remain.

Theorem 1. *If the three sets of acquired, issuing, and non-investing types S_a, S_e, S_n are consistent with a pure strategy PBE that satisfies D1, then*

1. S_a, S_e, S_n are ordered intervals with $S_a \leq S_e \leq S_n$
2. If no type issues equity, all types are acquired $S_a = [\underline{\rho}, \bar{\rho}]$
3. Whenever both $S_a, S_e \neq \emptyset$, then $V^a(\underline{p}) = V^e(\underline{p})$ where $\underline{p} = \sup S_a = \inf S_e$
4. Whenever both $S_n, S_e \neq \emptyset$, then $V^n(\bar{p}) = V^e(\bar{p})$ where $\bar{p} = \sup S_e = \inf S_n$

The equilibria in theorem 1 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.

Corollary 1. *Define the functions*

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

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

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

In the definition of corollary 1, the function g represents the difference between the payoff from issuing equity and being acquired for a type c , assuming that all types less than c are acquired and all types between c and \bar{p} issue equity. The function h represents the payoff from not investing and issuing equity for a type c firm when all types between \underline{p} and c issue equity and type c and above startups do not invest. The key distinction between the functions g, h and the payoff functions V is that g, h allow the inferences to move with the cutoff types, whereas the payoff functions V hold fixed the market's beliefs about which types take which actions.

3.3 The Effects of Blocking Acquisitions on the Market Equilibrium

Blocking acquisitions increases underinvestment whenever both actions occur in equilibrium. 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 startup bears strictly higher adverse selection costs with no offsetting benefit, and so no startup would sell all the shares.

Lemma 2. *Let $\sigma = 0$. Then in any equilibrium $S_a = \emptyset$.*

For each equilibrium with acquisitions, there exists a corresponding equilibrium without acquisitions that features more underinvestment. In this sense blocking acquisitions causes more underinvestment. Appendix B derives the regularity conditions for when all three actions occur in equilibrium.

Theorem 2. *Fix a set of primitives $\{f, a, b, I, \sigma\}$ that generate an equilibrium in which all three actions are taken. Without loss of generality, define $S_a = [\underline{\rho}, \underline{p}^*)$, $S_e = [\underline{p}^*, \bar{p}^*]$, and $S_n = (\bar{p}^*, \bar{\rho}]$, with $\underline{\rho} < \underline{p}^* < \bar{p}^* < \bar{\rho}$. If σ is changed to 0, there exists an equilibrium cutoff \bar{p}' with $\bar{p}' < \bar{p}^*$ such that $S_a = \emptyset$, $S_e = [\underline{\rho}, \bar{p}']$, and $S_n = (\bar{p}', \bar{\rho}]$ is a PBE.*

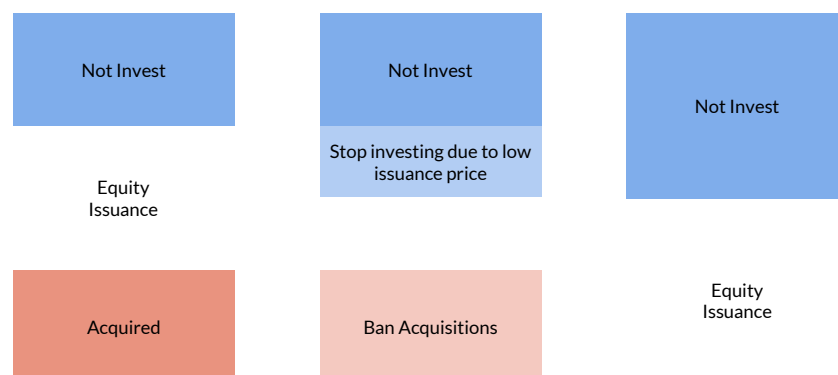
Figure 2 illustrates the intuition for the result. If acquisitions are blocked, types that would have been acquired will instead issue equity. This lowers the average type of equity issuers. As a result, the highest types that issue equity in the original equilibrium will instead choose to not invest. 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 higher 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.

3.4 Optimal Policy

Incorporating financial frictions into the analysis of antitrust leads to more permissive antitrust thresholds. The key idea is that antitrust should weigh the net effect of killed

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



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 startup. This assumption requires that the platform is sufficiently flexible that the incumbent is able to redirect it to develop products 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 $\kappa > 0$ of the acquired opportunities to invest in a competing product are discontinued. This is consistent with the evidence in Cunningham et al. (2021). I also allow for the possibility that, conditional on the incumbent developing the project, the project generates less consumer surplus when it's under the incumbent's control. This may occur because the incumbent will price the product higher to avoid cannibalization of its existing product. Formally, let the investment opportunity 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 will set higher prices if the startup's product overlaps with the incumbent's product.

I assume the antitrust authority maximizes ex-ante consumer surplus by choosing whether to allow the equilibrium with the baseline level of synergies σ or banning acquisitions by setting $\sigma = 0$. When the regulator is deciding between whether it is better to allow acquisitions or not, it does not know whether or not the startup will be of a type that will choose to be acquired. Ideally the regulator would like to ex-ante claim to be lenient towards acquisitions to relax financial frictions, but then block any acquisitions that are found to be anticompetitive ex-post. Because merger control is a repeated game, I rule out this possibility.

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

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

Where the effective killing rate κ^* is defined as

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

The expression for the effective killing rate captures two sources of ex-post efficiency loss from the incumbent's ownership of the startup's investment opportunity. First, the incumbent may kill the project before it reaches market ($\kappa > 0$), which Federico et al. (2019) term unilateral innovation effects. Second, even if the incumbent invests it will charge a higher price for the new product 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 new product, 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

$$\Delta W \propto \kappa^* P_A - (P'_N - P_N)$$

The first term is the standard benefit from blocking anticompetitive acquisitions. The coefficient κ^* is the percentage welfare loss per acquisition. The second term is novel and reflects the cost of lower investment due to more binding financial frictions. A regulator who ignored financial frictions would always block mergers provided that acquired firms produced less consumer surplus (i.e. $\kappa^* > 0$). However, in the presence of financial frictions the regulator also has to weigh the effect of blocking acquisitions on underinvestment at high type firms.

3.5 Parametric Example

In this section I present an example with uniformly distributed types in which a consumer surplus maximizing regulator approves anticompetitive mergers. Let $p \sim \text{Uniform}[0, 1]$. Given equilibrium cutoffs \underline{p}, \bar{p} , then the payoffs from the three options are

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

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

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

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

If the regulator were to ban acquisitions, fewer high type firms invest and the boundary between issuance and non-investment falls. The new upper boundary between issuance and not investing becomes

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

Therefore the change in the mass of types not investing is

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

Even if an antitrust regulator knew that all acquisitions would result in the investment opportunity being killed, she would still want to commit to allowing acquisitions to occur.

Let the effective killing rate of acquired projects be $\kappa^* = 1$. Then the change in consumer surplus from blocking acquisitions is proportional to

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

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.

4 Discussion

In this section I evaluate an important prediction of the model: that the startups who decide to be acquired have bad private information. I also discuss how various extensions such as entry, alternative security designs, and alternative bargaining assumptions would affect the model. I close this section with the implications of my model for antitrust and innovation policy.

4.1 Ordering of Types

A simple and important consequence of my model is that the startups that sell out are worse type firms. This is an essential step of the argument for why banning acquisitions lowers the average type of equity issuers.

This result on the private information of acquired firms 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 the future technology platform, not past products. Put another way, a firm might be good in that it has a lot of positive NPV projects a , but it may be a firm with a low probability p of future success.

Anecdotally, many successful entrepreneurs choose to turn down large early stage acquisition offers because of the view that their firm has high potential (i.e. high p) that is undervalued by acquirors. In spring 2006, Yahoo offered \$1 billion dollars to acquire Facebook. CEO Mark Zuckerberg was reluctant to sell because he thought that upcoming product changes, such as opening up Facebook beyond college campuses, would prove that Facebook was worth much more. After this change was implemented in fall 2006 and daily user sign ups more than doubled, acquisition negotiations with Yahoo ended (Kirkpatrick, 2010). More recently, Plaid, a fintech data aggregator, was set to be acquired by Visa for \$5.3 billion in January 2020. During the pandemic, the use of fintech products exploded, increasing Plaid's value as a platform for fintech data. Ultimately, Plaid opted to walk away from the acquisition. While part of the reason for turning down the offer was the result of the U.S. Department of Justice's antitrust case against the merger, it's likely part of the reason was also because Plaid's future prospects were now much better. After Plaid walked away from the deal, it raised another round of private equity finance at a valuation of \$13.4 billion (Rooney, 2021).

One could also object to the result that high types 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.

4.2 Alternative Security Designs

Alternative securities such as debt and convertible equity do not solve the problem with asymmetric information in my setting. In the startup setting, most of the value of the firm is derived from the unlikely states of the world where the startup grows by a substantial amount. Any security to finance the company will need to share some of the payoff from those high growth states of the world. In this case, asymmetric information will again affect the price of the security.

4.3 Entry

I do not model entry because it is not a good justification for allowing acquisitions in which the incumbent kills the project at the entrant. First, theoretical work in Cunningham et al. (2021) show that killer acquisitions are most likely to occur when the prospect of future entry is low. Second, from a more general equilibrium perspective, relying on entry to fix anticompetitive conduct is costly compared to directly intervening to restore competition (Kaplow, 2021). Intuitively, the scientists working to replace a drug lost to a killer acquisition could have been more productively employed elsewhere had the antitrust authority blocked the killer acquisition. In contrast, lost investments due to financial frictions are costly even if entry is difficult. If new ideas are rare, it is even more important to make sure entrepreneurs can obtain financing.

4.4 Bargaining

The assumption that the startup 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.

4.5 Implications for Antitrust and Entrepreneurship Policy

My model draws attention of antitrust policy away from the merging parties towards the standalone startups. In the context of the Visa/Plaid acquisition, conventional analysis would have focused on how the acquisition would have reduced the incentives of the combined entity to invest in online debit payment options. My model would predict that blocking the acquisition could have a chilling effect on investment activity at all fintech companies by exacerbating financial frictions. Blocking the merger would have signalled that acquisitions by acquirors with overlapping product portfolios were no longer an option. This would have limited other fintech companies' exit options, lowering the average type of equity issuers and worsening underinvestment.

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 a mature company like Novartis.

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.

The underinvestment channel I identify goes beyond the argument that blocking acquisitions lowers startup valuations, making it harder for startups to raise capital. Lower valuations are 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.

5 Case Study: Roche's Acquisition of Spark

The stock market reactions of gene therapy companies after the FTC delayed Roche's acquisition of Spark Therapeutics illustrates the importance of potential acquisitions on the valuations of early stage firms. I use techniques from the literature on merger arbitrage to estimate that, had the FTC blocked the merger, valuations of public gene therapy companies would dropped by around 10% or \$5 billion dollars. The losses would

have been broad based across gene therapy companies, both those who had products in the pipeline that could compete with incumbents and those who did not.

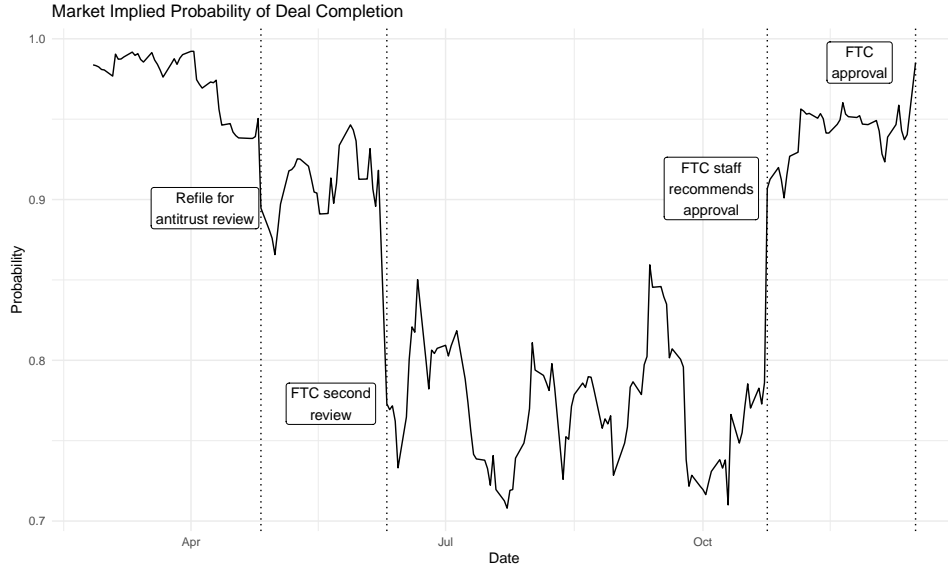
The Roche-Spark acquisition is a classic example of a large pharmaceutical company acquiring a nascent startup competitor with an innovative technology. Roche is a multinational pharmaceutical group and Spark Therapeutics at that time was an early stage gene therapy company. Spark had one drug on the market that treated a rare eye disorder and multiple promising treatments for hemophilia in the pipeline. Roche also had hemophilia drugs on the market. Roche's drug for hemophilia A, Hemlibra, was forecasted to earn around \$5 billion annually in peak revenues (Liu, 2019). While Roche also had a treatment for degenerative eye diseases, Lucentis, overlap in eye diseases ended up not being the focus of antitrust scrutiny (Pagliarulo, 2019). Spark's gene therapy candidates for hemophilia would be disruptive because they had the potential to be true cures instead of merely treating symptoms.

The deal faced unexpected regulatory hurdles. The first signs of trouble emerged on April 26 when Roche announced that it needed to give the government more time to review the merger (GlobeNewswire, 2019). More bad news came out on June 10, when the FTC formally issued a "second request" for information on the deal (Gardner, 2019). Eventually, the deal was approved by the FTC. On October 24, news came out that the FTC staff recommendation was for the agency to approve the merger, and on December 16 the merger was formally approved (Grover, 2019).

The stock price of Spark over this time period can be used to gauge the probability market participants put on the merger being approved. I plot the time series of the risk neutral probability of completion in figure 3. I use standard techniques from the literature on merger arbitrage to calculate the probability (Samuelson and Rosenthal, 1986). The probability of deal completion is calculated as $\rho_t = \frac{P_t^s - P_0^s}{114.50 - P_0^s}$, where P_t^s is the price of Spark on day t , P_0^s is the price of Spark on the day before the merger was announced, and 114.50 is chosen because that was the value of the cash offer Roche made for Spark. This chart shows that market participants quickly incorporated the negative news shocks into the price of Spark, and quickly reversed these effects on positive news.

The regulatory shocks allow me to quantify how investors would have revised their valuations for other gene therapy companies had this merger not been approved and how these revisions vary by company. For each company I run time series regressions of the

Figure 3: Risk neutral probability of deal completion and significant regulatory events



form

$$R_{it} = \alpha_i + \beta_i R_{mt} + \theta_i \Delta \rho_t \times Z_t + \epsilon_{it} \quad (1)$$

where R_{it} is the daily stock return for a company i on day t , R_{mt} is the market return on day t , $\Delta \rho_t$ is the change in the calculated risk neutral probability on date t , and Z_t is a dummy that takes a value of 1 provided that it is in the $[-3, +3]$ window of one of the four main regulatory shocks labeled in figure 3. This kind of probability regression has been used previously in the literature on the effects of mergers on company valuations (Warren-Boulton and Dalkir, 2001).

I run my regressions on a sample of 19 other public gene therapy companies with a market capitalization of more than \$500 million. Table 1 reports the sample of companies and their main clinical areas targeted by their pipeline at the time. I focus on gene therapy companies because they are a group of early stage biotech companies who would have been most directly affected by the change in antitrust enforcement. I focus on companies with at least \$500 million in market capitalization on average during the merger window to mitigate the effects of microstructure noise. To obtain the list of gene therapy companies, I consult industry newsletters such as Bell (2019). I also check the

Table 1: List of gene therapy companies used in event study analysis

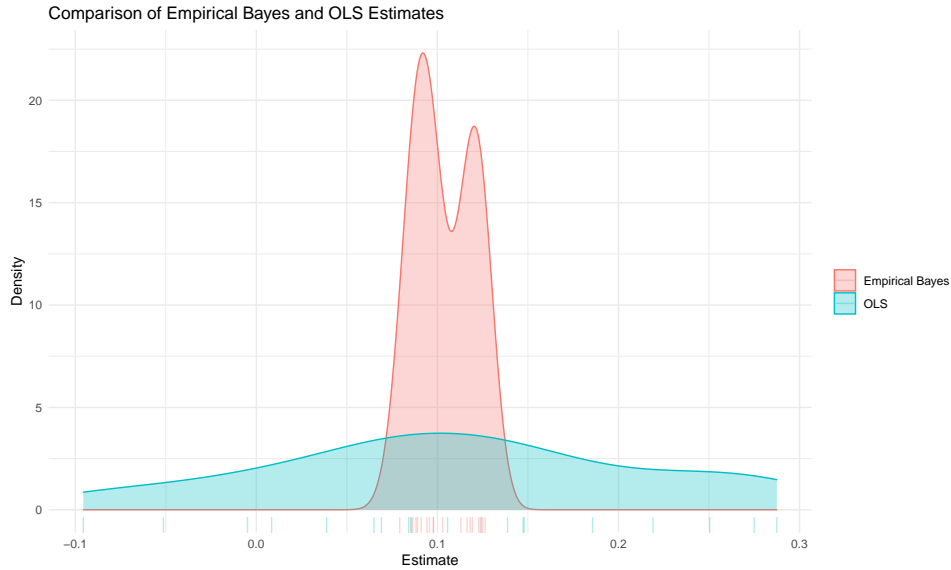
Ticker	Clinical Area	Overlap	Market Cap (Bn USD)
ADVM	Eye diseases	Yes	0.57
KRYS	Rare Skin Diseases		0.66
MGTX	Eye disease, Parkinson's	Yes	0.68
VYGR	Parkinson's, Huntington's, ALS		0.71
NTLA	Amyloidosis, AAT deficiency		0.72
RCKT	Danon disease, Fanconi Anemia		0.78
FIXX	Enzyme, lysosomal disorders		0.84
SGMO	Hemophilia, Fabry, beta-thalassemia, sickle cell	Yes	1.17
EDIT	Eye Disease, beta-thalassemia, sickle cell	Yes	1.22
BOLD	Rare Disease		1.64
RGNX	Retinal disease, Hunter and Hurler	Yes	1.64
QURE	Hemophilia, Huntington	Yes	2.34
PTCT	AADC deficiency		2.45
CRSP	Beta-thalassemia, sickle cell		2.54
FOLD	Batten Disease, CNS		2.73
RARE	Rare Disease		3.13
BLUE	Beta-thalassemia		6.42
SRPT	Duchenne Muscular Dystrophy		8.55
BMRN	Hemophilia	Yes	14.47

Pitchbook database to identify gene therapy companies who have gone public after 2009.

I use an empirical bayes estimator to recover the effect of the merger on each company. The empirical bayes approach treats each θ_i as a normally distributed random variable. The mean of each θ_i is $\bar{\theta}_i = \gamma_0 + \gamma_1 X_i$, where X_i contains covariates of company i , such as an indicator for a product overlap or the log market cap of the company. Empirical bayes is useful here because the precision of the OLS estimator of θ_i varies substantially across companies, and an empirical bayes approach allows me to incorporate that information in forming an estimate of θ_i . In deciding how much to weigh each estimate, I use precision weights as in Armstrong et al. (2021).

The average gene therapy company is worth 10% more in a world where the merger is approved, and there is little variation in returns across startups who had product overlaps with Roche and those who did not. Figure 4 plots the distribution of the empirical bayes

Figure 4: Comparison of the distribution of the empirical bayes estimates of the effect of the merger (blue) with the OLS estimates (red). A value of 0.10 should be interpreted as saying the company is worth 10% more in the world where the FTC approves the merger compared to the valuation of the company if the FTC blocks the merger.



and OLS estimates. As expected, while both distributions are centered around 10%, the empirical bayes distribution is much narrower.

The effect of the merger approval is large and not concentrated in the firms with the most potential for anticompetitive acquisitions. In table 2 I report how the estimates θ_i are related to firm size and whether the startup's portfolio overlapped with Roche. I classify all gene therapy companies with projects in hemophilia or eye diseases as having potential overlaps with Roche. I find 7 out of the 19 fit this criterion. The remaining companies largely treat rare diseases that do not have good treatment options and therefore do not compete directly with any incumbent pharmaceutical companies, even beyond Roche. While the estimates are noisy, the headline result is that the valuations of the other gene therapy companies are 10% higher in a world where the merger is approved than a world in which the merger is blocked. The startups with overlap benefit by an additional 2%, but given only around $1/3$ of startups have such an overlap the net effect on the valuation of the sector is less than 1%.

Table 2: Estimates of the relationship between the company level impact of the merger being approved θ_i and observable characteristics. The point estimate comes from the empirical bayes procedure. To compute the 95% confidence interval I use 100 draws of a Bayesian bootstrap that fixes the sample of companies but resamples returns for each company at the daily level.

Parameter	Estimate	95% CI
Intercept	0.10	[0.02, 0.18]
Overlap Dummy	0.02	[-0.10, 0.15]
Log Market Cap (Demeaned)	-0.01	[-0.06, 0.06]

Had the FTC blocked the merger, gene therapy companies as a whole would have lost around \$5 billion dollars in market capitalization, and only \$0.5 billion of this loss would have been attributed to the overlap between the gene therapy companies' portfolios and overlaps with incumbents' product portfolios. Assuming that none of the losses to the startups without overlap can be attributed to anticompetitive rents, and that all of the additional gains for startups with overlap reflects anticompetitive rents, these results suggest that turning off the market for acquisitions would cost startups around \$4.5 billion dollars in losses that do not reflect reductions in anticompetitive rents. The 95% confidence interval around this number is between \$0.6 billion and \$11.4 billion.

Interpreted through the lens of the model, the news that the FTC would block acquisitions of gene therapy companies caused investors to revise down their beliefs on how much financing gene therapy firms would be able to raise. Indeed, market participants at the time argued out that "if you paralyze the acquirers, that makes it very difficult to make a compelling case for a lot of these companies that certainly wouldn't be able to commercialize their own products without raising a lot of diluted capital" (Bell, 2019).

More generally, the case study illustrates the importance of an active market for acquisitions for early stage firms. The case study is equally consistent with acquirers having large technological synergies with target firms, and the market pricing in the loss of those synergies from tighter antitrust enforcement. Even if one thought that all of the effects on valuations that I document arise from changes in future anticompetitive rents, it is nonetheless important to recognize that the prospect of those anticompetitive rents have the potential to support financing conditions for a broad set of firms, and not just

the ones with product portfolios that overlap with existing incumbent firms.

6 Conclusion

I identify a novel tradeoff for antitrust in the 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 acquisitions against the positive effects of acquisitions on standalone startups. A case study suggests that the prospect of future acquisitions is valuable for startups. Future work can explore the quantitative magnitude of financial frictions in innovation markets featuring startups and incumbent acquisitions.

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A Proofs of Statements in Main Text

Proof of Lemma 1. Note that

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

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 $V^e(p') > V^a(p')$ 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. \square

Proof of Theorem 1. For the forward direction, the ordering of the three sets follows from lemma 1.

Next I show that if in equilibrium no types issue equity, then all types must be acquired. 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. Therefore it suffices to rule out the possibility that all firms do not invest, and the other possibility that some firms are acquired, some do not invest, and no firms issue equity.

There is no PBE in which all firms do not invest. The lowest type $p = \underline{\rho}$ could deviate to being acquired. For any belief $S \subset \mathcal{P}$,

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

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 $p^* \in (\underline{\rho}, \bar{\rho})$ such that $[\underline{\rho}, p^*) \subset S_a$ and $(p^*, \bar{\rho}] \subset S_n$. 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

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

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

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

In the language of Cho and Kreps (1987), the weakly better off set of valuations for a type p is $\text{WBR}(p) = [0, \phi_a(p)]$ and the strictly better off set $\text{SBR}(p) = [0, \phi_a(p))$. Fix any type $p \in [\underline{\rho}, p^*)$. Then there is some type $p' \in [\underline{\rho}, p^*)$ with $p' > p$. Since $\phi_a(p)$ is strictly increasing, $\text{SBR}(p') \supset \text{WBR}(p)$. The D1 criterion then strikes 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 non-investing 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 . Therefore by a similar argument, for any $p \in (p^*, \bar{\rho}]$, the weakly better off set is $\text{WBR}(p) = [0, \phi_n(p)]$ and the strictly better off set $\text{SBR}(p) = [0, \phi_n(p))$. Hence for any such p , there is some $p' \in (p^*, p)$. We would then have that $\text{SBR}(p') \supset \text{WBR}(p)$. 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.

For the forward direction, it remains to show indifference at the boundary points. Consider an equilibrium in which $S_a, S_e \neq \emptyset$. By inspection, V^a, V^e, V^n are continuous in the private type p . Suppose to the contrary $V^a(\underline{p}) > V^e(\underline{p})$. Then by continuity there is some $p' > \underline{p}$ such that $V^a(p') > V^e(p')$. This implies that $p' \notin S_e$, a contradiction. Hence $V^a(\underline{p}) \leq V^e(\underline{p})$. Repeating this argument with the assumption that $V^a(\underline{p}) < V^e(\underline{p})$ gives $V^a(\underline{p}) \geq V^e(\underline{p})$. Hence $V^a(\underline{p}) = V^e(\underline{p})$. Repeating this argument for S_e, S_n gives a similar indifference condition for the boundary point \bar{p} between S_e, S_n . \square

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

Now suppose $g(\bar{p}, \bar{p}) \leq 0$. I now claim that all firms choosing to be acquired and an issuer or non-investor is inferred to be type \bar{p} 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 \bar{p} firm does not want to deviate. This is given by $g(\bar{p}, \bar{p}) \leq 0$. To show that no type would want to deviate to not investing, it is sufficient for the type \bar{p} firm to not want to deviate. This is guaranteed because issuing leads to a payoff of $a + b\bar{p}$ under the D1 refinement, whereas not investing leads to a payoff of $b\bar{p}$. But since the type \bar{p} firm would not want to deviate to issuing, then it would not want to deviate to not investing either.

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 $h(\underline{\rho}, \bar{\rho}) \leq 0$. 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

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

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 $g(\underline{\rho}, \bar{\rho}) \geq 0$.

Going the other direction, suppose that $g(\underline{\rho}, \bar{\rho}) \geq 0$ and $h(\underline{\rho}, \bar{\rho}) \leq 0$. 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 $\bar{\rho}$ 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 $g(\underline{\rho}, \bar{\rho}) \geq 0$. The highest type firm stands to gain the most from deviating to not investing, and such a deviation is not profitable because $h(\underline{\rho}, \bar{\rho}) \leq 0$.

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. By theorem 1, $V^e(\underline{p}) = V^a(\underline{p})$. Equivalently, $g(\underline{p}, \bar{\rho}) = 0$. To rule out a firm deviating to not investing, it is sufficient to show that the type $\bar{\rho}$ firm must not want to deviate to not investing. But for this to be the case, a necessary condition is that $h(\underline{p}, \bar{\rho}) \leq 0$.

Going the other direction, suppose that there is some cutoff \underline{p} such that $g(\underline{p}, \bar{\rho}) = 0$ and $h(\underline{p}, \bar{\rho}) \leq 0$. 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 $\bar{\rho}$ is a PBE that survives D1. By single crossing, since $V^e(\underline{p}) = V^a(\underline{p})$, then $V^e(p) > V^a(p)$ for all $p > \underline{p}$, and $V^e(p) < V^a(p)$ 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 issuing. To show nobody would deviate to not investing, it suffices to show this is true for the highest type. This follows from $h(\underline{p}, \bar{\rho}) \leq 0$.

Low Types Issue, High Types Do Not Invest: In a putative equilibrium, there would be a cutoff \bar{p} such that all firms $p < \bar{p}$ issue, and all firms of type $p > \bar{p}$ do not invest. By a similar argument to the acquisition/issuance case, we have that $h(\underline{\rho}, \bar{p}) = 0$. 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 $g(\underline{\rho}, \bar{p}) \geq 0$.

Going in the other direction, suppose that there is some cutoff \bar{p} such that $g(\underline{\rho}, \bar{p}) \geq 0$ and $h(\underline{\rho}, \bar{p}) = 0$. I then claim that if types $p \leq \bar{p}$ choose issuance, types $p > \bar{p}$ 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 $V^n(\bar{p}) - V^e(\bar{p}) = h(\underline{\rho}, \bar{p}) = 0$, then no firm of type $p \leq \bar{p}$ would want to deviate to not investing, nor would any firm of type $p > \bar{p}$ 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 $g(\underline{\rho}, \bar{p}) \geq 0$.

Low Types Acquired, Medium Types Issue, and High Types Do Not Invest: In a putative equilibrium, there would be two cutoffs \underline{p}, \bar{p} such that firms of type $p < \underline{p}$ are acquired, firms of type $p \in (\underline{p}, \bar{p})$ issue, and firms of type $p > \bar{p}$ do not invest. By theorem 1, the firms at the cutoff must be indifferent. Hence $g(\underline{p}, \bar{p}) = h(\underline{p}, \bar{p}) = 0$.

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

$$\begin{aligned} V^n(\bar{p}) - V^e(\bar{p}) &= 0 \\ V^e(\underline{p}) - V^a(\underline{p}) &= 0 \end{aligned}$$

Again by single crossing, all types $p > \bar{p}$ find non-investment optimal, all types $p \in [\underline{p}, \bar{p}]$ find issuance optimal, and all types $p < \underline{p}$ prefer acquisition. \square

Proof of Lemma 2. 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 $g(\bar{\rho}, \bar{\rho}) > 0$. This follows as

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

To rule out the second case, suppose $\underline{p} > \underline{\rho}$ is the boundary point that separates acquired firms from issuing firms, and \bar{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 $\bar{p} = \bar{\rho}$. In both cases, $\underline{p} < \bar{p}$. As a result, the the payoff from issuing equity for the putative firm indifferent between issuance and acquisition is

$$\frac{a + b\mathbb{E}[\tilde{p} | \underline{p} \leq \tilde{p} \leq \bar{p}]}{a + b\mathbb{E}[\tilde{p} | \underline{p} \leq \tilde{p} \leq \bar{p}] + I} (a + b\underline{p} + I) = a + b\underline{p} + I \left(1 - \frac{a + b\underline{p} + I}{a + b\mathbb{E}[\tilde{p} | \underline{p} \leq \tilde{p} \leq \bar{p}] + I} \right) > a + b\underline{p}$$

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:

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

□

Proof of Theorem 2. By the characterization of equilibria in theorem 1, we have that $h(\underline{p}^*, \bar{p}^*) = 0$. If there are no acquisitions, then by theorem 1 a PBE with equity issuance and underinvestment can be found by solving for a \bar{p}' such that $h(\underline{\rho}, \bar{p}') = 0$. 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 $h(\underline{\rho}, \bar{p}^*) > 0$. We also have that

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

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

B Conditions for Equilibria with Acquisitions, Issuance, and Underinvestment

This appendix characterizes 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 3), but cannot be too large or else all firms would be acquired (lemma 4). The platform value b must also be large enough such that the cost of adverse selection is large enough relative to the gains from investing (lemma 5)

Lemma 3. *Let*

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

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 $g(\underline{\rho}, \bar{\rho}) \geq 0$ and in the second class, $g(\underline{\rho}, \bar{\rho}) \geq 0$ for the equilibrium cutoff $\bar{\rho}$. By inspection, g is increasing in its second argument. Therefore a sufficient condition to ensure that the resulting equilibrium features acquisitions is for $g(\underline{\rho}, \bar{\rho}) < 0$. Using the definition of g we then have that

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

This condition is equivalent to

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

□

The condition in lemma 3 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 4 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 4. *If*

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

Then not all firms are acquired in equilibrium.

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

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

□

Lemma 5 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 investment opportunity so that equity issuance is sufficiently costly.

Lemma 5. Define \underline{p}' as the maximal solution to the equation

$$g(\underline{p}', \bar{\rho}) = 0$$

Then provided that

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

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

Proof. The first two assumptions satisfy the conditions of lemmas 3 and 4, 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 $g(\underline{p}, \bar{\rho}) = 0$ and $h(\underline{p}, \bar{\rho}) \leq 0$. In particular I will show that under the assumptions of the lemma, for any lower cutoff \underline{p} satisfying $g(\underline{p}, \bar{\rho}) = 0$, we will have $h(\underline{p}, \bar{\rho}) > 0$.

By inspection, h is decreasing in \underline{p} . Therefore it suffices to show h satisfies that condition for a maximal cutoff \underline{p} with $g(\underline{p}, \bar{\rho}) = 0$. Let $P = \{\underline{p} \in [\underline{\rho}, \bar{\rho}] : g(\underline{p}, \bar{\rho}) = 0\}$. The assumptions on σ imply that $g(\underline{\rho}, \bar{\rho}) < 0$ and $g(\bar{\rho}, \bar{\rho}) > 0$. 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 $h(\underline{p}', \bar{\rho}) > 0$ is equivalent to.

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

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

$$b > \frac{a}{\frac{I}{a+I}\bar{\rho} - \mathbb{E}\left[p \mid \underline{p}' < p < \bar{\rho}\right]}$$

Which is also satisfied by assumption. Hence $h(\underline{p}', \bar{\rho}) > 0$, and so $S_n \neq \emptyset$. \square

As discussed above, these conditions are not necessary. For example, the lower bound on the synergy parameter in lemma 3 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 3. 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.