Co-opetition and Disruption With Public Ownership

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April 9, 2021

Abstract

Do mandatory disclosure requirements make public firms less disruptive and competitive? Not necessarily. We offer a new perspective showing that mandatory disclosure facilitates "co-opetition" — a strategy of competing on some dimensions while avoiding competition on others. Co-opetition encourages disruption by elevating profitability and lowering financing costs. However, it may undermine commitment to intermediately attractive investments, making the benefit of being public U-shaped in investment attractiveness. Being public is most beneficial when firms compete intensely on disruption and, at the other extreme, when protecting cash-cow businesses. Our results explain evidence that stricter disclosure requirements increase the profitability of disruptive public firms.

Keywords: competition, cooperation, co-opetition, public and private ownership, disruption, innovation.

JEL Classification: G31, G32, L41, O31

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†University of Amsterdam and CEPR, e-mail: Vladimirov@uva.n. We thank Andres Almazan, Jean-Noel Barrot, Efraim Benmelech, Dan Bernhardt, Matthieu Bouvard, Tolga Caskurlu, Lauren Cohen, Francesco D'Acunto, Jason Donaldson, Laruent Fresard, Paolo Fulghieri, Todd Gormley, Vincent Glode, Denis Gromb, Alexander Guembel, Gerard Hoberg, Peter Iliev, Ben Iverson, Roman Inderst, Tomislav Ladika, Doron Levit, Evgeny Lyandres, Richard Lowery, Vojislav Maksimovic, Richard Mathews, Rafael Matta, Ernst Maug, Todd Milbourn, Giorgia Piacentino, Merih Sevilir, Anjan Thakor, Ed van Wesep, Alminas Zaldokas, and conference and seminar participants at the SFS Cavalcade (Yale), European Finance Association (Warsaw), Financial Intermediation Research Society (Savannah), Carlos III Madrid, ESCP Paris, and the University of Amsterdam for helpful feedback.

1 Introduction

Economists have long worried that firms listed in public capital markets may suffer from inertia that ultimately causes their demise (Jensen, 1989). Yet the profitability of public firms has risen in all industries over the past decades (De Loecker et al., 2020), which is hard to square with public firms losing their edge. In this paper, we argue that being publicly listed can simultaneously nurture high profitability and promote disruption by helping firms better manage the competitive pressures they are facing. In particular, we show that mandatory disclosure requirements for public firms play a key role in facilitating implicit cooperation among such firms. This perspective sheds new light on how financial markets impact the real economy and its competitive landscape.

Better opportunities for implicit cooperation benefit public firms by making it easier to compete on some dimensions while cooperating or avoiding competition on others — a strategy known as "co-opetition." By combining the best of both worlds, co-opetition bridges the typical corporate finance view of perfect competition (Bolton and Scharfstein, 1990; Chod and Lyandres, 2010) with work in industrial organization, contending that firms often try to avoid competition (Tirole, 1988). The belief that "cooperation is key for competition" (Deloitte, 2015) is by now widespread among practitioners and academics alike (Brandenburger and Nalebuff, 1996; Gnyawali et al., 2006). Co-opetition has been actively encouraged also by regulators during the COVID-19 crisis to promote break-through investment in the pharma and health industries (OECD, 2020; Crick and Crick, 2020).

Co-opetition strategies raise public firms' profitability and improve their access to financing for disruptive investments. The cost is that commitment to disruption could suffer, as cooperating on existing technologies makes their replacement (via cannibalization) less attractive. This trade-off mainly encumbers intermediately attractive disruption opportunities, making the net "cooperation benefit" of being public U-shaped in investment attractiveness. We demonstrate that co-opetition opportunities, facilitated by being public, are especially valuable in growth industries, where the fear of being left behind by rivals puts commitment to disruption less at risk. These results explain why the enactment of stricter disclosure requirements has elevated markups in public firms, contrary to the predictions of prior theory (Bhattacharya and Ritter, 1983), and increased their investment in disruption.[1]

To provide a formal structure to our arguments, we develop a model featuring two firms that interact in the same industry and compete with their existing technologies. In addition,

[1] We offer evidence based on the adoption of the American Investors' Protection Act and the Food and Drug Administration Amendments Act, which mandated more disclosure of innovation activities. See also Hegde et al. (2020).

the firms might be able to invest in a disruption opportunity that allows them to displace their rival. This investment could involve a radical change in the firm's technology or business model, causing the other firm to become obsolete or unable to keep up. A firm making such an investment must raise external financing to fund it and exert effort to make it work. Since the disruption opportunity takes time to develop, however, the firm can still abandon it if the subsequent signals about its prospects are discouraging.

The model's main feature is that when neither firm has a competitive edge, the firms might benefit from cooperating to avoid competition. We focus on implicit cooperation, not involving communication with rivals. Such cooperation can range from competing less aggressively to sharing knowledge and resources. The latter is commonly practiced, for example, by large pharma and biotech firms.[2] The main challenge with implicit cooperation is that firms may have incentives to deviate and profit at their rival's expense. Such deviations are difficult to detect since firms can only make noisy inferences about the other firms' actions.

We show that the mandatory nature of disclosure associated with being public makes it easier for public firms (compared to private firms) to sustain implicit cooperation. In practice, public firms must report detailed sales and earnings figures and information on investments, products and services, and contracts with their main customers. This and all other information produced by financial markets can serve as a commonly-observed history of signals (indicative of whether firms deviate from implicit cooperation) around which public firms can coordinate actions. This result captures statements to this effect by policymakers:

> "Greater transparency in the market ... [can] produce anticompetitive effects by facilitating collusion or providing firms with focal points around which to align their behavior" (OECD, 2012).

It is important to stress that regulators do *not* consider such coordination illegal. Implicit cooperation is legitimate if it does not involve private communication with rivals (OECD, 2012). Such cooperation is easier in industries dominated by a few large public firms. Hence, consolidation waves among public firms, as recently seen in the U.S. (Gao et al., 2013; Doidge et al., 2017), make implicit cooperation easier.

Private firms that rely on voluntary reporting cannot achieve the same cooperation outcome because they can more easily hide information that is not in their best interest to disclose. Consider the example of pharma firms trying to cooperate on sharing the outcomes of early phase drug trials. In the absence of basic disclosure requirements about the

[2]Pharma and biotech firms, such as Eli Lilly, Pfizer, AstraZeneca, and Sanofi, compete to develop new drugs, while also implicitly cooperating by openly sharing proprietary information and data through, so-called, Open Innovation platforms. The benefits include helping the commercialization, adoption, and exploitation of innovations, and coordinating on industry standards (see Deloitte, 2015).

investments pursued by a private firm, it is hard for outsiders to judge whether the private firm is cherry-picking and sharing information only about a small subset of its investments. Moreover, we show that private firms have incentives not to disclose information that could trigger a breakdown in cooperation. With more opportunities for deviation from implicit cooperation and a weaker threat of punishment following signals indicating deviation, co-operative equilibria are more difficult to sustain. Thus, mandatory disclosure requirements are of first-order importance for cooperation even when voluntary disclosure is possible. Voluntary disclosure is a complement (but not a substitute) to mandatory disclosure.

Better cooperation opportunities, associated with being public, enhance profitability, which helps firms raise financing to invest in disruption. However, cooperation opportunities can be a double-edged sword. In particular, implicit cooperation, increasing the profitability of existing technologies makes their replacement more costly. This can erode a public firm's commitment to disruption and exacerbate agency problems related to making disruptive investment work. Raising financing could become then more difficult.

The trade-off between a higher profitability and a weaker commitment to disruption makes the net "cooperation benefit" of being public U-shaped, as commitment problems mainly encumber intermediately attractive investments. By contrast, very attractive investments are unlikely to be abandoned, regardless of whether the firm is public. Then, being public is beneficial because of the cooperation opportunities it offers. Being public is also beneficial at the other extreme, where disruptive investments are marginally attractive, and it is vital to have good exit options.

The cooperation benefit of being public also depends on the degree of rivalry between firms to invest in disruption. If this rivalry is intense, financiers are less concerned that a public firm would be less committed to investment, as the firms feel pressure to invest for fear of being left behind. We can interpret this case as firms in their growth phase. In addition, the benefit of co-opetition is magnified, as firms can also cooperate on new technologies after rivals have caught up.[3] Cooperation, such as in our pharma and biotech example, could then help firms internalize externalities that broaden the adoption of the newly-developed technologies (e.g., via common standards) or spur innovation by suppliers and customers (Gnyawali et al., 2006). The higher benefit of being public means that the intermediate region of the U-curve, in which public firms might be disadvantaged, narrows. These results are robust to introducing free entry and endogenous differences in size.

Being public is valuable also when firms no longer have disruption opportunities and, thus, do not seek financing for disruptive investments. Concerns about commitment to

[3]Note that we do not consider cooperation on developing a disruptive technology, as the disruptive investments we have in mind aim to displace rivals.

disruption are then irrelevant. That is, mature cash-cow businesses seeking to avoid head-on competition are better off being public.

Our paper's main result is that stricter disclosure requirements help public firms support implicit cooperation, which could make them more profitable and disruptive. To motivate this prediction's practical relevance, we provide evidence that the enactment of stricter requirements for disclosure of innovation activities leads to higher markups in firms investing in innovation. Specifically, we exploit the passage of the American Investors' Protection Act (AIPA) and the Food and Drug Administration Amendments Act (FDAAA), which mandated that firms disclose patent applications sooner and report on early phase trials. In line with our prediction about the benefits from co-opetition, we find a strong increase in markups among firms in more affected industries. Notably, the effects are stronger for firms offering similar products and services — arguably firms that are more likely to benefit from cooperation. All alternative theories studying the effect of such mandatory disclosure (that we are aware of) predict, instead, that the disclosure of information about innovation activities harms public firms (e.g., Bhattacharya and Ritter, 1983). Further in line with our predictions that mandatory disclosure can make firms not only more profitable but also disruptive, Hegde et al. (2020) find AIPA has led to more R&D spending and patenting.

Related Literature. Our paper adds a new perspective to the literature studying how mandatory disclosure requirements for public firms affect their disruptiveness and competitive standing. The new channel we highlight is that such disclosure can benefit public firms by facilitating co-opetition — a strategy where firms compete on some dimensions but avoid competition on others (Brandenburger and Nalebuff, 1996; Hoffmann et al., 2018). By contrast, prior work focuses mainly on the negative effects of leakage of information to competitors (Bhattacharya and Ritter, 1983; Maksimovic and Pichler, 2001).

While the steady decline in the number of public firms in the U.S. has coincided with an increase in disclosure requirements, empirical work finds that the main reason for this decline is a wave of consolidation among public firms (Gao et al., 2013; Doidge et al., 2017). Combined with stricter disclosure, such consolidation is likely to have increased the importance of implicit cooperation, as coordination among fewer and larger firms is easier. Moreover, further consolidation is more likely to encounter antitrust hurdles, reinforcing the benefits of implicit cooperation.[4]

To analyze how co-opetition works, we build on the industrial organization [IO] literature that examines the role of imperfect information in achieving cooperation (Kandori, 2002; Bo et al., 2018). While this literature typically assumes that signals about actions are either

[4] Also related is work investigating the role of being public for facilitating mergers and acquisitions (Celikyurt et al., 2010; Hsieh et al., 2011).

publicly or privately observable (Green and Porter, 1984; Bhaskar and van Damme, 2001), we argue that a firm's choice between public and private ownership effectively endogenizes the observability of signals. Crucially, we show that mandatory disclosure is instrumental for supporting cooperation even when voluntary disclosure is possible. Indeed, the two types of disclosure are complements and not substitutes.

Our basic premise that information shared by public firms can help them avoid competition has been recognized by regulators (OECD, 2012) and legal scholars (Steuer et al., 2011). Moreover, empirical research has documented that public firms appear to avoid head-on competition by implicitly cooperating on publicly sharing sensitive information (Bourveau et al., 2019; Bertomeu et al., 2020; Pawliczek et al., 2019). Our theory highlights the role of mandatory disclosure in supporting such outcomes. We also show that cooperating on some dimensions can go hand in hand with competing on others, which can make it easier for firms to raise financing for disruptive investments. Supportive of our theory, we provide evidence that stricter disclosure of innovation activities raises the markups of firms investing in innovation, especially when they are more similar to their rivals.

Our paper further predicts that the cooperation benefit of being public depends on the investment's attractiveness and whether there is intense rivalry on disruption (as in growth industries). Some of our insights contrast with the findings of Ferreira et al. (2014), who argue that exploratory investments are best developed in private firms, as the lack of transparency in private firms offers better exit options. In our setting, by contrast, firms and financiers have endogenously better exit options when firms are public, making it often easier to raise financing for disruptive investments. In line with our predictions, Acharya and Xu (2017) find that public firms in industries that depend on external financing spend more on innovation and have a better innovation profile than private firms, albeit going public may change the way that firms innovate (Bernstein, 2015).[5] Our predictions that the U-shaped benefit of being public depends on industry rivalry and maturity can further help explain why empirical evidence focusing on different industries is ambiguous about whether public firms have an advantage in financing new investment. In particular, while Asker et al. (2015) and Sheen (2019) find that public firms respond less to investment opportunities due to higher agency costs, Gilje and Taillard (2016) and Phillips and Sertsios (2017) find the opposite.

More broadly, our analysis of the link between co-opetition and being public adds to prior work bridging corporate finance and IO. That work has analyzed related phenomena such as the effect of interfirm equity stakes on competition (Mathews, 2006); the effect

[5] Being public could also make it easier to access investors with more-aligned beliefs (Allen and Gale, 1999; Boot et al., 2006).

of takeovers on innovation (Fulghieri and Sevilir, 2011); the advantage of public firms in competitive industries due to better diversification of financiers (Chod and Lyandres, 2010); and collusion among IPO underwriters (Kang and Lowery, 2014; Hatfield et al., 2020).

2 Model

Two penniless firms are operating in the same industry and are run by their owner-managers. Financing is offered at competitive terms at which financiers just break even. All players are risk-neutral. Time is discrete and infinite, and the common discount factor is $\delta \in (0, 1)$.

Cooperation and Competition under Uncertainty. Each firm $i = \{1, 2\}$ is endowed with a production technology that generates cash flows x_{it} in period t. These cash flows depend on the independent realizations of stochastic demand shocks for the firms' products and on whether the firms cooperate in that period. The actions "cooperate" ($a_i = C$) and "not cooperate" ($a_i = D$), $a_i \in \{C, D\}$, are not observable to outsiders. We denote with $x_{a_i a_j}$ firm i's *expected* cash flows in a period in which firms i and j take actions a_i and a_j, respectively, where the expectation is taken over the possible realizations of the stochastic demand shock in that period (see Figure 1). We restrict attention to cases in which $x_{DC} > x_{CC} > x_{DD} \geq x_{CD}$. That is, the *expected* cash flows when both firms cooperate are higher than when no firm cooperates and deviating from cooperation benefits the deviator at the expense of the other firm. These assumptions are consistent with Bertrand and Cournot models of competition (Tirole, 1988).

To give a concrete example, suppose that the firms compete on price; their unit cost of production is k; and the monopoly price is p. Assume that if both firms sell at this price, each firm can sell a quantity of x unless it faces a firm-specific demand shock. In that case, the firm cannot sell anything. The firms cannot determine whether low cash flows are due to the other firm's actions or a firm-specific demand shock. The probability that a firm faces no demand shock in any given period is ρ. If the firms cooperate in a period, each firm's expected payoff is $x_{CC} = \rho x (p - k)$. If one firm slightly undercuts the other, it can capture the whole demand, and its expected payoff is $x_{DC} = 2\rho x (p - k)$. The expected payoff of the other firm is zero ($x_{CD} = 0$). Finally, if both firms choose to compete on price, their expected payoffs are zero ($x_{DD} = 0$). We will use this model of price competition to illustrate how cooperation can be supported when the firms are public. We want to emphasize that none of our results depends on how competition and cooperation are precisely modeled as long as $x_{DC} > x_{CC} > x_{DD} \geq x_{CD}$. Throughout the analysis, we focus on pure strategies.

Interpretations of Cooperation and Competition. One way to interpret the cooperation action C is as an implicit understanding not to compete away each other's profits.

		Firm 2	
		C	D
Firm 1	C	x_{CC}, x_{CC}	x_{CD}, x_{DC}
	D	x_{DC}, x_{CD}	x_{DD}, x_{DD}

Figure 1: **Expected cash flows from cooperation and non-cooperation in period t.**

A more positive framing is that the firms cooperate on mutually beneficial actions, such as sharing knowledge and resources or developing technologies with significant knowledge spillovers. For example, pharmaceutical firms might share information on early-phase trials, or high-tech firms could make hard-to-verify investments that help establish common standards.

If firms do not cooperate (i.e., take action D), they compete. Based on the above discussion, this means that firms engage in price or quantity competition and do not internalize the positive or negative externalities of their actions on the other firm. Notably, if the firms do not cooperate, they can, at best, hope for a temporary advantage over the other firm. To achieve a permanent advantage, a firm must undertake a disruptive investment, which we model separately.

Investment in Disruption. Firms in our model can compete on two dimensions. First, they can compete with their existing technology by choosing action D. Second, they can make a disruptive investment aimed at displacing their rival. Typical examples of such disruptive investments include embarking on radical innovation, investing in aggressive winner-takes-all strategies, radically changing the firm's business model, or pursuing a risky (horizontal or vertical) merger to gain cost or revenue synergies. For brevity, we refer to the disruptive investment as a new technology that, if successful, replaces the old. We model this investment opportunity as follows.

The firms are initially not endowed with a disruptive investment opportunity, but such an opportunity could appear with probability α at the beginning of each period. To concisely model the idea that disruptive investment opportunities may vary from nonexistent to abundant, we assume that such investment opportunities arise only once for each firm. We can then make distinct predictions depending on whether no firm, one firm, or both firms can invest. The investment itself requires a capital outlay of K. Though we allow the investment to be delayed, we abstract from precautionary savings and assume that K is externally financed.[6]

The investment is risky. Its prospects depend on the realization of a firm-specific state $\theta_i \in \{0, \theta_M, \theta_G\}$, with $0 < \theta_M < \theta_G < 1$, and on the effort exerted to make the investment

[6] Hoarding cash will mitigate the agency problems we discuss.

work. Specifically, the disruptive investment of firm i is successful with probability θ_i and fails with probability $1 - \theta_i$. The realizations of θ_i are drawn independently for each firm i. The probability of state θ_i is π_{θ_i} if the firm's owner-manager exerts effort and q_{θ_i} otherwise, where $\pi_{\theta_M} - q_{\theta_M} > 0$ and $\pi_{\theta_G} - q_{\theta_G} > 0$, respectively. Effort comes at a non-monetary cost, c. An alternative interpretation of this cost is that it represents the loss of private benefits from allocating attention away from a privately preferred project. Throughout, we assume that investing is worthwhile only if the firm's owner-manager exerts effort.

As is common in multiperiod settings (e.g., Bolton and Scharfstein, 1990), the investment can be liquidated prematurely as the firm learns more about its prospects over time. We assume that at the interim date, $\tau_t = 0.5$, of the period in which the firm invests, the owner-manager and the firm's financiers observe a signal that shows the state θ_i. Outsiders cannot distinguish between signals θ_M and θ_G.[7] At this point, the firm has the exit option of falling back on its existing technology and recouping L by liquidating the investment, possibly after renegotiating with its financiers. The assumption of three states $\theta_i \in \{0, \theta_M, \theta_G\}$ is the minimum we need in our setting to introduce a tension between continuation policies that are optimal ex post but not ex ante. Notably, our insights generalize to the case in which θ_i is continuous.

If a firm continues with its investment at $\tau_t = 0.5$ and succeeds with it at the period's end, while the firm's competitor has no such success, the firm takes over the market and receives an expected cash flow of x_M in all remaining periods. The other firm's cash flows reduce to zero, and it drops out. Thus, pursuing the investment is risky, but being successful allows a firm to displace its rival. If both firms successfully develop the new technology, the firms' cash flows depend again on whether they have chosen to cooperate (following Figure 1). We do not consider cooperation in developing the disruptive investment since, by definition, the objective of this investment is to displace the other firm. Figure 2 summarizes the sequence of events.

Public vs. Private Ownership. Our paper's primary focus is on how mandatory disclosure associated with being public affects cooperation, competition, and investing in disruption. It is not our objective to develop a comprehensive theory of why firms go public. The only difference between private and public ownership in our setting is that a public firm must truthfully report more information about itself. In practice, public firms must report, for example, on new investments, R&D, large customers, products and services, and segment sales and earnings.[8] Stock analysts and trading in financial markets further contribute to

[7] Assuming that outsiders cannot distinguish the failure state $\theta_i = 0$ from θ_M and θ_G increases the likelihood of renegotiations at $\tau_t = 0.5$ about whether the investment should be continued. Qualitatively, not much changes.

[8] For example, one of Regulation S-K's provisions is that firms report and explain material investments

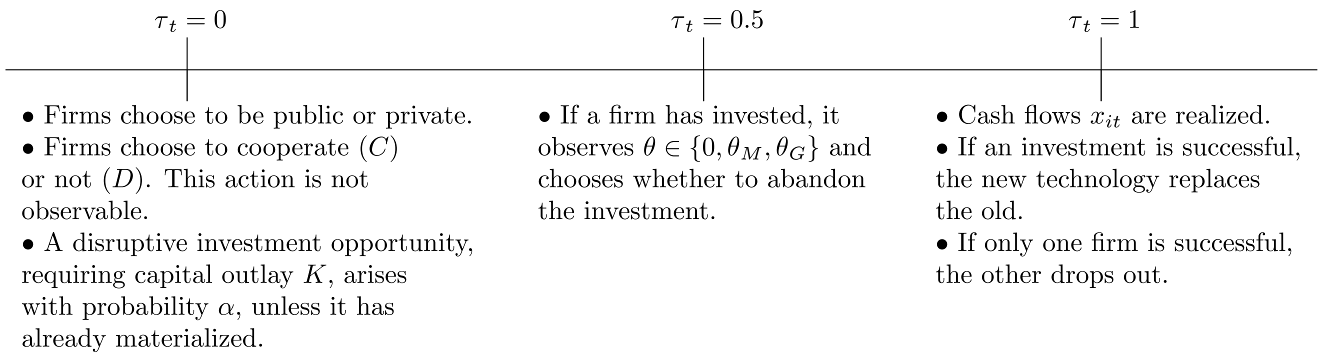

Figure 2: **Timeline of a period.**

information production. Since reporting requirements for private firms are much coarser (especially in the U.S.), we treat private firms' reporting as voluntary and potentially subject to misreporting. To keep things simple, we refer to the information reported by a public firm as its cash flows x_{it}. However, we mean not only cash flows but also all other types of reported information that can be indicative of whether firms cooperate.

To characterize the cooperation benefit brought by public ownership, our analysis allows firms to choose between public and private ownership. This decision is made at the beginning of each period and cannot be changed until the end of that period. What we need is that a private firm that has undertaken the disruptive investment cannot go public on short notice at the interim date $\tau_t = 0.5$ of that period. This assumption can be justified by the fact that an IPO requires careful communication with financiers and regulators and typically takes months for firms to arrange. By contrast, an investment can arguably be abandoned more quickly.[9] Such decisions are internal to the firm and do not typically require external validation or regulatory approvals. Initially, we assume that both firms observe whether their counterpart makes a disruptive investment regardless of whether they are public or private. Subsequently, we relax this assumption. Throughout the analysis, we make the standard assumption that the firms' strategies do not depend on irrelevant information.[10]

3 The Cooperation Benefit of Public Ownership

Proceeding recursively, we start with the case in which neither firm has a disruption opportunity (i.e., both firms' investments have either succeeded, failed, or been abandoned) and

in product research and development.

[9] In a previous working paper version, we also consider the case in which investment takes more than one period to complete, but that does not lead to additional interesting insights.

[10] That is, a firm's strategy depends only on its current posterior beliefs about the other firm's history of actions and signals and not on how the firm has reached these posterior beliefs.

show the distinct value that mandatory disclosure brings to public ownership. Subsequently, we study the case in which one or both firms can invest in disruption. After characterizing the various cases, we will link them to industry maturity.

3.1 Public Ownership and Implicit Cooperation

The effect of mandatory disclosure on cooperation is easiest to illustrate with the case in which neither firm has investment opportunities. When both firms use the same technology, their expected cash flows are higher if they cooperate. However, cooperating for only one period is not feasible. If one firm intends to cooperate, it is optimal for the other not to do so, as its expected cash flow from not cooperating, x_{DC}, is higher than that from cooperating, x_{CC} (Figure 1, p. 7). The only Nash equilibrium of the stage game is that both firms do not cooperate. With infinite periods, cooperation may be possible to sustain, but this depends crucially on what signals the firms observe at the end of each period.

When the firms' (histories of) actions are not observable, a firm can rely only on signals about whether the other firm has cooperated. Since the information disclosed by public firms is a noisy reflection of their actions, this information can be used as an informative albeit noisy signal. The central insight in what follows is that relying on voluntary disclosure (as with private ownership) is insufficient for supporting cooperation.

Public ownership and mandatory disclosure. Our benchmark case is that it is straightforward to support cooperative equilibria when both firms are public, and disclosure is mandatory. The reason is that mandatory disclosure provides a common history of signals around which the firms can align their actions. In particular, there is a perfect public equilibrium in which both firms cooperate in period t and continue to cooperate in period $t+1$ if and only if both firms realize high cash flows in period t and remain public. This equilibrium can be supported if firms sufficiently value future cooperation. To make this precise, consider the price competition model we described. There is no profitable one-shot deviation if the benefit from continued cooperation (which is not interrupted by negative demand shocks with probability ρ^2) satisfies:[11]

$$\begin{aligned} v^{pub} &= (1-\delta)\,\rho p\,(x-k) + \rho^2 \delta v^{pub} \\ &\geq (1-\delta)\,2\rho p\,(x-k)\,. \end{aligned} \tag{1}$$

Condition (1) is satisfied for $\delta \geq \frac{1}{2\rho^2}$. It is straightforward to extend the argument to show

[11] We follow the convention of normalizing the firms' expected payoffs by multiplying them by $(1-\delta)$. This normalization implies that the repeated game payoffs are comparable to the stage game payoffs. Intuitively, the infinite constant stream of 1 utils has a value of 1.

that there are also cooperative equilibria that involve lighter punishments, such as reverting to cooperation after a fixed number of periods. What is common to all these equilibria is that equilibrium price wars occur with a positive probability, $1-\rho^2$, (as the firms may face an adverse demand shock) even though both firms cooperate in equilibrium. However, the threat of abandoning cooperation is needed to discipline both firms to refrain from deviating from cooperation in the first place (Green and Porter, 1984).[12]

Private ownership and voluntary disclosure. Our first result is that mandatory disclosure is essential for cooperation, and private firms relying on voluntary disclosure cannot replicate the same outcome. The crucial difference between public and private ownership is that there is no commonly observable history based on which to coordinate strategies, as every firm's history of actions and signals, $h_i^t = (a_{i1}, x_{i1}, ..., a_{i,t-1}, x_{i,t-1})$, is its private information. In what follows, we show that this makes it more difficult not only to detect deviations but also to credibly commit to stop cooperating following signals indicating deviations.

Suppose, initially, that both firms are private. Consider the following sequential equilibrium candidate. Firm i cooperates in period t and cooperates again in period $t+1$ if and only if its cash flows in period t are high, $x_{it} = x$. The difference from public ownership is that these strategies cannot be conditioned on the signals of the other firm. While a private firm could voluntarily report its signals, we will show that the reports will be uninformative.

The problem for a private firm is that it has stronger incentives to deviate from cooperation and weaker incentives to punish deviations from cooperation. Specifically, if a private firm cooperates in period t by choosing action C but subsequently observes a low signal ($x_{it} = 0$), it has incentives to neglect that signal and continue cooperating in $t+1$ (i.e., under voluntary reporting, it would misreport its signal). The reason is that the private firm rationally attributes its bad signal to bad luck (i.e., a negative demand shock) rather than to a lack of cooperation by the other firm. Indeed, since in the suggested candidate equilibrium, both firms cooperate in period t, there is no other explanation for the low cash flows on the equilibrium path. Though the same reasoning is true also in the case of public ownership, the crucial difference is that public firms can coordinate their $t+1$ actions around the commonly observed history of signals. By contrast, private firms need to guess each other's signals and follow-up actions.

Faced with such uncertainty about the true actions and signals of the other firm, a private firm observing a negative signal — say firm i — will stop cooperating in period $t+1$ only if it expects the other firm, firm j, to do the same. However, this expectation does not

[12]The existence of cooperative equilibria is robust to alternative model formulations of competition. Green and Porter (1984), for example, model competition on quantities.

depend on firm i's signals, as, in equilibrium, the low signals are the result of firm-specific demand shocks, which are uncorrelated with those of the other firm. That is, if cooperation in $t+1$ is optimal for firm i after signal $x_{it} = x$, the same must be true after signal $x_{it} = 0$. Hence, the private firm will continue cooperating, and there is no credible trigger to abandon cooperation. Without such a trigger, the cooperation equilibrium unravels, as the lack of credible punishment will invite deviations from cooperation.

In a nutshell, private ownership cannot sustain a cooperative equilibrium, as deviations are difficult to detect and punishments are difficult to enforce. It is straightforward to extend the arguments to show that there can be no cooperation equilibrium in which one of the firms is public and the other private. Relegating all proofs to Appendix A, we have:

Lemma 1 *A pure strategies cooperative equilibrium cannot be supported if one or both firms are private.*

It is now straightforward that, if no firm has an option to make a disruptive investment, being public helps firms achieve higher profitability.

Proposition 1 *In the absence of disruptive investment opportunities, both firms benefit from being public.*

Complementarity of Mandatory and Voluntary Disclosure. Though public firms can sustain cooperative equilibria, not cooperating in all periods is also an equilibrium. In the presence of such multiplicity, complementary voluntary disclosure can help cooperation. To the extent that such additional voluntary disclosure is public for all, it is typically not considered illegal by regulators (OECD, 2012). Thus, we predict that public firms seeking cooperation will voluntarily report more than the mandated minimum.

Corollary 1 *Public firms can signal their willingness to play a cooperative equilibrium by voluntarily disclosing information that goes above and beyond the minimum mandated level.*

Another example in which mandatory and voluntary disclosure act as complements is when the implicit cooperation is about the voluntary sharing of information, such as in our pharma example in the Introduction. The reason private firms will find it harder to support such cooperation is the same as above — private firms have more leeway not to disclose information that they would rather keep private. In this interpretation of the model, the signals that a private firm can misreport concern not only its cash flows but also other types of information, such as the types of investments the firm is making. Without such information, it is hard for outsiders to judge whether the voluntarily disclosed information pertains to only a small subset or all of the firm's investments. That is, the signals about whether a firm has cooperated are nosier, making cooperation equilibria more difficult to sustain.[13]

Number of Firms, Mixed Strategies, and Correlated Demand Shocks. Among public firms, cooperative equilibria are easier to sustain when a few large firms dominate an industry. With fewer firms, individual firms have less to gain from deviating and more to lose from reverting to non-cooperation. Since there is a smaller likelihood that cooperation will break down, it becomes more attractive to start cooperating in the first place. As discussed in the Introduction, given the large consolidation trend over the last decades, which has led to fewer and larger public firms (Gao et al., 2013; Doidge et al., 2017), our theory would predict that implicit cooperation has become easier. We return to this discussion after analyzing free entry and endogenous size differences in Section 4.1.

Our baseline model assumes that the firms play pure strategies and that their demand shocks are uncorrelated. We can show that private firms can sometimes sustain cooperative equilibria if these assumptions were relaxed. However, even when such equilibria exist, they are more likely to break down, and the maximum equilibrium payoffs of private firms are lower than those of public firms. The lower profitability of private firms (when it comes to supporting implicit cooperation) is all that we use in Proposition 1.

3.2 Co-opetition and Financing of Disruptive Investment

Cooperation opportunities affect a firm's ability to raise financing to invest in disruption. Continuing to work backward through the model, we now consider the case in which the firms have investment opportunities, and we analyze how cooperation opportunities affect investment in disruption. First, we consider the case in which only one firm has such an opportunity, followed by the case in which both firms can invest.

3.2.1 Co-opetition if Only One Firm Can Invest in Disruption

Let firm i be endowed with a disruption opportunity while the other firm has none (it has tried and failed). The question is whether firm i benefits from being public. For the other firm, being public is (weakly) beneficial, as that provides the option to cooperate with firm i on the existing technology (Proposition 1).

[13] The noisiness of a firm's signal is implicitly captured by the firm-specific demand shock in the baseline formulation of the model.

The Firm's Investment and Financing Problem. Suppose that firm i invests at the beginning of period t. To fund the investment, the firm raises K from external financiers in exchange for equity. To keep the contracting problem general, we allow the equity stake to depend on the observable outcomes. In particular, the equity stake is γ_A if the investment is abandoned, γ_M if it succeeds and the firm takes over the market as a monopolist, and γ if the investment is unsuccessful.[14] Furthermore, we let the control right over whether the investment should be abandoned be optimally allocated. In a competitive capital market, outside financiers break even if

$$\sum_{\theta_i \in \{0,\theta_M,\theta_B\}} \pi_{\theta_i} \left(\left(\theta_i \gamma_M \frac{x_M}{1-\delta} + (1-\theta_i)\, \gamma \mathrm{E}x \right) \mathbf{1}_{\theta_i} + \gamma_A \left(L + \mathrm{E}x\right)\left(1 - \mathbf{1}_{\theta_i}\right) \right) = K, \qquad (2)$$

where $\mathrm{E}x = \frac{v^{pub}}{1-\delta}$ if both firms are public, and $\mathrm{E}x = x_{DD} + \frac{\delta v^{pub}}{1-\delta}$ if one of the firms is private in period t and, by Proposition 1, public thereafter; $\mathbf{1}_{\theta_i}$ is an indicator function taking the value of one if the investment is continued after the realization of state θ_i at the intermediate date and zero if it is abandoned.

Continuing the investment, which is successful with probability θ_i, creates more joint surplus for the owner-manager and financiers, compared to liquidating the investment and continuing with the old technology if

$$\begin{aligned} & \theta_i \frac{x_M}{1-\delta} + (1-\theta_i)\, \mathrm{E}x \geq L + \mathrm{E}x \\ \iff \quad & \frac{x_M}{1-\delta} \geq \frac{L}{\theta_i} + \mathrm{E}x. \end{aligned} \qquad (3)$$

Financing contracts that lead to a different continuation rule and, thus, lower expected surplus will be renegotiated.

Crucially, a public firm has a lower likelihood of continuing the investment because the expected exit payoff, $\mathrm{E}x$, is higher. Intuitively, cannibalizing the firm's existing business becomes costlier, as the option to cooperate with firm j increases the existing technology's profitability. This raises the bar for how profitable the new technology should be. In particular, condition (3) is satisfied for signals $\{\theta_M, \theta_G\}$ if the firm is private but only for signal

[14] Restricting attention to these three outcomes is without loss of generality, as they fully characterize the owner-manager's incentive constraint (6), which poses the main restriction on contracting.

θ_G if it is public if[15]

$$\frac{x_M}{1-\delta} \in (X', X''), \text{ where } \begin{cases} X' \equiv & \frac{L}{\theta_M} + x_{DD} + \delta \frac{v^{pub}}{1-\delta} \\ X'' \equiv & \frac{L}{\theta_M} + \frac{v^{pub}}{1-\delta} \end{cases}. \tag{4}$$

Using the financiers' break-even condition (2), firm i's net present value from investing is higher than its effort costs, c, and its outside option of not investing, $\frac{v^{pub}}{1-\delta}$, if

$$V_I \equiv \sum_{\theta_i \in \{0, \theta_M, \theta_B\}} \pi_{\theta_i} \left(\left(\theta_i \frac{x_M}{1-\delta} + (1-\theta_i) \operatorname{E}x \right) (1 - \mathbf{1}_{\theta_i}) + (L + \operatorname{E}x) \mathbf{1}_{\theta_i} \right) - K \geq c + \frac{v^{pub}}{1-\delta}. \tag{5}$$

The firm's objective is to maximize V_I by optimally designing $\{\gamma, \gamma_M, \gamma_A\}$ and allocating the continuation control right at the intermediate date in anticipation that continuation decisions other than those given by (3) will be renegotiated. Furthermore, the contract is subject to the financiers' break-even condition (2) and the incentive constraint ensuring that the owner-manager exerts effort:

$$\sum_{\theta_i \in \{0, \theta_M, \theta_B\}} (\pi_{\theta_i} - q_{\theta_i}) \left(\left(\theta_i (1-\gamma_M) \frac{x_M}{1-\delta} + (1-\theta_i)(1-\gamma) \operatorname{E}x \right) \mathbf{1}_{\theta_i} \right.$$
$$\left. + (1-\gamma_A)(L + \operatorname{E}x)(1 - \mathbf{1}_{\theta_i}) \right) \geq c. \tag{6}$$

How Cooperation Opportunities Affect Agency Costs. Cooperation opportunities are a double-edged sword when raising financing for investment in disruption. Conditional on being able to finance its investment, the firm's expected payoff V_I is higher when it is public because of the better cooperation opportunities. However, the key problem is that a public firm's weaker commitment to continuing the disruptive investment could worsen the agency problem of incentivizing insiders to exert effort to make the investment work.

More precisely, being public could disadvantage the firm if the disruptive investment is intermediately attractive, i.e., if $\frac{x_M}{1-\delta} \in (X', X'')$. In this intermediate range, the investment is continued after signals $\{\theta_M, \theta_G\}$ if the firm is private but only after θ_G if it is public. This endogenous "impatience" associated with being public has two countervailing effects. On the one hand, it incentivizes the owner-manager to exert effort to avoid a low payoff in case of abandonment. On the other hand, there is a negative effect, as the owner-manager's effort increases the likelihood not only of state θ_G but also of state θ_M. Hence, the owner-

[15] To be precise, we also need to guarantee that $\frac{x_M}{1-\delta} > \frac{L}{\theta_G} + \frac{v^{pub}}{1-\delta}$ (i.e., a public firm continues investment if it observes signal θ_G). However, if this condition is not satisfied, the investment is not undertaken regardless of whether the firm is public or private (see condition (5)).

manager's effort is wasted if the firm ends up in state θ_M. The higher likelihood that her effort is wasted reduces the owner-manager's effort incentives. If this "wasted effort effect" dominates, the high stake that insiders need to retain to stay incentivized could be incompatible with external financing.[16] As a result, the firm may be able to finance the investment only if it is private.

Outside the intermediate region (X', X''), firm i always benefits from being public and being able to engage in co-opetition — i.e., investing in disruption but cooperating if it does not have an edge over its rival. In particular, being public is preferable if the disruptive investment is highly attractive, $\frac{x_M}{1-\delta} \geq X''$. In this case, the firm is unlikely to abandon investment regardless of whether it is public or private (in both cases, it continues in states $\{\theta_M, \theta_G\}$). Thus, the agency costs are the same, but being public benefits the firm because it offers the opportunity to cooperate on the existing technology. Being public also dominates at the other extreme, i.e., $\frac{x_M}{1-\delta} \leq X'$, where the investment is marginally attractive. In this case, the continuation decision is again the same (the firm continues only in state θ_G), and the opportunities to cooperate on the existing technology are even more valuable.[17] Summarizing, we obtain a U-shaped relation between the cooperation benefit of being public and the attractiveness of investment:

Proposition 2 *Suppose that only firm i can make a disruptive investment. Being public makes it harder to raise financing to invest in disruption if investment opportunities are intermediately attractive and agency problems are severe: $\frac{x_M}{1-\delta} \in (X', X'')$ and $\pi_{\theta_M} - q_{\theta_M} > \Delta^*_{\theta_M}$ (the threshold $\Delta^*_{\theta_M}$ is defined in the Appendix). The cooperation benefit of being public makes raising financing easier in all other cases.*

The cooperation benefit brought by public ownership is U-shaped in all cases in which a firm can invest in disruption. However, the width of the intermediate range in which private firms can more easily fund the disruptive investment depends on the degree of competition to invest in disruption. As we show next, such rivalry makes the intermediate range smaller.

3.2.2 Co-opetition if Both Firms Can Invest in Disruption

Consider the case in which both firms have the option to invest. The cooperation benefit of being public receives even more weight in this case. To avoid being repetitive, we relegate the analysis to the Appendix, as it is very similar to that in the previous section. In what

[16] We need at least three states to generate the wasted effort effect, but this effect generalizes to any number of states larger than two.

[17] Note that if firm i chooses not to invest in period t, it will also not invest in later periods, as it faces the same problem in all these periods. Thus, firm i either invests immediately when its investment opportunity arises or does not invest at all.

follows, we focus on the main qualitative difference, which is how the firm decides whether to continue the investment. Let q_j be the (endogenous) probability that firm j succeeds with its investment. After observing state θ_i, firm i optimally continues its investment (potentially, after renegotiating) if the owner-manager's and financier's joint surplus is higher compared to if the firm were to liquidate the investment and continue with the old technology:

$$
\begin{aligned}
& (1-q_j)\left(\theta_i \frac{x_M}{1-\delta} + (1-\theta_i)\,\mathrm{E}x\right) + q_j \theta_i \mathrm{E}x \geq L + (1-q_j)\,\mathrm{E}x \\
\iff \quad & \frac{x_M}{1-\delta} \geq \frac{L + \theta_i \mathrm{E}x\,(1-2q_j)}{\theta_i\,(1-q_j)}. \qquad (7)
\end{aligned}
$$

There are two main differences from the previous section. First, when both firms make a disruptive investment, abandoning the investment threatens a firm's survival, as the other firm may succeed with its investment (with probability q_j). Second, even if a firm succeeds with its investment, it may still have to share the market with the other firm if that firm also succeeds. Hence, the value of co-opetition is reinforced, as the firms can benefit from cooperation not only on their old technologies if their investments fail (or are abandoned) but also on the new technologies if both firms succeed and still share the market. Because of these two effects, the intermediate region in which financing disruption could be more difficult for public firms shrinks. For a sufficiently high level of competition, being public can even lead to more continuation and lower agency costs, and the intermediate region disappears altogether.

Proposition 3 *Suppose that both firms can make a disruptive investment. Being public makes it harder to raise financing to invest in disruption if* $\frac{x_M}{1-\delta} \in (X_c', X_c'')$ *and* $\pi_{\theta_M} - q_{\theta_M} > \Delta^*_{\theta_M}$ *(X_c', X_c'' and $\Delta^*_{\theta_M}$ are defined in the Appendix). In all other cases, the cooperation benefit of being public makes raising financing easier. The intermediate region, (X_c', X_c''), shrinks in the probability that a firm's competitor successfully invests in disruption.*

The likelihood that a firm will abandon the disruptive investment depends on its beliefs about the likelihood that the other firm will abandon its investment. This creates scope for multiple equilibria. There is also scope for multiple equilibria at the stage at which an investment is initiated. There are two effects. On the one hand, competition stimulates investment by eroding a firm's outside option of not investing. On the other hand, competition makes investment less attractive by reducing its expected payoff. Because of these conflicting effects, there are equilibria in which neither firm, only one, or both firms invest.

3.3 Link to Industry Maturity

The case in which no firm has an investment opportunity (Proposition 1) could be associated with mature or cash-cow businesses. Being public then always dominates, as no investment is at risk, and being public benefits the firm by helping it maintain high margins.

The case in which both firms invest in disruption best describes an industry's growth phase (Proposition 3). In that case, rivalry and the fear of being left behind make the commitment to disruption less problematic, which causes the intermediate range of the U-shaped relation to shrink. When rivalry on disruption is intermediate and only one firm can pursue disruption (Proposition 2), the intermediate region of the U-shaped relation is wider.[18]

Our results also extend to the case in which a disruptive firm is not endowed with an existing technology. The ability to cooperate on that technology and cannibalization concerns are then irrelevant, and being private is much more likely to be optimal. However, also such a firm can benefit from cooperating after introducing a new technology if the incumbent quickly catches up by also developing that technology. Being public becomes then again potentially optimal.

4 New Entry, Information Leakage, Liquidity, and Alternative Cooperation Mechanisms

Our baseline analysis made several simplifying assumptions that helped us distill the main economic forces. Now, we relax some of our assumptions and derive additional predictions. We start by investigating the effect of size, new entry, and stricter disclosure.

4.1 Size, New Entry, and Stricter Disclosure Requirements

To endogenize differences in size and new entry, we consider the case of price competition and assume that firm i is more cost-efficient than firm j, $k_i < k_j$. To simplify the exposition, assume that demand is inelastic. Specifically, if neither firm faces an adverse demand shock, the firms can sell a total quantity d as long as the price is below a reservation price p. Furthermore, we assume that, with probability σ, outsiders cannot detect whether a firm is

[18] Proposition C.1 in the Appendix studies the case in which only one firm has discovered a disruption opportunity. The main difference from Section 3.2 is that a firm not investing today may change its decision to invest if its rival also becomes able to invest in the new technology. Apart from this difference, the analysis is qualitatively similar to that of Proposition 2 and, thus, relegated to the Appendix.

misreporting its signals.[19] This probability is lower if disclosure requirements are stricter.

Cooperation is more difficult to sustain when firms have asymmetric cost structures, as the more cost-efficient firm i can keep firm j out of the market by selling at a price just below k_j while still making a profit. That is, firm i will be larger and will not allow firm j to enter.

Our novel point is that more disclosure for public firms could make it profitable for firm i to allow the less-cost-efficient firm to enter by facilitating cooperation between the firms. Intuitively, when both firms are public, they can benefit from avoiding a costly price war and implicitly cooperating on selling at the consumers' reservation price p as long as the less-efficient firm stays small enough.

Proposition 4 *When both firms are public, stricter disclosure requirements can help sustain a cooperative equilibrium in which the less-efficient competitor remains active as long as it stays small.*

New Entry. With free entry, the public firms' high cooperation profits are likely to attract new entrants. Since cooperation is more difficult to achieve with multiple players (see Section 3.1), free entry can lead to a breakdown in opportunities for cooperation.

Proposition 4 suggests that cooperation is still possible if firms are not identical and exhibit, for example, different cost structures. In such cases, the more-efficient firms endogenously become larger. Furthermore, they can avoid dissipative price wars as long as the less-efficient among them stay small enough. To make sure that there are not too many players and that cooperation is feasible, the more-efficient firms could cooperate on keeping the less-efficient ones out of the market (e.g., by selling at the less efficient firms' marginal costs). That is, it will be the (endogenously) larger firms that play cooperative equilibria. Again, what is novel is that more stringent disclosure requirements could allow more firms to remain active or enter by making cooperation with less efficient firms easier (Proposition 4).[20]

Corollary 2 *The enforcement of stricter disclosure requirements for public firms can simultaneously lead to lower industry concentration and higher markups.*

4.2 Information Leakage and Public Ownership

A common argument in the literature is that mandatory disclosure associated with public ownership hurts firms by forcing them to disclose sensitive information that could benefit

[19]In our baseline model, we assumed that $\sigma = 0$ for public firms and $\sigma = 1$ for private firms.

[20]The data in Appendix B supports this prediction.

competitors (Bhattacharya and Ritter, 1983; Bhattacharya and Chiesa, 1995). To investigate this effect, we relax our assumption that it is common knowledge whether a firm invests and assume that this information leaks to outsiders only if a firm is public. In our setting, the leakage of such information can harm the firm, as it can help its rival make a more-informed decision of whether to invest in disruption and, subsequently, whether to continue investment.

However, information leakage can also benefit a public firm. It may help sustain cooperation if both firms are public and manage to develop the new technology. Furthermore, disclosing information can benefit a public firm by discouraging its rival from investing. In particular, for the rival, the prospect that it may have to share the market even if its investment succeeds lowers its expected present value from investing or continuing an investment.[21] This effect is stronger if the public firm's rival is private, as then the public firm lacks information about the private firm's investment and will not be discouraged by it. That further discourages the private firm.[22]

Proposition 5 *Leakage of information about a public firm's investment has an ambiguous effect on its profitability. While the information could harm the public firm by helping its competitor make a more informed investment decision, it may simultaneously discourage that competitor from investing, benefiting the public firm.*

A private firm can naturally also disclose information about its investment. However, such a firm can also benefit from cooperating after introducing a new technology if the incumbent quickly catches up by developing that technology. Being public becomes then again potentially optimal.

4.3 Discussion: Endogenous Liquidity and Alternative Cooperation Mechanisms

Endogenous Liquidity. A corollary of our baseline model is that the better exit options facilitated by public financing endogenously improve liquidity for financiers. Since this prediction is the opposite of the assumptions in some related work (Ferreira et al., 2014), it is worth discussing it in more detail. Consider a simple extension of our model in which the

[21] Such intimidation effects following the announcement of investment have been documented by Cookson (2017, 2018) and Noh (2020).

[22] This positive effect of information leakage benefits a public firm if its investment is very likely to succeed or if the two firms' investments are highly correlated. In these cases, the leaked information does not harm the public firm, as it does not increase the likelihood that its rival will use that information to displace it in future periods.

financiers can encounter a liquidity shock at the interim date of the period in which they provide financing, forcing them to sell their equity stakes. Assume that outsiders cannot distinguish whether the reason for selling is a bad intermediate signal θ_i or a liquidity shock. Better exit options from the investment guarantee that the downside risk for potential buyers of the equity stake is smaller. Thus, there will be a smaller adverse-selection discount for a financier selling due to a liquidity shock. Measuring liquidity by this adverse-selection discount, as in Eisfeldt (2004), we obtain:

Corollary 3 *Public firms offer better liquidity than private firms for financiers that must sell due to a liquidity shock.*

Alternative Cooperation Mechanisms. An alternative way for firms to obtain information about their rivals is to become shareholders in these rivals.[23] If firms agree to sell equity stakes to their rivals, the better access to information implies that cooperation can be achieved following the same arguments as in Proposition 1. The qualitative insights from Propositions 1-3 about when firms benefit from cooperation opportunities would then apply.[24] The main qualitative difference from cooperation via stand-alone public ownership is that cooperation through equity stakes is likely to dampen disruption. An equity stake reduces an acquirer's investment incentives, as the equity stake allows the acquirer to benefit from the target's investment. This effect is stronger the larger the acquirer's stake. If a firm buys a controlling equity stake in its competitor, it can shut it down without investing in disruption (Cunningham et al., 2020).[25]

We could rephrase Propositions 1-3 more broadly in the context of firms choosing whether to participate in a mechanism that forces them to disclose information about themselves. Apart from public ownership, such a mechanism is also offered to some extent by industry associations that collect price and trade statistics and make them available to members.[26] Such information may substitute for information disclosed by public firms. Indeed, Kepler (2020) and Pawliczek et al. (2019) find that the information disclosed by public firms decreases

[23] Coordination and control through minority equity stakes is particularly wide-spread in continental Europe and East Asia (see La Porta et al., 1999; Claessens et al., 2000).

[24] Note that cooperation in this setting is achieved differently than in the recent literature on common ownership. That literature argues that publicly listed firms achieve coordination because managers maximize the value of the portfolio of all firms in which their shareholders have invested and not only the value of the firm they are managing (Schmalz, 2018).

[25] We show these effects formally in Appendix B. A countervailing effect is that an active M&A market may encourage investment by small firms hoping to be acquired by large firms (Phillips and Zhdanov, 2013).

[26] A good example is The Open Competition Plan. This plan involved a central clearing house for information on prices, trade statistics and practices, with the aim of keeping all members fully and quickly informed of what the others have done. Though this plan was struck down by antitrust authorities, various industry associations still offer similar services.

when firms enter formal alliances or are members of industry associations. Also notable is that recent advances in information technology such as the blockchain have made it easier for private firms to disseminate verifiable information about themselves to outsiders.[27] Our main predictions for how opportunities for co-opetition will affect investment in disruption also extend to cases in which cooperation is achieved over such alternative channels.

4.4 Empirical Implications and Evidence

A comprehensive theory of why firms go public is beyond the scope of our paper. Instead, our main objective is to highlight the cooperation benefit of being public and to explore when it makes public firms more disruptive and competitive. In this section, we summarize our model's empirical implications.

The Effect of Mandatory Disclosure on Cooperation and Competition. Many of the best-known disruptive firms are public and have extensively financed their growth in public capital markets (Bowen et al., 2020).[28] At the same time, the top decile of public firms in all industries have reached profitability levels that are hard to square with cut-throat competition and are considerably higher than those among the overall population of (mostly) private firms (De Loecker and Eeckhout, 2017; De Loecker et al., 2020; Díez et al., 2018; Ayyagari et al., 2019). Consistent with this evidence, our first result is that being public facilitates higher profitability by making it easier for firms to cooperate.

Implication 1 *Mandatory disclosure requirements help public firms achieve higher profitability by facilitating implicit cooperation. This effect is likely to be stronger when public firms offer similar products and services and operate in more concentrated industries.*

In Appendix B, we offer support for Implication 1 by providing evidence from the enactment of the American Inventor's Protection Act (AIPA) of 2000 and the Food and Drug Administration Amendments Act (FDAAA) of 2007. Both pieces of legislation mandated more-detailed disclosure regarding the outcome of innovation by requiring patent applications to be disclosed sooner and the results of early phase trials to be reported regardless of their outcome. These reforms speak directly to the example of pharma and biotech firms in the Introduction. In line with our predictions about the benefits of co-opetition, our

[27] Related, Cong and He (2019) argue that, by serving as record keepers, firms active on the blockchain may be better able to infer aggregate business conditions and detect deviations. This could help sustain collusive equilibria.

[28] Bowen et al. (2020) argue that, compared to a strategic sale, an exit via an IPO allows firms to disrupt the market more easily by remaining independent. Our model complements this explanation by highlighting that firms can maintain high profitability even after rivals have caught up with the disruptive innovation.

difference-in-differences results show that the markups of firms in more strongly affected industries were significantly higher after the reforms — a finding that is in stark contrast to the predictions of prior theoretical work (Bhattacharya and Ritter, 1983). As predicted by our model, the effects are particularly strong when the affected firms are more similar to their peers, as such firms are more likely to benefit from cooperation. Cooperation could then help firms internalize externalities that broaden the adoption of the newly-developed technologies (e.g., via common standards) or spur innovation by suppliers and customers (Gnyawali et al., 2006; Bushee et al., 2020).[29]

Implication 1 is also in line with the argument made by regulators (OECD, 2012) and legal scholars (Steuer, 2011) that greater transparency requirements in public markets could act as focal points around which public firms could tacitly coordinate their strategies.[30] We expect that this channel has become more important over the last decades, as that period has witnessed consolidation leading to fewer and larger public firms (Gao et al., 2013; Doidge et al., 2017). As a result of this, implicit cooperation of the type we describe is easier, while further consolidation as an alternative way to avoid competition is likely to be harder due to antitrust hurdles.

Implication 2 *The benefit of voluntary disclosure is higher for public than private firms. For public firms, voluntary disclosure is valuable as a complement to mandatory disclosure. For private firms, voluntary disclosure lacks credibility.*

For public firms, voluntary disclosure can serve as a complement to mandatory disclosure (Corollary 1). This prediction is consistent with recent empirical evidence that public firms voluntarily disclose more information when seeking to avoid competition (Bourveau et al., 2019; Bertomeu et al., 2020). What we add to this literature is that voluntary disclosure cannot substitute for mandatory disclosure but only complement it. Private firms cannot replicate cooperation strategies by voluntarily disclosing information, as their disclosure lacks credibility. That is, it is hard for outsiders to evaluate whether a private firm cherry-picks the information it discloses.

Investment, Co-opetition, and Industry Rivalry. Our analysis further predicts that opportunities to cooperate depend on the attractiveness of investment.

[29] Interestingly, Breuer et al. (2020) find that stricter reporting standards benefit innovative large firms, but the effect is opposite for small firms. Indeed, the cooperation opportunities that we focus on are relevant mainly for larger players in concentrated industries (Proposition 4).

[30] Being public should be particularly beneficial when competition is harder to track. This could be the case when firms offer non-standardized goods or serve corporate customers to whom they offer pricing schemes that are difficult to compare with those of other firms.

Implication 3 *The cooperation benefit of being public is U-shaped in the attractiveness of investment. Specifically, better cooperation opportunities help public firms raise external financing to invest in disruption if disruption opportunities are either marginally attractive or, at the other extreme, very attractive.*

What Implication 3 points at is that cooperation could backfire for intermediately attractive investment opportunities. In particular, it makes cannibalizing existing technologies costlier and, thus, could erode the commitment to continue disruptive investments. Indeed, Aghamolla and Thakor (2019) find that public firms have a higher likelihood of prematurely abandoning innovative projects.[31] Our model shows that this cost mainly dominates for intermediately attractive investments and makes the net cooperation benefit of being public U-shaped in the attractiveness of investment. In all other cases, being public benefits the firm by helping it raise financing for disruptive investments. In line with this prediction, Acharya and Xu (2017) show that the innovation profile of public firms in industries that depend on external financing is better than that of private firms. Further consistent with our model's prediction that stricter disclosure requirements can increase investment in disruption, Hedge et al. (2020) find that the passage of AIPA (which has increased disclosure requirements about patent applications) has led to an increase in R&D investment and patenting.

Another implication from our analysis is that the benefit of being public depends on the state of the industry — i.e., the rivalry to invest in disruption.

Implication 4 *The cooperation benefit of being public helps firms raise financing to invest in disruption, especially in growth industries, in which disruption opportunities are abundant and pursued by rivals. Being public is also particularly beneficial at the other extreme, in mature industries in which firms are not seeking to disrupt their cash-cow businesses.*

In growth industries, the intense rivalry on disruption makes firms worry about being left behind, and, thus, the commitment to disruption is less at risk.[32] As a result, the benefit of co-opetition and being public weighs more. What is more, firms in growth industries could benefit from cooperating on new technologies. By this, we do not mean that they cooperate in the development phase of such technologies, as the objective of disruption is to displace rivals. Rather, cooperation can help with the adoption and commercialization of a technology (Gnyawali et al., 2006), boosting not only profit margins but also the appeal of new technologies to suppliers and customers. A prominent example is the pharma industry,

[31] Related, Breuer et al. (2020) document that stricter disclosure requirements impede innovation in concentrated industries.

[32] Since everyone is investing, concerns about keeping investment in disruption secret by staying private arguably also receive less weight.

where co-opetition has been relevant for decades (Deloitte, 2015). This industry has received much attention in the context of the COVID-19, where regulators have sought to promote co-opetition with the objective of stimulating investment in innovative treatments and vaccines (OECD, 2020, Crick and Crick, 2020). Our empirical findings and those of Hegde et al. (2020) that mandatory disclosure requirements have made firms investing in innovation more profitable and have increased their investment in innovation support the idea that such requirements could foster co-opetition among public firms, making them more profitable and disruptive.[33] Further supportive of the importance of co-opetition for growth firms, Chen et al. (2020) document that such firms disclose more information in an effort to cooperate with their peers.

Finally, being public is very valuable also at the other extreme: In mature industries, where disruption opportunities are rare, cooperation is very valuable to preserve the cash-cow nature of the existing business. Since a commitment to disruption is not important, being public is always optimal. Effectively, the U-shaped relation disappears.

Implications 3 and 4 shed light on the empirical debate about whether public or private firms find it easier to finance new investment opportunities. What is notable about this literature is the conflicting empirical evidence. While Asker et al. (2015) and Sheen (2019) find that public firms respond less to investment opportunities due to higher agency costs, Gilje and Taillard (2016) and Phillips and Sertsios (2017) find the opposite but focus on different industries. Similarly, while some empirical work finds that public firms might find it easier to finance and invest in innovation (Acharya and Xu, 2017; Feldman et al., 2018), others find a more nuanced picture (Bernstein, 2015; Gao et al., 2018). Implications 3 and 4 suggest that the conflicting evidence could result from the U-shaped benefit of being public and differences in the rivalry to invest in disruption.

5 Conclusion

Many public firms are highly profitable and disruptive, defying predictions about the demise of the public corporation. We propose a novel rationale based on the effects of mandatory disclosure in public firms. Mandatory disclosure helps firms cooperate and avoid competition on some dimensions while competing on others — a strategy known as "co-opetition." We demonstrate that co-opetition not only improves profitability but can also stimulate disruption. The cooperation we have in mind can range from sharing knowledge and resources to

[33] Kim and Valentine (2020) also find that AIPA has had an overall positive effect on R&D and patenting but show that the benefit differs depending on whether firms are more likely to benefit or lose from knowledge spillover.

possibly more questionable market-sharing practices.

Pursuing co-opetition is arguably a legitimate objective of running businesses and is extensively discussed by practitioners and the strategic management literature. Such a strategy can be particularly valuable if it helps preserve high margins on existing technologies or helps improve the adoption and further development of new ones. We show that voluntary disclosure by private firms lacks commitment and cannot substitute for mandatory disclosure when it comes to supporting cooperation.

Better cooperation opportunities increase public firms' profitability. However, by facilitating cooperation on existing technologies and making them more profitable, public ownership could undermine the commitment to disruptive investments. The reason is that more-profitable existing technologies present a more attractive exit option when investments run into early difficulties. Hence, public firms are endogenously more "impatient" and concerned with cannibalizing their existing technology. In light of this impatience, the advantage of being private is that it could help a firm commit not to abandon disruptive investments.

Taking these results as a starting point, we find that the cooperation benefit of being public is U-shaped in the attractiveness of investment. For highly attractive investment opportunities, concerns about commitment weigh less, and being public is valuable because of the cooperation opportunities it offers. Being public is also beneficial at the other extreme: when investment opportunities are only marginally attractive, being public helps by improving the firms' exit options. Thus, private firms' main advantage is in the case of intermediately attractive investments, where being public undermines commitment.

We show that better opportunities to engage in co-opetition (facilitated by public ownership) are particularly valuable in the growth phase of an industry when investment opportunities are abundant and also pursued by rivals. With such rivalry, commitment to investment is less at risk. The cooperation benefit of being public also dominates at the other extreme: in mature industries. Firms then do not seek to disrupt their cash-cow businesses, and cooperation helps firms become more profitable.

The paper's main insight is that stricter mandatory disclosure can help public firms support implicit cooperation and make them more disruptive and profitable. To stimulate further research into the topic, we present evidence based on two pieces of legislation that increased disclosure requirements about innovation activities. In line with our predictions about the benefits of co-opetition, and contrary to the predictions of prior theory, the evidence is that stricter disclosure requirements lead to higher markups and more innovation in more-affected industries. The effects are stronger for firms offering more similar products and services, which are arguably more likely to benefit from cooperation. For future work, it would be interesting to expand empirically and theoretically on the implications for overall welfare.

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Appendix A Proofs

Proof of Lemma 1. We show that the only equilibrium that can be sustained is the repetition of the Nash equilibrium of the stage game after all histories. Since the only equilibrium of the stage game is (D, D), the result follows.

Consider a strategy profile $\sigma = ((\sigma_1^t)_{t=1}^{\infty}, (\sigma_2^t)_{t=1}^{\infty})$ for the two firms with $\sigma_i^t : H_i^t \to A_i$, where a private history of player i is an element $h_i^t = (x_{i1}, a_{i1}, ..., x_{it}, a_{it}) \in H_i^t$ and $A_i = \{C, D\}$. We refer to the two players as player i and player j, and (with slight abuse of notation) take the first period of cooperation to be period 1. Observe that for all x_{j1}, x_{i1} and $a_{j1} \neq \sigma_{j1}$ it holds that the probability that firm j has played the out-of equilibrium action a_{j1} and has received signal x_{j1} given that firm i has played its equilibrium strategy σ_{i1} and has received signal x_{i1} is

$$\Pr(a_{j1}, x_{j1} | \sigma_{i1}, x_{i1}) = 0.$$

This probability is independent of firm i's signal x_{i1}. Furthermore, given that firm-specific demand shocks are drawn independently, in a pure strategies equilibrium, the probability that firm j plays its equilibrium strategy σ_{j1} and observes signal x_{j1} given that firm i plays its equilibrium action σ_{i1} and observes signal x_{i1} is

$$\Pr(\sigma_{j1}, x_{j1} | \sigma_{i1}, x_{i1}) = \frac{\Pr(x_{i1}, x_{j1} | \sigma_{i1}, \sigma_{j1})}{\Pr(x_{i1} | \sigma_{i1}, \sigma_{j1})} = \Pr(x_{j1} | \sigma_{i1}, \sigma_{j1}).$$

The latter probability is also independent of firm i's signal x_{i1}. Since firm i's initial signal x_{it} does not affect its belief about firm j's private history $h_j^1 = (x_{j1}, a_{j1})$, the continuation strategy of firm i induced by its strategy in period 1 must be independent of its signal x_{i1} in period 1. Similarly, the continuation strategy of firm j induced by its strategy in period 1 must be independent of its signal x_{j1} in period 1. This means that firm i's strategy in period 1 must be a best-reply to firm j's strategy in period 1, and the same must apply to firm j. Hence, both firms' strategies in period 1 must constitute a Nash equilibrium of the stage game in period 1. Proceeding by induction, we can extend the argument to all remaining periods. **Q.E.D.**

Proof of Proposition 1. The proof follows immediately from the discussion in the main text and Lemma 1, as the expected payoff from cooperation in at least some periods is higher than that from non-cooperation in all periods. Hence, the firms choose public ownership. **Q.E.D.**

Proof of Proposition 2. We compute the maximum pledgeable income (i.e., the maximum expected payoff) that the owner-manager can pledge to outside investors, while satisfying the continuation rule (3) and the owner-manager's incentive constraint (6), under both public and private ownership. Observe that, regardless of whether the firm is public or private, maximizing the pledgeable income requires setting $\gamma_A = 1$, as this relaxes the incentive constraint (6), while increasing the pledgeable income.

Suppose that $\frac{x_M}{1-\delta} \in (X', X'')$. That is, the continuation condition (3) is satisfied for $\{\theta_M, \theta_G\}$ if the firm is private but only for θ_G if it is public. As discussed in the main text, in all remaining cases, being public dominates. Since outsiders cannot distinguish between signals showing states θ_M and θ_G, the control right to continue the investment becomes important. Note that the owner-manager of firm i prefers to continue the investment at the intermediate date $\tau_t = 0.5$ if

$$\theta_i (1-\gamma_M) \frac{x_M}{1-\delta} + (1-\theta_i)(1-\gamma)\,\mathrm{E}x \geq (1-\gamma_A)(L + \mathrm{E}x)$$

Defining for convenience the owner-manager's claims as $S_M \equiv (1-\gamma_M)\frac{x_M}{1-\delta}$, $S \equiv (1-\gamma)\,\mathrm{E}x$, and $S_A \equiv (1-\gamma_A)(L+\mathrm{E}x)$, the investor prefers continuation if

$$\theta_i \left(\frac{x_M}{1-\delta} - S_M \right) + (1-\theta_i)(\mathrm{E}x - S) \geq L + \mathrm{E}x - S_A. \tag{A.1}$$

Since any continuation decision that does not coincide with the socially optimal continuation rule will be renegotiated, we stipulate that the investment is abandoned if it is a failure ($\theta_i = 0$) and allocate the continuation control right to the party that will take the efficient decision in case of θ_M and θ_G. This improves the ex ante contracting possibilities by removing the renegotiation-proofness constraint. In what follows let

$$\begin{aligned} PV^{pub} &= (1-\pi_{\theta_G})\left(L + \frac{v^{pub}}{1-\delta}\right) + \pi_{\theta_G}\left(\theta_G \frac{x_M}{1-\delta} + (1-\theta_G)\frac{v^{pub}}{1-\delta}\right) && \text{(A.2)} \\ PV^{priv} &= (1-\pi_{\theta_M} - \pi_{\theta_G})\left(L + x_{DD} + \frac{\delta v^{pub}}{1-\delta}\right) && \text{(A.3)} \\ &\quad + \sum_{\theta_i \in \{\theta_M, \theta_G\}} \pi_{\theta_i}\left(\theta_i \frac{x_M}{1-\delta} + (1-\theta_i)\left(x_{DD} + \frac{\delta v^{pub}}{1-\delta}\right)\right) \end{aligned}$$

denote the present values of investing depending on whether firm i is public and continues investment in state θ_G or private in which case it continues the investment in both states θ_M and θ_G. To further simplify notation, we define $\Delta_{\theta_i} \equiv \pi_{\theta_i} - q_{\theta_i}$ as the change in the probability of state θ_i when the owner-manager exerts effort to make the investment work.

Public ownership and cooperation. Suppose for now that the continuation decision lies with the financier. We assume for now and then verify that the financier will continue the investment if and only if it is efficient to do so and it satisfies (3).

Using that $S_A = 0$ (i.e., $\gamma_A = 1$), it must hold that $\theta_G S_M + (1-\theta_G) S \geq \frac{c}{\Delta_{\theta_G}}$. Maximizing the pledgeable income further requires this expression to be binding. Using this, we obtain that the maximum pledgeable income is

$$\begin{aligned}\Pi^{pub} &= PV^{pub} - \pi_{\theta_G} \left(\theta_G S_M + (1-\theta_G) S\right) \\ &= PV^{pub} - \pi_{\theta_G} \frac{c}{\Delta_{\theta_G}}.\end{aligned}$$

We now verify that the financier makes the efficient continuation decision at the intermediate date $\tau_t = 0.5$. Observe that if the signal is θ_M, then by construction we are in the case in which (A.1) would not be satisfied for any $S_M, S \geq 0$. If the signal is θ_G, then condition (A.1) must be satisfied by construction, as, otherwise, exerting effort would not be ex ante optimal and the investment would not have been initiated.

Private ownership and non-cooperation. Giving the continuation control right to the owner-manager now trivially guarantees that the investment is continued in states θ_M and θ_G, as the owner-manager otherwise does not receive anything ($S_A = 0$). Hence, from the incentive constraint, we obtain that the firm must retain an expected claim of at least

$$\sum_{\theta_i \in \{\theta_M, \theta_B\}} \Delta_{\theta_i} \left(\theta_i S_M + (1-\theta_i) S\right) \geq c. \tag{A.4}$$

To maximize the pledgeable income, define the Lagrangian

$$\begin{aligned}L &= PV^{priv} - \sum_{\theta_i \in \{\theta_M, \theta_B\}} \left(q_{\theta_i} + \Delta_{\theta_i}\right) \left(\theta_i S_M + (1-\theta_i) S\right) \\ &\quad + \mu \left(\sum_{\theta_i \in \{\theta_M, \theta_B\}} \Delta_{\theta_i} \left(\theta_i S_M + (1-\theta_i) S\right) - c \right) + \zeta S + \xi S_M,\end{aligned} \tag{A.5}$$

where μ, ζ, ξ are the weakly positive Kuhn-Tucker multipliers. Note that it cannot be that $S = S_M = 0$, as then (A.4) is not satisfied. Thus, either $\mu, \zeta > 0$ or $\mu, \xi > 0$, and we can replace $\sum_{\theta_i \in \{\theta_M, \theta_B\}} \Delta_{\theta_i} \left(\theta_i S_M + (1-\theta_i) S\right)$ in the first line of (A.5) with c. Applying Kuhn

Tucker's theorem and taking the first-order conditions, we have

$$\begin{aligned}
\frac{\partial L}{\partial S_M} &= -\sum_{\theta_i\in\{\theta_M,\theta_B\}} q_{\theta_i}\theta_i + \mu \sum_{\theta_i\in\{\theta_M,\theta_B\}} \Delta_{\theta_i}\theta_i + \zeta = 0 \\
\frac{\partial L}{\partial S} &= -\sum_{\theta_i\in\{\theta_M,\theta_B\}} q_{\theta_i}\left(1-\theta_i\right) + \mu \sum_{\theta_i\in\{\theta_M,\theta_B\}} \Delta_{\theta_i}\left(1-\theta_i\right) + \xi = 0
\end{aligned}$$

If $\zeta = 0$, we have that $\mu = \frac{\sum_{\theta_i\in\{\theta_M,\theta_B\}} \pi_{\theta_i}\theta_i}{\sum_{\theta_i\in\{\theta_M,\theta_B\}} \Delta_{\theta_i}\theta_i}$. Plugging into the second first-order condition, we obtain

$$\left(q_{\theta_G}\Delta_{\theta_M} - q_{\theta_M}\Delta_{\theta_G}\right)\frac{\theta_G-\theta_M}{\theta_G\Delta_{\theta_G}+\theta_M\Delta_{\theta_M}} + \xi.$$

Hence, if $q_{\theta_G}\Delta_{\theta_M} < q_{\theta_M}\Delta_{\theta_G}$, we must have that $\xi > 0$. That is, $S = 0$ and $S_M = \frac{c}{\sum_{\theta_i\in\{\theta_M,\theta_B\}} \Delta_{\theta_i}\theta_i}$. However, if $q_{\theta_G}\Delta_{\theta_M} > q_{\theta_M}\Delta_{\theta_G}$, we have a contradiction to the second first-order condition. In this case, we can set $\xi = 0$, derive $\mu = \frac{\sum_{\theta_i\in\{\theta_M,\theta_B\}} q_{\theta_i}(1-\theta_i)}{\sum_{\theta_i\in\{\theta_M,\theta_B\}} \Delta_{\theta_i}(1-\theta_i)}$ from the second first-order condition, and verify that $\zeta > 0$. Hence, $S_M = 0$ and $S = \frac{c}{\sum_{\theta_i\in\{\theta_M,\theta_B\}} \Delta_{\theta_i}(1-\theta_i)}$. Thus, the maximum pledgeable income is

$$\Pi^{priv} = \begin{cases} PV^{priv} - \frac{\sum_{\theta_i\in\{\theta_M,\theta_B\}} q_{\theta_i}\theta_i}{\sum_{\theta_i\in\{\theta_M,\theta_B\}} \Delta_{\theta_i}\theta_i}c & \text{if } q_{\theta_G}\Delta_{\theta_M} \leq q_{\theta_M}\Delta_{\theta_G} \\ PV^{priv} - \frac{\sum_{\theta_i\in\{\theta_M,\theta_B\}} q_{\theta_i}(1-\theta_i)}{\sum_{\theta_i\in\{\theta_M,\theta_B\}} \Delta_{\theta_i}(1-\theta_i)}c & \text{if } q_{\theta_G}\Delta_{\theta_M} > q_{\theta_M}\Delta_{\theta_G} \end{cases}.$$

Comparing pledgeable incomes under public and private ownership. Comparing the maximum pledgeable income under public and private ownership, we obtain that

$$\Pi^{pub} - \Pi^{priv} = \begin{cases} PV^{pub} - PV^{priv} - \frac{\theta_M}{\Delta_{\theta_G}}\frac{q_{\theta_G}\Delta_{\theta_M} - q_{\theta_M}\Delta_{\theta_G}}{\theta_G\Delta_{\theta_G}+\theta_M\Delta_{\theta_M}} > 0 & \text{if } q_{\theta_G}\Delta_{\theta_M} \leq q_{\theta_M}\Delta_{\theta_G} \\ PV^{pub} - PV^{priv} - \frac{1-\theta_M}{\Delta_{\theta_G}}\frac{q_{\theta_G}\Delta_{\theta_M} - q_{\theta_M}\Delta_{\theta_G}}{\Delta_{\theta_G}(1-\theta_G)+\Delta_{\theta_M}(1-\theta_M)} & \text{if } q_{\theta_G}\Delta_{\theta_M} > q_{\theta_M}\Delta_{\theta_G} \end{cases} \tag{A.6}$$

Observe that, if $q_{\theta_G}\Delta_{\theta_M} \leq q_{\theta_M}\Delta_{\theta_G}$, being public leads to a higher pledgeable income. However, if $q_{\theta_G}\Delta_{\theta_M} > q_{\theta_M}\Delta_{\theta_G}$, the agency costs under private ownership are lower, which could make private ownership preferable. To find when being private dominates in this case, we use that from expressions (A.2)–(A.3)

$$PV^{pub} - PV^{priv} = \left(1-\theta_G\pi_{\theta_G}\right)\left(v^{pub} - x_{DD}\right) + \pi_{\theta_M}\left(L - \theta_M\left(\frac{x_M}{1-\delta} - x_{DD} - \frac{\delta v^{pub}}{1-\delta}\right)\right).$$

Plugging this difference into expression (A.6) and differentiating with respect to Δ_{θ_M}, we obtain that $\frac{\partial\left(\Pi^{pub}-\Pi^{priv}\right)}{\partial\Delta_{\theta_M}} < 0$. Hence, in terms of comparative statics, we obtain that private ownership becomes more attractive as Δ_{θ_M} increases. In particular, there is a threshold $\Delta^*_{\theta_M}$

(where $\Delta^*_{\theta_M} > \frac{q_{\theta_M}\Delta_{\theta_G}}{q_{\theta_G}}$), implicitly defined by $\Pi^{pub} = \Pi^{priv}$, for which it holds that being private is better if $\Delta_{\theta_M} > \Delta^*_{\theta_M}$.[34] If the parameter values are such that $\Delta^*_{\theta_M} > 1 - q_{\theta_M} - q_{\theta_G}$, there are no Δ_{θ_M} and Δ_{θ_G} for which $\Pi^{pub} \leq \Pi^{priv}$, and being public is always optimal. **Q.E.D.**

Proof of Proposition 3. In analogy to the way we derived firm i's expected profit (5) in the previous section, we obtain that firm i's net present value from investing is higher than the owner-manager's effort cost, c, and outside options if

$$\begin{aligned} V_{II} \equiv & \sum_{\theta_i \in \{0,\theta_M,\theta_G\}} \Bigg(\pi_{\theta_i} \left((1-q_j) \left(\theta_i \frac{x_M}{1-\delta} + (1-\theta_i)\,\mathrm{E}x \right) + q_j \theta_i \mathrm{E}x \right) \mathbf{1}_{\theta_i} \\ & + (L + (1-q_j)\,\mathrm{E}x)\,(1 - \mathbf{1}_{\theta_i}) \Bigg) - K \\ \geq\ & c + (1-q_j)\max\left(x_{a_i a_j} + \delta\,(V_I - c)\,, \mathrm{E}x\right). \end{aligned} \tag{A.7}$$

The max-operator in the last line of expression (A.7) captures that if firm j's investment fails or is abandoned, firm i can still choose to invest in the following period as in Proposition 1.[35]

The owner-manager's problem is to design the financing contract to maximize V_{II} subject to the financier's break-even condition and the owner-manager' incentive constraint, while also anticipating that ex post inefficient continuation decisions at the intermediate date will be renegotiated. We state all of these constraints below, where we compute the maximum pledgeable income under public and private ownership when both firms make disruptive investments.

If only one firm invests, Proposition 2 applies. Observe that being public has no benefit if the other firm is private, as then the firms cannot cooperate in the investment period. Therefore, we compare the maximum pledgeable income under public and private ownership for firm i only for the case in which firm j is also public. The proof is a straightforward modification of the Proof of Proposition 2.

Consider the continuation rule (7). If $q_j \geq 1/2$, the right-hand side of the continuation rule (7) increases in $\mathrm{E}x$ (i.e., in firms' expected payoff when the firms operate the same technology), which is higher when the firm is public. Hence, firm i is more likely to continue the investment if it is public than if it is private. Thus, the only case we need to consider is

[34] We do not give the explicit expression for $\Delta^*_{\theta_M}$, as it is not very informative.

[35] As in Proposition 2, if it is not optimal for firm i to invest in the following period, it is also not optimal in all subsequent periods.

where, in equilibrium, $q_j < 1/2$ and

$$\frac{x_M}{1-\delta} \in \left(X_c', X_c''\right), \text{ where } \begin{cases} X_c' \equiv & \frac{L+\theta_M\left(x_{DD}+\delta\frac{v^{pub}}{1-\delta}\right)(1-2q_j)}{\theta_M(1-q_j)} \\ X_c'' \equiv & \frac{L+\theta_M\frac{v^{pub}}{1-\delta}(1-2q_j)}{\theta_M(1-q_j)} \end{cases}. \tag{A.8}$$

That is, firm i continues the investment in states $\{\theta_M, \theta_G\}$ if the firm is private but only in state θ_G if it is public. In all remaining cases, public ownership dominates. Note that firm i prefers to continue the investment if

$$(1-q_j)\left(\theta_i S_M + (1-\theta_i) S\right) + q_j\theta_i S \geq (1-q_j) S_A$$

while the investors if

$$(1-q_j)\left(\theta_i\left(\frac{x_M}{1-\delta} - S_M\right) + (1-\theta_i)\left(\mathrm{E}x - S\right)\right) + q_j\theta_i\left(\mathrm{E}x - S\right) \geq L + (1-q_j)\left(\mathrm{E}x - S_A\right)$$

In these expressions, S_B is the owner-manager's claim if both firms' investments succeed. As in Proposition 1, S_M, is the owner-manager's claims in case firm i's investment succeeds and it displaces firm j, S is the owner-manager's claim if both investments fail, and S_A is the owner-manager's claim if firm i abandons its investment.

Since any continuation decision that does not coincide with the socially optimal continuation rule will be renegotiated, we optimally allocate the continuation control right to the party that will take the efficient decision without renegotiating the initial contract, as this allows for more efficient ex ante contracting (by removing the renegotiation-proofness constraint). In what follows define

$$\begin{aligned} PV^{pub} &= (1-q_j)\left((1-\pi_{\theta_G})\left(L + \frac{v^{pub}}{1-\delta}\right) + \pi_{\theta_G}\left(\theta_G\frac{x_M}{1-\delta} + (1-\theta_G)\frac{v^{pub}}{1-\delta}\right)\right) \quad (A.9) \\ &\quad + q_j\left((1-\pi_{\theta_G})L + \pi_{\theta_G}\theta_G\frac{v^{pub}}{1-\delta}\right) \\ PV^{priv} &= (1-q_j)\left((1-\pi_{\theta_M}-\pi_{\theta_G})\left(L + x_{DD} + \frac{\delta v^{pub}}{1-\delta}\right)\right. \quad (A.10) \\ &\quad \left. + \sum_{\theta_i\in\{\theta_M,\theta_G\}}\pi_{\theta_i}\left(\theta_i\frac{x_M}{1-\delta} + (1-\theta_i)\left(x_{DD} + \frac{\delta v^{pub}}{1-\delta}\right)\right)\right) \\ &\quad + q_j\sum_{\theta_i\in\{\theta_M,\theta_G\}}\left((1-\pi_{\theta_G})L + \pi_{\theta_i}\theta_i\left(x_{DD} + \frac{\delta v^{pub}}{1-\delta}\right)\right) \end{aligned}$$

the present value of investing depending on whether the firm is public or private, respectively.

The incentive constraint that the owner-manager of firm i exerts effort becomes now

$$\sum_{\theta_i \in \{0,\theta_M,\theta_B\}} (\pi_{\theta_i} - q_{\theta_i}) \left(\left((1-q_j) \left(\theta_i S_M + (1-\theta_i) S\right) + q_j \theta_i S_B \right) \mathbf{1}_{\theta_i} + S_A \left(1 - \mathbf{1}_{\theta_i}\right) \right) \geq c. \tag{A.11}$$

Public ownership and cooperation. This case applies if both firms are public. Suppose for now that the continuation decision lies with the financier. We assume for now and then verify that the financier will continue the investment if and only if it is efficient to do so and it satisfies (7).

To calculate the maximum pledgeable income, it is optimal to set $S_A = 0$, as this relaxes the incentive constraint (A.11), while increasing the pledgeable income. Thus, to exert effort, firm i's expected continuation stake must be at least $(1-q_j)(\theta_G S_M + (1-\theta_G) S) + q_j \theta_G S_B \geq \frac{c}{\Delta_{\theta_G}}$. With such a stake, the maximum pledgeable income to the financier is

$$\Pi^{pub} = PV^{pub} - \pi_{\theta_G} \frac{c}{\Delta_{\theta_G}}.$$

Just as in Proposition 2, it can be verified that the financier takes the ex post efficient continuation decision.

Private ownership and non-cooperation. This case applies if one of the firms is private. Suppose now that the firm has the control right over the continuation decision. We assume and then verify that the firm will make the efficient continuation decision.

To calculate the maximum pledgeable income, it is optimal again to set $S_A = 0$, as this relaxes the firm's incentive constraint (A.11), while increasing the pledgeable income. Note that this trivially implies that the firm continues the investment in both θ_M and θ_G. Hence, from the incentive constraint, we obtain that the firm must retain a claim that satisfies at least

$$\sum_{\theta_i \in \{\theta_M,\theta_B\}} \Delta_{\theta_i} \left((1-q_j) \left(\theta_i S_M + (1-\theta_i) S\right) + q_j \theta_i S_B \right) = c. \tag{A.12}$$

To maximize the pledgeable income, define the Lagrangian

$$\begin{aligned} L \quad = \quad & PV^{priv} - \sum_{\theta_i \in \{\theta_M,\theta_B\}} (q_{\theta_i} + \Delta_{\theta_i}) \left((1-q_j) \left(\theta_i S_M + (1-\theta_i) S\right) + q_j \theta_i S_B \right) \qquad \text{(A.13)} \\ & + \mu \left(\sum_{\theta_i \in \{\theta_M,\theta_B\}} \Delta_{\theta_i} \left((1-q_j) \left(\theta_i S_M + (1-\theta_i) S\right) + q_j \theta_i S_B \right) - c \right) + \zeta S + \xi S_M + \psi S_B \end{aligned}$$

Applying Kuhn Tucker's theorem and taking the first-order conditions, we have

$$\begin{aligned}
\frac{\partial L}{\partial S_M} &= -\sum_{\theta_i \in \{\theta_M,\theta_B\}} q_{\theta_i}\theta_i + \mu \sum_{\theta_i \in \{\theta_M,\theta_B\}} \Delta_{\theta_i}\theta_i + \xi = 0 \\
\frac{\partial L}{\partial S} &= -\sum_{\theta_i \in \{\theta_M,\theta_B\}} q_{\theta_i}(1-\theta_i) + \mu \sum_{\theta_i \in \{\theta_M,\theta_B\}} \Delta_{\theta_i}(1-\theta_i) + \zeta = 0 \\
\frac{\partial L}{\partial S_B} &= -\sum_{\theta_i \in \{\theta_M,\theta_B\}} q_{\theta_i}\theta_i + \mu \sum_{\theta_i \in \{\theta_M,\theta_B\}} \Delta_{\theta_i}\theta_i + \psi = 0.
\end{aligned}$$

where we have used that in all cases, we must have $\mu > 0$, and we have replaced

$$\sum_{\theta_i \in \{\theta_M,\theta_B\}} \Delta_{\theta_i}\left((1-q_j)\left(\theta_i S_M + (1-\theta_i) S\right) + q_j \theta_i S_B\right)$$

with c in the first line of (A.13). Just as in Proposition 2, we obtain that if $q_{\theta_G}\Delta_{\theta_M} < q_{\theta_M}\Delta_{\theta_G}$, it is optimal to set $S = 0$ and $(1-q_j) S_M + q_j S_B = \frac{c}{\sum_{\theta_i \in \{\theta_M,\theta_B\}} \Delta_{\theta_i}\theta_i}$. However, if $q_{\theta_G}\Delta_{\theta_M} > q_{\theta_M}\Delta_{\theta_G}$, we have $S_M = S_B = 0$ and $S = \frac{c}{(1-q_j)\sum_{\theta_i \in \{\theta_M,\theta_B\}} \Delta_{\theta_i}(1-\theta_i)}$. Thus, the maximum pledgeable income is

$$\Pi^{priv} = \begin{cases} PV^{priv} - \frac{\sum_{\theta_i \in \{\theta_M,\theta_B\}} q_{\theta_i}\theta_i}{\sum_{\theta_i \in \{\theta_M,\theta_B\}} \Delta_{\theta_i}\theta_i} c & \text{if } q_{\theta_G}\Delta_{\theta_M} \leq q_{\theta_M}\Delta_{\theta_G} \\ PV^{priv} - \frac{\sum_{\theta_i \in \{\theta_M,\theta_B\}} q_{\theta_i}(1-\theta_i)}{\sum_{\theta_i \in \{\theta_M,\theta_B\}} \Delta_{\theta_i}(1-\theta_i)} c & \text{if } q_{\theta_G}\Delta_{\theta_M} > q_{\theta_M}\Delta_{\theta_G} \end{cases}.$$

Comparing pledgeable incomes with public and private ownership. Comparing the maximum pledgeable income under public and private financing for firm i, we obtain that

$$\Pi^{pub} - \Pi^{priv} = \begin{cases} PV^{pub} - PV^{priv} - \frac{\theta_M}{\Delta_{\theta_G}} \frac{q_{\theta_G}\Delta_{\theta_M} - q_{\theta_M}\Delta_{\theta_G}}{\theta_G\Delta_{\theta_G} + \theta_M\Delta_{\theta_M}} > 0 & \text{if } q_{\theta_G}\Delta_{\theta_M} \leq q_{\theta_M}\Delta_{\theta_G} \\ PV^{pub} - PV^{priv} - \frac{1-\theta_M}{\Delta_{\theta_G}} \frac{q_{\theta_G}\Delta_{\theta_M} - q_{\theta_M}\Delta_{\theta_G}}{\Delta_{\theta_G}(1-\theta_G) + \Delta_{\theta_M}(1-\theta_M)} & \text{if } q_{\theta_G}\Delta_{\theta_M} > q_{\theta_M}\Delta_{\theta_G} \end{cases}$$

Observe that, if $q_{\theta_G}\Delta_{\theta_M} \leq q_{\theta_M}\Delta_{\theta_G}$, being public leads to a higher pledgeable income. However, if $q_{\theta_G}\Delta_{\theta_M} > q_{\theta_M}\Delta_{\theta_G}$, the agency costs under private ownership are lower, which could make private ownership preferable. Since it holds again that $\frac{\partial\left(\Pi^{pub} - \Pi^{priv}\right)}{\partial \Delta_{\theta_M}} < 0$, we obtain again that private ownership is preferable only if Δ_{θ_M} is above a threshold $\Delta_{\theta_M}^{**}$ (where $\Delta_{\theta_M}^{**} > \frac{q_{\theta_M}}{q_{\theta_G}}\Delta_{\theta_G}$), implicitly defined by $\Pi^{pub} = \Pi^{priv}$.

Finally, since

$$\frac{\partial\left(X_c'' - X_c'\right)}{\partial q_j} = -\frac{v_{pub} - x_{DD}}{\left(1-q_j\right)^2} < 0.$$

it holds that the distance between X_c'' and X_c' is decreasing in q_j. **Q.E.D.**

Proof of Proposition 4. Recall that, by Lemma 1, there can be no equilibrium in which a private firm truthfully reports zero cash flows. Thus, misreporting low cash flows, which is not detected with probability σ, must belong to the firms' equilibrium strategies. Clearly, a firm that deviates to stealing market share from the other firm will also misreport its (high) cash flows. Thus, strategies can only be conditioned on signals and not reports. Consider an equilibrium candidate in which firms cooperate in period t and cooperate in $t+1$ if their signals indicate that the other firm has cooperated in the preceding period. Let λ and $1-\lambda$ be the market shares of firm j and i respectively. The incentive constraint for the less-efficient firm j is

$$\begin{aligned}\widehat{v}_j^{pub} &= (1-\delta)\,\lambda\rho d\,(p-k_j)+\delta\,(\sigma+\rho-\sigma\rho)^2\,\widehat{v}_j^{pub}\\ &\geq (1-\delta)\,\rho d\,(p-k_j)+\delta\sigma^2\widehat{v}_j^{pub},\end{aligned}$$

requiring that $\delta \geq \delta_j^* \equiv \frac{1}{(\sigma+\rho-\sigma\rho)^2\frac{1}{1-\lambda}-\sigma^2\frac{\lambda}{1-\lambda}}$. For the more cost-efficient firm, abandoning cooperation means that it reduces prices and takes over the market. Thus, its incentive constraint is

$$\begin{aligned}\widehat{v}_i^{pub} &= (1-\delta)\,(1-\lambda)\,\rho d\,(p-k_i)+\\ &\quad\ \delta\left((\sigma+\rho-\sigma\rho)^2\,\widehat{v}_i^{pub}+\left(1-(\sigma+\rho-\sigma\rho)^2\right)\rho d\,(k_j-k_i)\right)\\ &\geq (1-\delta)\,\rho d\,(p-k_i)+\delta\left(\sigma^2\widehat{v}_i^{pub}+\left(1-\sigma^2\right)\rho d\,(k_j-k_i)\right),\end{aligned}$$

requiring in turn that $\delta \geq \delta_i^* \equiv \frac{1}{(\sigma+\rho-\sigma\rho)^2\frac{p-k_j}{\lambda(p-k_i)}-\sigma^2\frac{(1-\lambda)(p-k_i)-\left(k_j-k_i\right)}{\lambda(p-k_i)}}$. If the firms had equal market share, $\lambda=1/2$, we have that $\delta_i^* > \delta_j^*$, and the more cost-efficient firm would have stronger incentives to deviate. Countering these incentives requires that the more cost-efficient firm retains a higher market share. Cooperation is easiest to maintain when $\delta_i^* = \delta_j^*$, which is true for $\lambda = \frac{p-k_j}{2p-k_i-k_j} < \frac{1}{2}$. Stricter disclosure (lower σ) makes cooperation easier to maintain by reducing both δ_i^* and δ_j^*. **Q.E.D.**

Proof of Proposition 5. Let q_i be firm i's probability of investment success if it invests. Furthermore, let $\alpha_{i,t}$ be the probability that firm j assigns to firm i investing in period t. We show that the leakage of information can be profitable for firm i in for the special cases in which $q_i \to 1$ and, separately, when the probability that firm j's investment succeeds is perfectly correlated with firm i's probability of success.

If firm j has invested in period t, its decision to continue with the new technology after observing θ_j at the interim stage of that period is given by

$$\begin{aligned} & \alpha_{i,t}\left((1-q_i)\left(\theta_j\frac{x_M}{1-\delta}+(1-\theta_j)\,\mathrm{E}x\right)+q_i\theta_j\mathrm{E}x\right)+(1-\alpha_{i,t})\left(\theta_j\frac{x_M}{1-\delta}+(1-\theta_j)\,V_{f,j}\right) \\ \geq\ & L+\alpha_{i,t}\,(1-q_i)\,\mathrm{E}x+(1-\alpha_{i,t})\,V_{f,j} \end{aligned} \tag{A.14}$$

where $\mathrm{E}x = x_{DD} + \delta\frac{v^{pub}}{1-\delta}$ if one of the firms is private in t and $\mathrm{E}x = \frac{v^{pub}}{1-\delta}$ if both firms are public in t. $V_{f,j}$ is firm j's expected payoff if it attempts investing and fails. We do not derive this payoff explicitly, as we only need two properties. First, $\mathrm{E}x \geq V_{f,j}$, as firm j can be displaced by firm i in a later period. Second, $V_{j,f}$ decreases in the likelihood that firm i invests in displacing it in a later period.

Taking all terms to the left-hand side of expression (A.14) and taking the derivative with respect to $\alpha_{i,t}$, it holds

$$\begin{aligned} & \theta_j\left((1-q_i)\left(\frac{x_M}{1-\delta}-\mathrm{E}x\right)+q_i\mathrm{E}x\right)-\theta_j\left(\frac{x_M}{1-\delta}-V_{f,j}\right) \\ =\ & \theta_j\left(V_{f,j}-\mathrm{E}x-q_i\left(\frac{x_M}{1-\delta}-2\mathrm{E}x\right)\right). \end{aligned}$$

The last expression is negative if the monopoly profits are at least as high as the joint duopoly profits, i.e., $\frac{x_M}{1-\delta} \geq 2\mathrm{E}x$.[36] Hence, if firm i is public, so that firm j learns that firm i has also invested, firm j updates $\alpha_{i,t}$ to one. This makes it more likely that firm j abandons investment. If firm i's probability of success is one ($q_i = 1$), this is the only relevant effect of leaking information.

If firm i's probability of success is less than one and firm j has not invested in t, the leakage of information allows firm j to make a more-informed decision whether to invest and abandon investment in subsequent periods. Consider period $t+1$. If firm i's investment was successful, it takes over the market and the game ends. If firm i's investment was not successful, but the success probability of the two firms is perfectly correlated, firm j will also not succeed if it invests. Hence, it will not invest, and the two firms will cooperate in all remaining periods. Firm i is (weakly) better off, as firm j might have otherwise gone private to invest, leading to no cooperation in that period. **Q.E.D.**

[36] This condition is satisfied out in all standard models of competition such as Cournot and Bertrand.

Appendix B Information Disclosure and Markups

In this section, we show evidence supporting our theoretical prediction that stricter information disclosure requirements help public firms achieve higher profitability. We exploit the passage of two pieces of legislation that have a similar effect in terms of increasing disclosure requirements. The first is the American Inventor's Protection Act (AIPA) of 1999. Prior to the passage of the act, information about patents became available only after they were granted, which was on average more than two years following application. AIPA forced firms to make such information public after 18 months, even for patents that were not granted eventually. Affected were patent applications starting in November 2000. The key source of variation that we explore is that AIPA affected some industries more than others, as there is wide-ranging variation in the average time it took to approve patents in different industries in the pre-AIPA period. The idea is that industries with longer lags between patent application and grant date were more strongly affected by the passage of AIPA. This allows us to construct a continuous treatment variable that is defined as the average time from patent application to grant date for the industry. For a more detailed description of AIPA, we refer to Johnson and Popp (2003), Graham and Hedge (2015), and Saidi and Zaldokas (2020).[37]

The second piece of legislation that we exploit is the Food and Drug Administration Amendments Act (FDAAA), signed into law on September 27, 2007. This act required that the results of all clinical trials in Phase II or above of drug development be publicly reported (see Aghamolla and Thakor (2020) for a detailed description). For this second experiment, we define our treatment variable as a dummy taking the value of one if a firm is a pharmaceutical company (SIC code starting with 283).

We expect that the effect of AIPA and FDAAA is similar in that the reforms have made it easier for firms to engage in co-opetition. In particular, the public dissemination of proprietary information about innovation activities can help them avoid head-on competition by specializing in different areas and avoiding competition when no firm has a clear edge over its rival. Furthermore, this information has a public goods character that can benefit firms by making them more efficient in their own innovation activities and help them coordinate on common standards.[38] The effects should be particularly strong in firms whose products and services are similar to those of their peers.

[37] Pre-AIPA delay between patent application and grant date is uncorrelated with the number of patents filed in the respective industry and the industry's total factor productivity (Saidi and Zaldokas, 2020). This evidence reduces the likelihood that the pre-AIPA delay is correlated with other factors that could influence markups.

[38] It should further be mentioned that both AIPA and FDAAA apply equally to public and private firms. Thus, they make cooperation equilibria for both types of firms easier to maintain. Aghamolla and Thakor (2020) find that FDAA has lead to an increase in public listings.

INSERT TABLE 1

Results. To test for the hypothesis that the passage of the two legislations has led to an increase in markups of affected firms, we estimate the following difference-in-differences regression

$$\begin{aligned} markup_{it} &= \alpha + \beta_1 Post_t \times Treated_i + \beta_2 Post_t \times Treated_i \times Similarity_i \\ &\quad + \beta_3 Post_t \times Similarity_i + \gamma X_{i,t} + \nu_k + \nu_i + \mu_t + \varepsilon_{i,t} \end{aligned} \tag{B.1}$$

In equation (B.1), the treatment variable in the case of AIPA is the average time between the patent application and grant dates for the respective industry. In the case of FDAAA, the treatment variable is a dummy variable indicating whether the firm is a pharmaceutical company. Post is a dummy variable that takes the value of one in the three years following the passage of the respective act and zero in the three preceding years. For each legislation, we take a window of three years around the passage of each reform, but the results are robust to taking shorter and longer periods. *Similarity* is Hoberg and Phillips' (2016) total similarity score, which measures how similar a firm's products and services are to those of its peers. This score is from the year before the enactment of the respective legislation to avoid that the new laws might have affected that score. The main coefficients of interest are β_1 and β_2, which we expect to be positive. In particular, the enactment of stricter disclosure should lead to higher markups, and this effect should be stronger in firms whose products are more similar to those of their peers.

$X_{i,t}$ is a vector of firm-level control variables that includes size, defined as $\ln(sale)$, and sales, general and administrative costs scaled by sales. The regressions control for firm, year, and industry fixed effects. Standard errors are clustered at the firm level. Financial information comes from Compustat, and patent information from Kogan et al.'s (2017) patent database. markups are calculated using De Loecker et al.'s (2020) production approach as $\theta_{kt}\frac{sale_{it}}{cogs_{it}}$ where $sale_{it}$ and $cogs_{it}$ are firm-level sales and cost of goods sold, and θ_{kt} is the output elasticity of inputs measured at industry level made available by De Loecker et al. (2020).[39] As in De Loecker et al. (2020), we focus on markups, as this compares whether firms can sell at higher prices compared to their variable costs of production. The use of firm fixed effects should mitigate concerns that differences in markups may be driven by differences in fixed costs, as it is unlikely that the fixed costs of affected firms systematically change around the two reforms in a way that leads to higher markups.

In line with Implication 1, Table 1 shows that markups increase significantly following

[39] See pp. 570-572 in De Loecker et al. (2020) for details.

the enactment of both legislation. For example, the markups of pharma firms increased by 0.4, which is more than 20% of that variable's standard deviation. The statistical and economic effect of AIPA on markups is comparable. Consistent with the model, the effects are particularly strong in firms whose products and services are more similar to those of their peers. We run placebo tests by shifting the pre and post AIPA and FDAAA periods by three years in each direction, and we find no corresponding changes in markups.

Appendix C For Online Publication: Additional Results

Cooperation When Only One Firm Has the Option to Invest. We can proceed as in Propositions 1–3 to show that cooperation on the existing technology cannot be achieved with private ownership. It can be achieved with public ownership if the firms sufficiently value future cooperation, i.e., δ is sufficiently high. The critical threshold for δ is higher than in Section 3.2, as the firms expect that their rival may invest in the future and end cooperation. Recall that being public is optimal for the firms when they do not invest, as this gives them the option to cooperate. For the same reason, if a firm is not public when it raises financing, it is optimal to go public in the subsequent period if its investment fails or is abandoned.

To analyze firm i's decision to invest, we proceed as in Proposition 2 with few small modifications. The continuation rule (3) at the interim date of the period in which the firm invests becomes

$$\theta_i \left(\frac{x_M}{1-\delta} - V_f \right) \geq L,$$

where $V_f \in \left\{ V_f^{pub}, V_f^{priv} \right\}$ replaces Ex as firm i's expected payoff if it attempts investing but fails, in which case the two firms cooperate until firm j potentially takes over the market. Note that $V_f \leq \mathrm{E}x$ since firm i might be displaced by firm j in the future. Replacing Ex by V_f also in the investor's break-even condition, firm i's investment condition, which is the analogue to expression (5), becomes

$$V_{III} \equiv \sum_{\theta_i \in \{0, \theta_M, \theta_B\}} \pi_{\theta_i} \left(\left(\theta_i \frac{x_M}{1-\delta} + (1-\theta_i) V_f \right) \mathbf{1}_{\theta_i} + (L + V_f)(1 - \mathbf{1}_{\theta_i}) \right) - K \geq c + V_d. \tag{C.1}$$

In this expression V_d is the firm's expected payoff if it delays investment.[40] The owner-

[40] It is ambiguous whether V_d is larger than $\frac{v^{pub}}{1-\delta}$. We do not give the precise expressions for V_f and V_d, as they are not informative for the analysis.

manager's incentive constraint is again given by (6). Note that if condition (C.1) cannot be satisfied, delaying is optimal not only in period t but also in all subsequent periods until firm j obtains the option to invest (at which point Proposition 3 applies). Clearly, it is optimal to cooperate with firm j until that point. If condition (C.1) can be satisfied, then proceeding as in Proposition 1, it holds:

Proposition C.1 *Suppose that only firm i can make a disruptive investment in the current period, but firm j might also be able to invest in a future period. Being public makes it harder to raise financing and invest in disruption if the investment opportunities are intermediately attractive*

$$\frac{x_M}{1-\delta} \in \left(X'_e, X''_e\right), \ \textit{where} \ \begin{cases} X'_e \equiv & \frac{L}{\theta_M} + V_f^{priv} \\ X''_e \equiv & \frac{L}{\theta_M} + V_f^{pub} \end{cases} \tag{C.2}$$

and the agency problems are server: $\Delta_{\theta_M} > \Delta^{***}_{\theta_M}$ (where $\Delta^{***}_{\theta_M}$ is implicitly defined by the condition that the firm is indifferent between being public and private). The cooperation benefit of being public dominates in all other cases.

Finally, observe that $X''_e - X'_e = v^{pub} - x_{DD}$, which is the same as distance as between X'' and X' (Proposition 1) albeit the cutoff points are different.[41]

The Effects of Buying Equity Stakes. Suppose that firm j has an equity stake β in firm i. Since the firms do not observe each other's signals, the signal of firm i does not affect the continuation decision of firm j and vice versa. Hence, the firm j's continuation decision is unaffected by its stake in firm i. What differs for firm j is its incentive to undertake the investment in the first place. If firm i invests in period t, firm j also benefits from investing if

$$\begin{aligned} & \sum_{\theta_j \in \{0,\theta_M,\theta_G\}} \pi_{\theta_j} \left(\left((1-q_i) \left(\theta_j \frac{x_M}{1-\delta} + (1-\theta_j) \,\mathrm{E}x \right) + q_i \theta_j \mathrm{E}x \right) \left(1 - \mathbf{1}_{\theta_j}\right) \right. \\ & \left. + (1-q_i)\left(L + \mathrm{E}x\right) \mathbf{1}_{\theta j} \right) - K + \beta V_{II} \\ \geq \ & c + (1-q_j) \max \left(x_{a_j a_i} + \delta \left(V_I - c\right), \frac{v^{pub}}{1-\delta} \right) + \beta V_{III}, \end{aligned} \tag{C.3}$$

[41] Note that $V_f^{pub} - V_f^{priv} = v_{pub} - x_{DD}$, as the firm optimally goes public if the investment fails. Thus, the only difference between the two payoffs is in the expected cash flows in the investment period.

where the value of firm j depending on whether firm i invest is

$$\begin{aligned} V_{II} &\equiv \sum_{\theta_i\in\{0,\theta_M,\theta_G\}} \pi_{\theta_i} \left(\left((1-q_j) \left(\theta_i \frac{x_M}{1-\delta} + (1-\theta_i)\,\delta \frac{v^{pub}}{1-\delta} \right) + q_j \theta_i \mathrm{E}x \right) \mathbf{1}_{\theta_i} \right. \\ &\quad \left. + (1-q_j)\,(L+\mathrm{E}x)\,(1-\mathbf{1}_{\theta_i}) \right) - K \\ V_{III} &\equiv \sum_{\theta_i\in\{0,\theta_M,\theta_B\}} \pi_{\theta_i} \left(\left(\theta_i \frac{x_M}{1-\delta} + (1-\theta_i)\,V_f \right) \mathbf{1}_{\theta_i} + (L+V_f)\,(1-\mathbf{1}_{\theta_i}) \right) - K \end{aligned}$$

We have that $V_{III} > V_{II}$. To see this, not that V_f is firm i's expected payoff if it attempts investing and fails. In this case firm i cooperates with firm j until firm j possibly takes over the market in some future period. Hence, V_f is larger than $(1-q_j)\,\delta\frac{v^{pub}}{1-\delta}$ in V_{II}, as the risk of being overtaken tomorrow is better than a risk of being overtaken today, and the likelihood q_j that firm j continues the investment is (weakly) higher when both firms invest. Thus, we have $V_{III} > V_{II}$, and increasing β makes condition (C.3) more difficult to satisfy. **Q.E.D.**

Table 1: **Markups and Disclosure Requirements.** The dependent variable *Markup* is defined as the ratio of sales to cost of goods sold times the output elasticity of inputs measured at industry level, computed as in De Loecker et al. (2020). *Treatment* is defined at the three-digit industry level. In models (1)-(3), *Treatment* measures the mean difference in years between the filing date and the grant date, across all patents granted in the respective industry between 1996 and 2000. In models (4)-(6), *Treatment* is a dummy equal to one if the firm is a pharmaceutical company (SIC code starting with 283). *Post* is a dummy variable for the post-AIPA period from 2001 onwards and post FDAAA period from 2007 onward, respectively. *Similarity* is the Hoberg and Philips (2010) total similarity score measure in the year before the enactment of the respective legislation. *Ln*(*sale*) is the natural log of sales, adjusted to inflation (base year 1999); *SG&A*/*sale* are sales, general, and administrative costs over sales. Robust standard errors clustered at the firm level are in parentheses. *, **, and *** indicate that the coefficient is statistically significant at the 10%, 5%, and 1% level, respectively.

Panel A: Descriptive statistics	Markup	Ln(sale)	SG&A/sale	Filing to grant (years)	Pharma firm
Mean	1.845	4.806	0.797	2.190	0.060
Median	1.326	4.921	0.268	2.189	0.000
Sd	1.895	2.884	2.545	0.347	0.237
N	52643	51767	42081	58663	66016

Panel B: Regression results	AIPA of 1999			FDAAA of 2007		
	Markup			Markup		
	(1)	(2)	(3)	(4)	(5)	(6)
Post × Treatment	0.223***	0.230***	0.086**	0.418***	0.406***	-0.176
	(0.046)	(0.041)	(0.042)	(0.137)	(0.117)	(0.153)
Post × Treatment × Similarity			0.008***			0.069***
			(0.001)			(0.018)
Post × Similarity			-0.010***			-0.014***
			(0.002)			(0.001)
Ln(sale)	-0.024***	-0.001	-0.046	-0.024***	-0.015	0.029
	(0.007)	(0.023)	(0.030)	(0.009)	(0.030)	(0.043)
SG&A/sale	-0.015**	-0.027**	-0.062***	-0.009	-0.025*	0.029
	(0.007)	(0.011)	(0.018)	(0.009)	(0.013)	(0.027)
Year and industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	No	Yes	Yes	No	Yes	Yes
N	43,974	43,974	26,513	40,783	40,783	22,560
Adjusted R^2	0.137	0.007	0.025	0.157	0.009	0.071