Collusion with Public and Private Ownership and Innovation

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October 23, 2017

Abstract

We argue that public ownership gives firms the option to collude and engage in rent seeking on existing technologies. This option can enhance firm value. However, it also reduces the commitment to developing new technologies. We show that the option to collude is valuable when the expected profitability of innovation is either very low or very high. For intermediate values, private ownership dominates. By comparing antitrust lawsuits against firms that go public to firms that withdraw their IPO filings for arguably exogenous reasons, we offer evidence for our result that public firms are more likely to engage in collusion.

Keywords: public and private ownership, innovation, coordination, collusion.
JEL Classification: G31, G32, L41, O31

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1 Introduction

The demise of the public corporation has been widely trumpeted in the news and academic literature (Gao et al., 2013; Doidge et al., 2016). Fewer firms go public nowadays than they have done historically, and new firms delay longer their initial public offerings. One explanation that stands out is the plethora of regulation, information requirements, and public scrutiny faced by public firms, which could lead to leaking of valuable information to competitors (Bhattacharya and Ritter, 1984) or to pressures to focus on the current share price and behave myopically (Stein, 1989). Yet despite such arguments, public firms are profitable like never before, calling into question such concerns and gloomy projections.[1] If anything, the more relevant question seems to be why not more firms go public.

To add to the contradiction, the recent empirical literature has argued that private firms' innovation is more impactful (Bernstein, 2015). Such findings seem hard to reconcile with the fact that public firms, such as Amazon, Apple, and IBM, are at the forefront of innovation with the common belief that "Google is furthest along in quantum-computer technology and that Microsoft has the most comprehensive plan to make the software required."[2]

In this paper, we argue that a key argument in favor of public ownership is that the more transparent availability of information about a public firm's cash flows allows for better coordination or collusion among incumbents. Thus, new players go public when their technology is becoming a commodity and they seek collusion to maintain high margins.

The flipside of having the option to collude on existing technologies is that it could weaken incentives for innovation, as it makes it more difficult to commit not to abandon the development of a new technology in the face of early difficulties. This could lead to time-inconsistency problems not present under private ownership, and creates a trade-off between the option to collude and the ability to commit to long-term innovation. One of our main findings is that this trade-off leads to a U-shaped relation between the attractiveness of public ownership and the expected profitability of innovation, with private ownership dominating the middle ground—a finding that could shed light on the above contradictory evidence. By analyzing the role of controlling or non-controlling stakes as an alternative tool to achieve collusion, our model further shows that a decline in public ownership would go hand-in-hand with an increase in takeover activity, consistent with recent findings (Doidge et al., 2016).

[1] See "Larry Summers: Corporate profits are near record highs. Here's why that's a problem," Washington Post, March 30, 2016.

[2] The Economist, Technology Quarterly, March 9, 2017.

To address these issues, we develop a model in which two firms, an innovative player ('the innovator') and an incumbent, operate in the same market. Our model has two main elements. First, in the initial period of the model, the innovator can start exploring a new technology, which requires hiring an R&D team that needs to be motivated to exert unobservable effort. At an interim date of that period, the innovator obtains a signal indicating the new technology's profitability. At this point, exploration can be abandoned and the innovator can adopt the incumbent's technology. However, if the new technology is not abandoned and is successful, the innovator gets high returns. The second main element of our model is that, when both firms use the same technology, they might engage in tacit collusion. What stands in the way of such collusion, however, is that each firm faces a type of prisoner's dilemma: Coordination over two periods is beneficial, but firms might have incentives to deviate since such deviations might be difficult to detect. This is because firms use their cash flows to draw signals about each other's actions, and these inferences are imperfect.

Our first main result is that public ownership helps in sustaining collusion when both firms use the same technology. The key difference between public and private ownership that we model is that the cash flows of public firms are observable to all, while those of private firms are not. This lack of transparency under private ownership has two implications. First, the firms draw noisier signals about each other's actions, making a breakdown in collusion due to wrong inferences more likely. Second, the threat to punish deviations might not be credible under private ownership, as firms have incentives to disregard their signals. This insight builds on Bhaskar and van Damme (2001). The intuition is that in a conjectured equilibrium in which firms are supposed to collude, a signal that the other firm has not colluded can only be wrong. Thus, if the firm observing such a signal is private (and, thus, the signal it infers from its cash flows is private), it has incentives to disregard its signal, as it expects that the other firm will most likely collude next period. However, without a credible punishment, a collusion equilibrium cannot be sustained. All of this changes under public ownership, as cash flows are then mutually observable, implying that firms observe each other's inferences. Thus, if one firm (correctly or not) infers that the other has not colluded, this becomes common knowledge. Neglecting one's signal is now never optimal, as firms do not have to guess what the other firm will do. They know that a punishment to a non-colluding equilibrium should follow, making it, indeed, mutually optimal to stop colluding. Thus, punishments are credible and a collusion equilibrium can be sustained.

Our second main result is that securing the ability to collude might not be beneficial if the firm pursues innovation. The option to collude on a high-margin existing technology makes it more likely that the innovator abandons the development of the new technology in the face of a discouraging signal. This could lead to a time-inconsistency problem: abandonment becomes too likely, making it very expensive to motivate the R&D team to exert effort. Thus, public ownership leads to a trade-off between a higher cost of motivating effort and having a better abandonment option.

Which of these two effects dominates depends on the new technology's expected profitability. We show that, if that profitability is low, the innovator is better off under public ownership. In this case, the option to abandon the new technology in case of early difficulties and collude on the existing one is more valuable than the ability to motivate the R&D team at a lower cost. Things change if the new technology's expected profitability becomes sufficiently high. Then, the option to collude on the existing technology associated with public ownership becomes less important and what starts to matter more is the higher cost of motivating the R&D team. However, if the new technology's expected profitability is so high that also the incumbent decides to pursue it, such highly-profitable innovation opportunities are best developed in public firms. In this case, the incumbent and the innovator can substantially benefit from colluding on the new technology if both firms successfully develop it. This leads to a U-shaped relation between the attractiveness of public ownership and the new technology's expected profitability.

We extend the model along several dimensions. First, we analyze equity stakes as alternative ways to achieve collusion and discuss their impact on innovation incentives compared to public ownership depending on whether they are controlling or non-controlling. Second, we analyze the effect of the relative size of the incumbent and innovator and show that a small innovator's ability to chip away market share from large incumbents without triggering a response could reduce its innovation incentives. Third, we show that voluntary reporting by private firms does not help much in terms of achieving collusion, as absent exogenous strict reporting requirements, the private firm will have ex post incentives to add noise to its report, making collusion ultimately unsustainable.

Our paper offers a number of novel empirical implications that build on the idea that collusion is easier to achieve in public firms. Since this result underpins our analysis, we provide strong empirical support for it by comparing the propensity of public and private firms to be engaged in antitrust lawsuits. Specifically, following Bernstein (2015), we collect a sample of firms that file for an IPO and compare those that complete their IPOs with those that subsequently withdraw their filings due arguably exogenous reasons (instrumented with negative NASDAQ fluctuations in the two months after the filing). This experiment explicitly seeks to deal with the endogeneity of the going public decision. We find that the likelihood that a firm that completes its IPO is involved in an antitrust case in the four years after the filing is ten percentage points higher compared to firms withdrawing their IPOs. Since over 90% of the antitrust cases in our sample are brought by directly affected private parties (rather than the DOJ, FTC, or state attorney generals) that arguably do not need to rely on the defendants' financial reporting to feel the harm of antitrust behavior, this evidence lends support to our result that public ownership facilitates collusion.

The question when firms prefer public and when private ownership has a long history in the finance literature. Our main contribution is to address this question from a novel angle by building on insights from the game theoretic literature that more transparency among competitors allows to support collusion (Green and Porter, 1984; Bhaskar and Van Damme, 2001). Indeed, the higher transparency in public firms is one of the text-book differences between public and private ownership, but the implications for collusion and how that affects innovation incentives in public and private firms have not been thoroughly explored in prior work. The corporate finance view seems to be that the higher transparency associated with public ownership is the cost that an innovative firm needs to pay for gaining access to cheaper financing (Bhattacharya and Ritter, 1984; Maksimovic and Pichler, 2001). The cheaper access to capital can help the firm invest in more innovation, especially if the firm gains access to investors who have more aligned beliefs with those of the firms' managers (Allen and Gale, 1999). The empirical evidence is supportive of such theories. Acharya and Xu (2016) find that public firms in external finance dependent industries spend more on innovation and have a better innovation profile than private firms, while the same is not true for internal finance dependent industries. We depart from this discussion, as financial constraints do not feature in our model. Furthermore, our notion of transparency relates to whether cash flows of public firms are publicly observable, and not whether sensitive information becomes available to competitors.

One of the advantages of private ownership in our model is that it features more tolerance for failure, in the sense of a lower likelihood of abandoning innovation after a discouraging signal. Specifically, the inability to commit to a new technology gives rise to time inconsistency problems, which might be exacerbated under public ownership. These insights differentiate our work from Ferreira et al. (2014) who argue that the lack of transparency with private financing could facilitate exit by early investors. In their model, the lack of transparency associated with private ownership prevents outside investors from inferring whether the true reason for exit is an illiquidity shock or that the firm's innovation has failed—somewhat reminiscent of Grossman and Stiglitz (1980). This makes early private investors more tolerant for failure in the sense that they are more likely to invest in risky innovations in the first place. There are no time inconsistency problems in Ferreira et al. (2014). Another key difference is that private ownership in their paper always dominates when exploring new ideas. By contrast, we show that, new ideas are better explored under public ownership if they are expected to be either very profitable or only sightly profitable. Private ownership dominates only for intermediate values for the new technology's profitability. Furthermore, we discuss the effect of equity stakes and the relative sizes of the firms involved for the ability to collude and how that affects innovation and the public-private choice. These different perspectives generate an interesting contrast in empirical predictions.

The U-shaped relationship between the attractiveness of public ownership and the new technology's profitability is also the main difference to the managerial myopia literature (Stein, 1989) in which public ownership creates time inconsistency due to a manager's focus on the current stock price. In our model, the reason for time inconsistency is that the firm undermines ex ante innovation incentives when it can fluently respond to interim signals on the new technology; this becomes particularly acute when it can collude on the existing technology, and thus faces an attractive exit option. A further difference is that in our model the ability to collude under public ownership is also valuable when firms compete to develop the new technology, as then they could collude not to eat into its other's profits if equally successful.

Our analysis relates also to the vast industrial organization literature analyzing whether market concentration is good for innovation. The conceptual difference in our paper is that we are not interested in the effect of competition on innovation per se,[3] but in the endogenous interaction between the choice of public and private ownership, buying equity stakes, and collusion and innovation incentives.[4] In particular, we argue that the firm's ownership structure determines whether or not its cash flows are observable to a competitor, which is of importance for collusion and innovation incentives. We show that such interactions could help explain stylized facts, such as why the recent decrease in public ownership coincides with increased takeover activity (Doidge et al., 2016).

Our paper continues as follows. Section 2 describes the baseline model. Sections 3–5 contain our main results, extensions, and empirical implications, and Section 6 concludes.

[3] The question whether competition is good for innovation goes back to Schumpeter (1934, 1942). Key factors are whether innovation focuses on processes that would have a similar advantage to all firms (Arrow, 1962) or products that could allow some firms to price discriminate (Greenstein and Ramey, 1998); the extent of competition before or after innovation (Dasgupta and Stiglitz, 1980); the dynamics of R&D (Harris and Vickers, 1985); and whether innovation is preemptive (Gilbert and Newbery, 1982). Another key question is whether patenting is good for innovation (Kultti et al., 2007). See Gilbert (2006) for an extensive literature review.

[4] Prior work shows that cross-ownership could reduce the need to compete (Reynolds and Snapp, 1986), may reduce innovation incentives (Matthews, 2006), or make collusion more difficult (Malueg, 1992).

All proofs are in the Appendix.

2 Model

There are two firms, an innovator and an incumbent, operating in a two-period economy with three dates, $t = 0$, $t = 1$, and $t = 2$. Both firms are risk neutral and there is no discounting.

The technologies At $t = 0$, the innovator has access to two technologies—an innovative (new) technology and an incumbent (old) technology. Neither technology requires an initial investment, but the innovator has the capacity to choose only one. The new technology is risky. It is viable and returns positive cash flows with probability θ and is unviable, returning 0, with probability $1 - \theta$. This probability is unknown at date $t = 0$ when the technology choice is made. It is only commonly known that it can take on three values $\theta \in \{0, \theta_B, \theta_G\}$ where the ex ante probabilities of θ_B and θ_G are p_B and p_G, respectively, and where $0 < \theta_B < \theta_G$. At the interim date $t = 0.5$, an observable but not verifiable signal is realized that shows the value of θ. At this point in time, if the innovator has started the new technology, it can abandon it and switch to the incumbent technology. In either case, the first-period cash flows are realized only at the end of the period.

If the innovator decides to start the new technology, it needs to hire an R&D team. If the R&D team exerts effort, it can increase the likelihood of θ_B and θ_G to $p_B + \tau_B$ and $p_G + \tau_G$, respectively. However, the R&D team's effort is not verifiable, and by shirking (which leaves the probabilities of θ_B and θ_G unchanged at p_B and p_G), the R&D team can save a non-monetary cost c. We assume that the decision whether or not to abandon the new technology at $t = 1$ lies with the innovator, and not the R&D team.[5]

Unlike the innovator, the incumbent firm operates for sure the incumbent technology in period one. It can additionally try to develop the new technology itself, but this would require hiring the necessary R&D talent to generate the ideas behind the new technology. For our purposes, it is sufficient to assume that this is associated with a deadweight cost of k, and a likelihood of ρ that the new technology is successful. Regardless of who develops the new technology, it replaces the incumbent technology in period two if it is successfully developed.

If only one of the two parties successfully develops the new technology, it enjoys first-mover cash flows of x_{FM} for periods one and two, while the other firm's cash flows are

[5] This emerges naturally if the realization of θ is the innovator's private information.

zero in both periods. If none of the firms is successful in developing the new technology, and the innovator has pursued it until the end of period one, the incumbent reaps the monopoly profits x_M from the incumbent technology, while the innovator gets zero in both periods. If the new technology is abandoned or never undertaken in period one, both firms use the incumbent technology. If both firms use the same technology (either the new or the old one), collusion might come into play. Figure 1 summarizes the sequence of events.

Coordination Problem if Both Firms Use the Same Technology How does collusion work? In each period when using the same technology both firms decide whether to collude (action C) or not collude (action NC). The action affects the firms' cash flows, which are stochastic and realized at the end of the respective period. If both firms collude in a given period, their expected cash flows when utilizing the preferred (and available) technology in that period are x_C for each. If neither firm colludes, their expected cash flows are $x_{NC} < x_C$. If one of the firms colludes, while the other does not, the former firm's expected cash flow is $x_C - m$, while the latter firm's expected cash flow is bx_{NC}, with $m > 0$ and $b > 1$. Intuitively, one can think of this case as one firm setting high prices, while the other firm undercutting it and stealing market share.

A feature of the model is that in a one-shot game (single period) both firms face a prisoner's dilemma, making collusion over one period impossible. However, collusion is potentially possible in a two period setting. To facilitate this, we assume that firms face a (one-time) cost K the first time they seek collusion, but no such cost in the following period. We now let $x_C - K < bx_{NC}$. This means that in a one-period setting the prisoner's dilemma is acute: anticipating collusion by the other firm, makes choosing no collusion optimal. However, if collusion is chosen nonetheless, colluding again in the following period yields $x_C > bx_{NC}$. Assuming in addition that $(x_C - K) + x_C > bx_{NC} + x_{NC}$ makes collusion over two periods potentially worth it. Summarizing:

Assumption 1: $2x_C - (bx_C + x_{NC}) > K > x_C - bx_{NC} \geq 0$.

These conditions are necessary (but not sufficient) that collusion is sustainable at least under some circumstances in a multi-period setting.[6] A final condition we need is that collusion (e.g., setting high prices) cannot be optimal for a firm if the other firm does not collude (sets lower prices). In that case not colluding (also setting lower prices) makes the firm better off:

Assumption 2: $x_C - m < x_{NC}$.

For simplicity, the expected cash flows x_C and x_{NC} (and the parameters m and b) are

[6] In the infinite horizon extension of this model, K can be set to zero and the second inequality is not necessary.

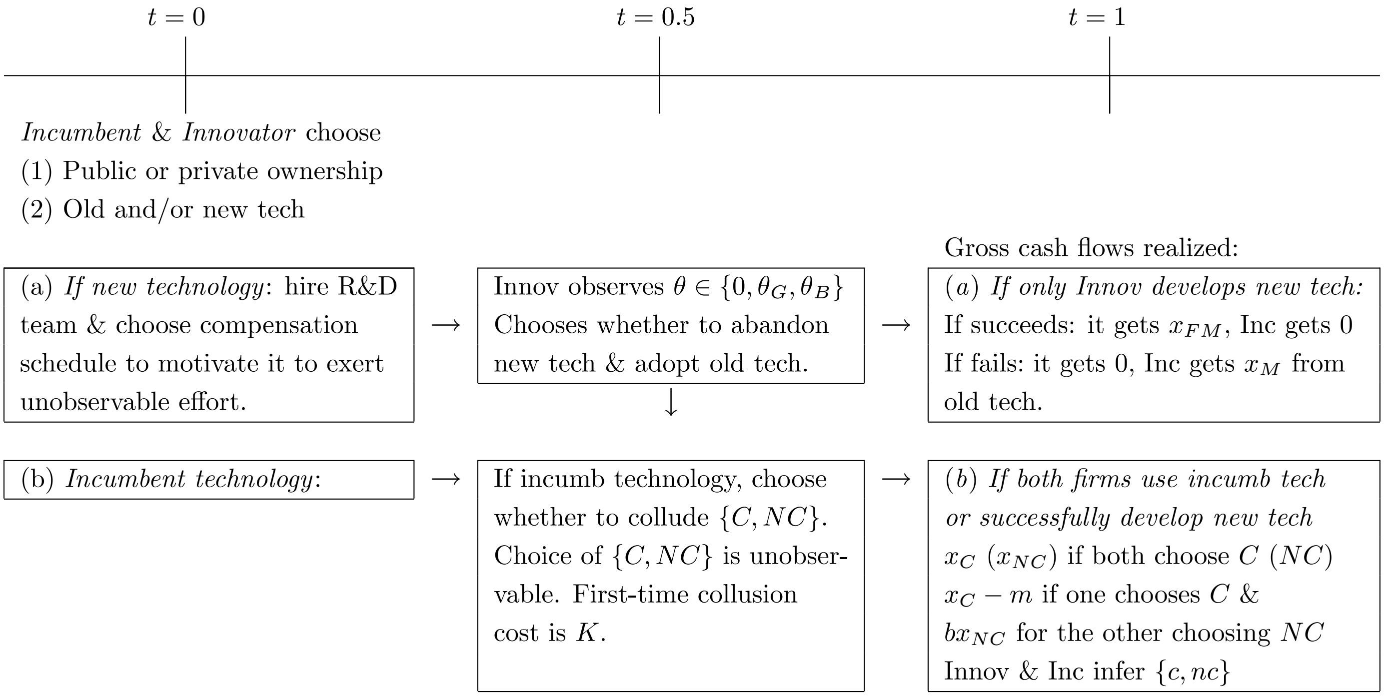

Figure 1: **Timeline of first period.**

initially the same for both firms. In practice, they might differ depending on the firms' size and first-mover status. Where relevant, we will discuss the consequences of relaxing this and allow for different sizes between the innovator and the incumbent.

Information Structure and Public vs. Private Ownership We assume that direct collusion between the firms is not feasible or (legally) possible. Actions are not observable, but at the end of every period, each firm observes its own cash flows, from which it extracts a signal $s = \{c, nc\}$ about whether or not the other firm has colluded. Since cash flows are stochastic (x_C and x_{NC} are the *expected* values), the signal is noisy, and the inference is correct only with probability $1 - \varepsilon$.[7]

A critical difference between private and public ownership is that a public firm's cash flows are observable to the other firm. This implies that: (i) The signal a public firm extracts from its cash flows is observable to the other firm; (ii) The inference error ε (weakly) decreases, since the signal is based on *both* firms' cash flows. The decision whether the firm should be public or private is made at the beginning of the first period ($t = 0$). In Section 4.3, we extend the model to allow a private firm to engage in voluntary reporting.

[7] At the expense of introducing additional notation, we could derive ε from primitivies using Bayes rule. However, this is not necessary for our purposes.

3 The Choice Between Public and Private Ownership

There are three main choices in this model: (i) whether firms that use the same technology will collude, (ii) whether the innovator abandons the new technology at $t = 0.5$ and (iii) whether the innovator is better off innovating under public or private ownership.

In what follows, we show that public ownership facilitates collusion on the incumbent technology. This could lead to a time inconsistency problem in which the innovator responds too aggressively (from an ex ante perspective) to unfavorable intermediate signals on the viability of the new technology, i.e., abandons it too often. We proceed as follows. First, we explain how collusion works and how it depends on being public or private. Subsequently, we focus on the time inconsistency problem and analyze when public or private ownership is preferred.

3.1 Public Ownership as a Coordination Mechanism

We start by analyzing the first choice. Both firms' cash flows are higher if they manage to collude. However, colluding only in one period is not feasible. If one firm intends to collude, it is optimal for the other not to do so, as its expected cash flow from not colluding, bx_{NC}, is higher than that from colluding, $x_C - K$.

The key insight in what follows is that collusion can be sustained if both firms use the same technology for two periods, but this crucially depends on whether the firms choose public or private ownership. The choice of ownership affects two ingredients. First, it affects the inference error on whether the other firm has colluded in the preceding period. Second, it affects what a firm learns about the other firm's signal.

Consider the following equilibrium candidate under private ownership: Both firms collude in period one, and collude in period two if and only if they infer from their cash flows that the other firm has colluded as well (i.e., their signals are c).

Private ownership hampers collusion for two reasons. First, by increasing the inference error ε, it makes it less likely that collusion in period two can be sustained. For collusion in period two following signal c to be preferable to not colluding, it must hold

$$(1-\varepsilon)\, x_C + \varepsilon\, (x_C - m) > (1-\varepsilon)\, bx_{NC} + \varepsilon x_{NC}. \tag{1}$$

This expression takes into account that even if a firm colludes in period one, the other firm infers signal nc with probability ε, which prompts that firm not to collude in period two. Such punishment reduces the expected payoff from colluding in both periods.[8]

The second reason is that a private firm that has colluded in period one has incentives to collude also in the second period *regardless* of the signal it infers about the other firm's actions. This creates incentives for the other firm not to collude in both periods, making it impossible to sustain a collusion equilibrium.

To see why a private firm that has colluded in the first period might ignore its signal and collude also in period two, consider the case of independent signals. Since both firms are supposed to collude in period one, they attribute signal nc to the inference error ε, as non-collusion is an out-of-equilibrium (i.e., zero probability) event. In particular, if a private firm colludes in period one, it expects that the other firm receives signal c with probability $1-\varepsilon$ and, thus, colludes also in period two with such probability. Hence, regardless of its signal, the private firm's expected payoffs from colluding and not colluding in period two are the same as on the left- and right-hand side of expression (1), respectively. Hence, if the firm colludes after inferring c, it has the same incentive to collude after inferring nc. Thus, it is individually optimal not to go through with the threat of not colluding in that period. This is true for any inference error $\varepsilon > 0$.

This problem could be ameliorated if both firms' signals are dependent and if that dependence implies that the *conditional* likelihood $\widetilde{\varepsilon}$ after observing nc that also the other firm has inferred nc is higher than after signal c (in this case the inference error ε in (1) differs depending on whether the firm infers c or nc). Then, if $\widetilde{\varepsilon}$ is sufficiently high, the expected payoff from not colluding in period two becomes higher than that from colluding (as $x_C - m < x_{NC}$). Thus, not colluding following signal nc becomes a credible threat.[9]

Public ownership circumvents the above two problems, as it makes both firms' signals mutually observable. Thus, the equilibrium candidate can be amended as: collude in the first period, and collude in the second period if and only if both firms observe signal c. In this case, if a firm observes signal nc, this becomes common knowledge and the expectation that it will not collude in period two makes it, indeed, a mutual best response not collude in that period. The opposite holds if both firms observe signal c.[10] What further simplifies collusion is that the inference errors decrease, making the expected payoff from colluding

[8] To get the expected payoff from coordinating in period two, add x_C to the left-hand side of (1). To get the deviation payoff from not coordinating twice, add bx_{NC} to the right-hand side of (1).

[9] In practice, dependence could arise if both firms experience an unobservable common demand shock. Signal correlation could artificially arise also if firms play mixed strategies (Bhaskar and Van Damme, 2001).

[10] Observe that signal dependence is irrelevant for this argument. Furthermore, note that since signals are imperfect, equilibrium "price wars" occur despite the fact that both firms coordinate. However, this threat is needed to discipline both firms to start coordinating in the first place.

in both periods

$$x_C - K + (1 - \varepsilon)(1 - \varepsilon) x_C + (2\varepsilon - 1) x_{NC},$$

more likely to be higher than that from deviating and not colluding in both periods

$$bx_{NC} + (1 - \varepsilon) \varepsilon bx_{NC} + \left(1 - \varepsilon + \varepsilon^2\right) x_{NC}.$$

Proposition 1 ***(Public ownership as a collusion mechanism):*** *(i) Public ownership facilitates collusion. (ii) Coordination cannot be achieved under private ownership if the firms' signals are independent. Coordination under private ownership is feasible only if signals are sufficiently correlated (i.e., one firm observing signal nc goes hand-in-hand with a higher likelihood that the other firm also observes nc), and the inference errors are sufficiently small.*

Corollary 1 *Firms go public if they are ready to join the incumbents and collude with them on a commoditized technology. Alternatively, firms go public if their own technology is becoming commoditized and they seek collusion on it.*

To avoid trivial cases, we assume in what follows that collusion is always achieved under public, but never under private ownership. Formally, this would be the case if $\varepsilon = 0$ under public ownership and if the signals are not (very) interdependent.

3.2 Private Ownership and Overcoming Time Inconsistency

Given the easier collusion and higher profits with public ownership, one might wonder why not all firms go public in our model. Our answer is that collusion might undermine innovation incentives. Choosing private ownership might then become a commitment mechanism. To make the point, suppose for now that only the innovator can develop the new technology (i.e., the incumbent's success likelihood is $\rho = 0$).

The problem is that if the innovator receives signal θ_B about the new technology, it might be tempted to respond aggressively by dropping the innovative technology and adopting the incumbent firm's technology. This temptation is especially strong with public ownership, as then both firms can collude and obtain high profits from the existing technology.

Though the option of early termination might be valuable ex post, it could reduce the R&D team's incentives to exert effort ex ante. Let $\mathbf{w} = \{w_0, w_A, w\}$ be the contract the innovator offers the R&D team, which pays w_0 in case of zero cash flows, w_A in case the new technology is abandoned, and w in case the new technology is successful and yields positive cash flows. Note that the R&D team's wage can only be contingent on what is verifiable, i.e., the innovator's decision to continue or abandon the new technology and the subsequent cash flows. Since the innovator is protected by limited liability, we can set $w_0 = 0$. In case the contract is renegotiated at $t = 0.5$, we denote the R&D team's bargaining power with γ.

The R&D team's incentive constraint is

$$U(\mathbf{w},\tau) - c \geq U(\mathbf{w},0), \tag{2}$$

where $U(\mathbf{w},\tau)$ denotes the R&D team's expected payoff if it exerts effort, and $U(\mathbf{w},0)$ is its expected payoff if it exerts no effort. Since, by optimality for the innovator, (2) will be satisfied with equality and the R&D team's outside option is zero, $U(\mathbf{w},0)$ represents the R&D team's agency rent. It is straightforward to show that it is optimal to pay the R&D team only if the new technology is continued (i.e., $w_A = 0$).

The tension between ex post optimality and ex ante incentives arises because the abandonment of the new technology in case of unfavorable θ realizations has two effects. One is the standard positive disciplining effect of not getting paid ($w_A = 0$) if the new technology is abandoned. The strength of this effect increases in the impact of effort (τ_G) on the likelihood of landing in state θ_G. However, the second effect is negative. In particular, exerting effort increases also the likelihood of state θ_B by τ_B. Since this effort is wasted in case the new technology is abandoned in state θ_B, such abandonment makes it more difficult to satisfy the R&D team's incentive constraint. This negative effect dominates if τ_B is sufficiently large (formally, if $\tau_B > \tau_G \frac{p_B}{p_G}$). Then, the better abandonment option in $t = 0.5$ under public ownership makes it more expensive to motivate the R&D team compared to private ownership.

The key insight is that the resulting time inconsistency problem of not being able to commit not to abandon the new technology in case of state θ_B could make private ownership preferable. This occurs if the ex ante expected profitability of the new technology is sufficiently high (i.e., p_G is high), as then then the innovator needs to pay the R&D team a higher wage (if $\tau_B > \tau_G \frac{p_B}{p_G}$), while benefiting less from the better collusion possibilities of public ownership in states $\theta = \{0, \theta_B\}$.

Proposition 2 ***(Time inconsistency and private ownership):*** *The inability to commit not to abandon the new technology in case of signal θ_B gives rise to a time inconsistency problem. At $t = 0$, such commitment would decrease the cost of hiring the R&D team, but sticking to this commitment at $t = 0.5$ might be infeasible if the innovator observes θ_B. (ii)*

There is a threshold for $\widehat{p}_G$, such that the innovator prefers private ownership if $p_G > \widehat{p}_G$, and public ownership otherwise.

The second part of Proposition 2 states that, despite making it easier to overcome the time-inconsistency problem, private ownership is preferable only if the new technology is sufficiently attractive. This is because, if abandonment is very likely, the option to collude becomes more valuable. Clearly, if the innovator does not even initiate the new technology's development, public ownership is always preferable.

3.3 Competition for Innovation and the Public-Private Choice

Consider now the possibility that the incumbent also develops the new technology. The incumbent firm would do that if its success likelihood ρ is sufficiently high to compensate it for its investment costs k (we endogenize this decision in Section 4.2). Note that in this case, the incumbent firm would not abandon the new technology at $t = 0.5$, as it does not face the innovator's trade off between developing the new or adopting the old technology.

Competition on the new technology has two key effects. First, if both firms successfully develop the new technology, they can benefit from colluding not to compete away each other's profits. Thus, collusion can have a positive effect on innovation, as it increases the reward in case of success. This effect becomes increasingly valuable for the innovator, the more likely it is that both firms successfully develop the new technology (i.e., if both p_G and ρ are high).

Second, competition makes it less likely that the innovator abandons thew new technology at $t = 0.5$, as it will make zero profit from the incumbent technology if the incumbent develops the new technology. If the incumbent's success likelihood ρ is sufficiently high, this effect could make the innovator's continuation decision under both public and private ownership the same. Specifically, if ρ is high, the collusion prospects are not sufficiently likely to warrant abandonment in states θ_B and θ_G under both ownership types. But when the continuation decision under both ownership types is the same, the cost of hiring and motivating an R&D team is the same, making the collusion benefits of public ownership more beneficial.

Proposition 3 ***(Competition for innovation)*** *Suppose that both firms compete to develop the new technology. (i) An advantage of public over private ownership is that both firms can collude in case they both successfully develop the new technology. This advantage can dominate the effects in Proposition 2 if p_G and ρ are high. (ii) There is a threshold*

$\widehat{\rho}$, such that the innovator does not abandon the new technology in states θ_B and θ_G under both ownership types, making public ownership preferable for $\rho > \widehat{\rho}$.

Since in practice, ρ and p_G are likely to be correlated, assume for simplicity that $\rho = p_B\theta_B + p_G\theta_G + \delta$ (where δ could be positive or negative). Summarizing the results from this section, we obtain a U-shaped relationship between the attractiveness of innovation and that of public ownership:

Corollary 2 *The innovator's choice between public and private ownership is U-shaped in the new technology's profitability. If that profitability is:*
(i) low, it is optimal to choose public ownership;
(ii) medium, it is optimal to choose private ownership;
(iii) high, it is optimal to choose public ownership.

4 Equity Stakes, Size, and Voluntary Reporting

A common practice of incumbents is to buy equity stakes in growth firms or acquire such firms. In what follows, we turn to the question whether such stakes can act as a substitute to public ownership of the growth firm for achieving collusion. We then extend our model to analyze the effect of size on collusion and innovation incentives.

4.1 Coordination Through Equity Stakes

Suppose that the incumbent buys a non-controlling stake β in the innovator, which gives him a proportional right to the firm's cash flows, but otherwise no control rights. A rationale for buying a non-controlling stake is that it could allow the incumbent to observe the innovator's cash flows, even if the innovator is private. Following the same arguments as in Proposition 1, this would imply that collusion can be achieved on the existing (incumbent) technology provided that the incumbent is public and, thus, its cash flows can be observed by the innovator.

Both public ownership and buying a non-controlling equity stake discourage innovation by allowing for collusion on the incumbent technology. However, buying an equity stake has a further negative effect on the incumbent's innovation incentives. Specifically, if the innovator engages in the new technology, the incumbent benefits from it via its non-controlling equity stake which lowers its own incentives to innovate. This negative effect is stronger, the bigger the incumbent's stake.

If the incumbent buys a controlling stake, however, collusion issues are no longer present. This leads to a natural specialization in which the incumbent firm's incentives to innovate are even lower, while those of the innovator are higher compared to when the firms operate independently. The incumbent has now the option to adopt the new technology, even without developing it itself, as long as the innovator is successful. This further decreases its own incentives to develop it. However, absent collusion issues, the two firms will not compete away the first-mover profits on the new technology. What is more, since the opportunity cost of abandoning the new technology in order to collude on the existing one is no longer present, the innovator can keep developing the new technology even after receiving signal θ_B. The latter two effects increase the likelihood that the innovator develops the new technology.

Proposition 4 *(i) Buying a non-controlling equity stake in the innovator can help achieve collusion on the existing technology, but it reduces the incumbent's innovation incentives. (ii) Buying a controlling equity stake further reduces the incumbent's innovation incentives, but it increases the likelihood that the innovator develops the new technology.*

Overall, the main insight from this section is that buying equity stakes can help achieve collusion, but affects innovation incentives, as such collusion via public ownership or equity stakes are not perfect substitutes. Nevertheless, one would expect that imposing additional (e.g., regulatory) costs on public ownership would make collusion through equity stakes more likely.

Corollary 3 *An increase in the cost of public ownership increases the likelihood that collusion is achieved through controlling or non-controlling equity stakes.*

4.2 Size, Innovation, and Coordination

In this section, we extend our baseline model by introducing a date $t = -1$ at which the innovator can choose to operate at larger scale at no additional cost. Let φ be the scaling parameter, which increases expected profits to φx_{NC}, φx_C, and φx_{FM}. Since such scaling up does not affect the relative attractiveness of colluding versus not colluding, what is more important is how it affects the incumbent's profits. We assume that in case of non-collusion, the incumbent's profits fall by φm. Specifically, for the incumbent's cash flows, we assume that $x_C - \varphi m < x_{NC} < x_C - m$. That is, Assumption 2 is satisfied if the innovator is large, but not if it is small.

If Assumption 2 does not hold and the innovator adopts the incumbent's technology, the incumbent chooses the colluding action regardless of the action taken by the innovator.

Intuitively, the incumbent would not bother to respond to a player who can steal only a small market share. Thus, the innovator can free ride and choose non-collusion while expecting that the collusion action will be a dominant strategy for the incumbent. This makes abandoning the new technology and adopting that of the incumbent more attractive at $t = 0.5$ compared to when the innovator is large. This has several implications.

First, the innovator's choice between collusion and no collusion is the same under public and private ownership. Second, because the incumbent does not engage in price wars with the innovator, the innovator's incentives to abandon the new technology and adopt that of the incumbent are at least as high as those under public ownership in Proposition 1. Hence, its incentives to innovate are lower than those of the innovator, described in Section 3.2.

Proposition 5 *(i) If the innovator remains small, the incumbent takes action C regardless of the innovator's action. In this case, the innovator is more likely to abandon the new technology and is indifferent between public or private ownership. (ii) The innovator is better off remaining small if the impact of size on the incumbent's payoff, φm, is low relative to b or if the incumbent is not public or does not buy an equity stake in the innovator.*

An important consequence of Proposition 5 is that without the option to collude, the innovator might strategically decide to remain small to stay "under the radar screen" and avoid responses by the incumbent. To illustrate this, note that if the new technology's attractiveness is low (i.e., p_G is low), so that the new technology is abandoned in both cases, the cost of motivating the R&D team is the same. However, being small allows the innovator to steal market share from the incumbent technology, which could be more profitable than collusion. What is important, is that this might be preferable also for the incumbent. The latter can influence the innovator's size decision by choosing private ownership or not buying a stake in the innovator, since this precludes collusion opportunities even when the innovator is large.

4.3 Private Ownership and Voluntary Reporting

We have assumed so far that a firm can make its signal $s \in \{c, nc\}$ public under public, but not under private ownership. However, one could argue that also a private firm could voluntarily report its cash flows. The key difference is that regulation governing public firms has explicit requirements regarding the type and quality of information that needs to be published. No such regulation applies to private firms, and when reporting requirements exist, the required quality is much coarser than that for public firms. In what follows we analyze the consequences for collusion when both firms operate the same technology. Without loss for the qualitative results, we assume that one of the firms is public, while the other private. We continue to assume that a firm's signal is public information under public ownership. However, we now also allow the private firm to reports its cash flows, but (facing laxer regulation), the private firm can choose to communicate its report with noise $\eta \in [0, \overline{\eta}]$, such that its true signal s is interpreted as $s' \neq s$ with probability η. The upper bound $\overline{\eta} < 1$ captures the private firm's discretion of communicating less precise information. In what follows, we maintain Assumption 2.

Consider the same candidate equilibrium as in Section 3.1 according to which each firm colludes in period one, and colludes again in period two if and only if it infers signal c following period one and infers from the information reported by the other firm that it has also observed c. Suppose that both firms follow the proposed equilibrium strategies of colluding in the first period, and suppose that at the end of that period the public firm infers c (which becomes then common knowledge). If the private firm infers signal nc from its cash flows, we know from Section 3.1 that it has incentives to neglect this negative signal and collude again. Consider, therefore, the consequences of adding noise η to the private firm's report: With probability η, the public firm infers c and colludes, and with with probability $1 - \eta$, it infers nc and does not collude. Hence, the private firm's payoff from colluding in period two is $\eta x_C + (1 - \eta)(x_C - m)$, while from not colluding $\eta b x_{NC} + (1 - \eta) x_{NC}$. Two insights follow immediately. First, in both cases the private firm's period-two payoffs increase from adding noise to its report. Thus, without the ability to commit not to add noise, the private firm will choose the ex post maximum level $\overline{\eta}$. Second, comparing the two payoffs, colluding in period two is ex post beneficial if

$$\eta > \eta^* \equiv \frac{x_{NC} - (x_C - m)}{x_C - b x_{NC} - (x_{NC} - (x_C - m))} \tag{3}$$

Hence if $\overline{\eta} > \eta^*$, the private firm will choose to collude also in the second period following But then, going back to period one, we have again the problem that, expecting this behavior, the public firm will not start colluding. Thus, collusion cannot be sustained.

Even if (3) is not satisfied ($\overline{\eta} < \eta^*$), the private firm's ex post incentive to add the maximum level of noise to its report reduces the public firm's payoffs from following the proposed equilibrium strategy in period one relative to one in which it does not collude in both periods. Thus, overall, we continue to obtain that private ownership reduces the likelihood of collusion even when voluntary reporting is possible.

Corollary 4 *With voluntary disclosure in the case of private ownership, though, ex ante, the private firm would like to commit not to add noise to its report, ex post, it adds the maximum amount of noise. This lack of commitment problem reduces the opportunities for collusion.*

5 Empirical Implications and Evidence

First, we discuss the implications of our model related to collusion on existing technologies. Subsequently, we discuss the model's predictions concerning the choice between public, private, and shared ownership and its effect on innovation. Since our model is built around the result that public firms are more likely to collude, we provide empirical evidence for this result in Section 5.2.

5.1 Empirical Implications

The question why private firms choose to go public is long-standing in the finance literature. Key reasons that have been given include improving diversification opportunities and liquidity, raising capital for investment, exploiting favorable market conditions, facilitating acquisitions, and making the firm more visible (Ritter and Welch, 2002). We add one more reason to this discussion, which is surprisingly neglected in prior work: facilitating collusion.

Implication 1 *Public firms are more likely to be able to collude than private firms. Hence, profits of public firm are higher than they should be under head-to-head competition.*

By endogenizing the choice of public ownership, our paper shows that firms choose public ownership if they fear that head-to-head competition will erode their future profits. Thus, despite evidence that profits decline after firms go public (Pastor et al., 2009), we argue that these profits are higher than would have been the case in a competitive market. Indeed, high profit margins in the tech, biotech and pharma industries, as well as in traditional, cartel-prone industries, such as rail and air travel are hard to square with a competitive market and have recently gained considerable media attention.[11] In the next section, we find strong empirical support for Implication 1.

Recent advances in information technology have made it possible that private firms communicate valuable information about themselves to outsiders even without public own-

[11] See Larry Summer's article cited in footnote 1.

ership. As highlighted by Corollary 4, this could allow even private firms to achieve collusion. With the advance of new technologies, such as the blockchain, that further improve the verifiability of information, we expect such development to become even stronger in the future. This could have a negative impact on competition.

Implication 2 *Advances in information technology that ease the (credible) dissemination of information would help collusion even under private ownership and would allow also private firms to retain high margins without going public.*

An open question in recent empirical work is what could explain the declining popularity of public ownership in the U.S. (Gao et al., 2013). It seems that information disclosure requirements and compliance costs play an important role. However, it has been argued that such increases alone cannot explain the decline of public ownership, which seems to be compounded by an increase in merger and acquisition activity (Doidge et al., 2016). Our paper suggests that these phenomena could be related, as acquiring equity stakes could substitute for public ownership in achieving collusion. Thus, when the cost of public ownership increases, firms are more likely to seek collusion over such equity stakes (Corollary 3).

Implication 3 *An increase in the cost of public ownership will lead incumbent public firms to acquire private innovators (or public firms considering going private) or take equity stakes in such firms.*

Collusion can be achieved also through non-controlling equity stakes (Proposition 3). However, such collusion is not a substitute for public ownership, as it has additional negative effects on innovation. Furthermore, it is typically infeasible for small firms to buy stakes in much larger firms (Allen and Phillips, 2000). In such cases, collusion will only be achieved if the large firm is public. Thus, strategically buying non-controlling stakes in small innovators is more likely to emerge when public equity markets are more developed. This is consistent with the evidence that Corporate Venture Capital (CVC), which specializes in taking strategic minority stakes in innovators, is better developed in such markets, but is not associated with stronger competition in such markets (Dushnitsky, 2006).

Implication 4 *Well-developed public equity markets increase the likelihood of collusion, as collusion through non-controlling equity stakes is not a perfect substitute for public ownership.*

In a recent paper Azar et al. (2016) find that financial investors, such as BlackRock, who own stakes in competing firms could contribute to softer competition among these firms. The paper's motivation is based on the argument that if the same investor owns 50% of two firms, the management of either firm will take both firms' profits equally into account in their optimization decisions. Implication 4 cautions against drawing stark regulatory implications based on such findings, as public ownership alone could also act as a collusion mechanism.

Our second set of implications investigates how collusion and the choice between public and private ownership interacts with innovation incentives. Our first key insight is that private ownership could help overcome the time-inconsistency problem that a firm would like to commit to pursuing the development of a new technology. Specifically, it avoids the temptation of abandoning development in case of early difficulties in favor of colluding on a profitable existing technology (Proposition 1). There is more tolerance for failure also if the incumbent buys the innovator, as then the incumbent operates the existing technology anyhow, so it faces no temptation to abandon the development of the new one.

Implication 5 *If an innovator seeks to develop a new technology (and faces no competition on this from the incumbent), private ownership makes it more tolerant for failure, in the sense that it is less likely to abandon the new technology in the face of early difficulties.*

However, a higher tolerance for failure is not necessarily in the best interest of the innovator. First, if the new technology is not expected to be very profitable, the innovator might prefer to have the option to collude and choose public ownership (Corollary 2). This hurts innovation, but benefits the firm at the expense of consumers. Second, private ownership might even be bad for innovation if the innovator faces competition on innovation from the incumbent. In this case, the opportunity to collude not to compete away each others' profits in case both firms succeed in the new technology, spurs innovation incentives.

Implication 6 *Public ownership dominates private ownership (i) if the expected profitability is low, so that the value of the option to fall back on high-margin existing technology is high; or (ii) if the expected profitability is high, so that the innovator could benefit from colluding with the incumbents on the existing technology. For intermediate values, private ownership is more beneficial, as it helps to deal with the time inconsistency problem of not being able to commit not to prematurely abandon the new technology's development.*

Implication 6 could help understand why private firms are not always champions in innovation, despite the prediction of prior theory (Ferreira et al., 2012) and the evidence of some empirical settings (Bernstein, 2015). Indeed, many public firms, such as Apple, Google, and Tesla, are paramount examples of innovation. We predict that private ownership will be unambiguously better for innovation only in the case of new technologies that do not appear sufficiently interesting to incumbents to warrant investments in technologies that cannibalize their existing business. However, as we show in Proposition 4:

Implication 7 *If both an innovator and an incumbent seek to develop new technologies, public ownership could sharpen the incentives to innovate.*

Finally, based on Proposition 5, we have the following prediction about how the firm's size interacts with collusion and its innovation incentives:

Implication 8 *(i) Large private firms could be more tolerant to early discouraging news compared to small private firms, as for large firms adopting the incumbent's technology is more likely to trigger a price war. (ii) Innovators might have incentives to remain small, but this is bad for their innovation incentives.*

5.2 Evidence: Collusion in Public and Private Firms

Estimating the effects of going public on the propensity to be involved in collusion is challenging due to the inherent endogeneity of the going public decision. To tackle the latter problem, we follow Bernstein (2015) and construct a sample of firms that file an initial registration statement with the SEC (Form S-1). We then compare firms that go through with their IPO to firms that withdraw their IPO filing (by submitting Form RW), where we instrument IPO withdrawal with the NASDAQ two-months ahead return following the IPO filing. The idea is that negative fluctuations in NASDAQ in the two months following the filing could drive firms to withdraw their filings for reasons that are orthogonal for how firms' fundamentals predispose them to innovate or collude.

5.2.1 Data

We first collect U.S. IPO filings and withdrawals from Thomson One's New Issues database from 1985 until 2017. As it is standard, we exclude financial firms (SIC codes 6000-6999), unit offers, closed-end funds, American depositary receipts, limited partnerships, special acquisition vehicles, and spin-offs. Financial information comes from Compustat, Thomson One, and from the S-1 filing forms. We have such data for approximately 70% of the firms.[12]

[12] We thank Tolga Caskurlu for providing us with the financials of firms that withdraw their IPOs, which was manually extracted from the S-1 filigns.

INSERT TABLE I

To proxy for collusion, we collect all U.S. lawsuits with a key nature related to antitrust or anticompetitive behavior from Thomson Reuters' Westlaw database for the period 1990-2017.[13] We then manually match the defendants in these lawsuits to our IPO filings sample. To allow for a four-year post-filing window, we restrict attention to IPOs between 1994–2013. In this period we have 4762 IPO filings, 22% of which were withdrawn. We have matched 308 of the filing firms to antitrust cases between 1990–2017. More than 90% of the cases were brought by private parties, such as businesses or individuals (rather than the FTC, DOJ or state attorney generals) seeking damages or court orders preventing anticompetitive conduct. This is important, as affected parties are unlikely to need the defendants' financial statements to feel the harm of anticompetitive behavior; and such statements can anyway be required by the court during the case proceedings.[14]

Table I offers further summary statistics comparing the firms going through with their IPOs and those withdrawing their filings within four years of their S-1 filing. The two groups are similar in terms of size and sales, but those that withdraw are slightly less profitable. The key notable difference is that the likelihood of being involved in an antitrust lawsuit in the four years surrounding the filing is insignificantly different before and after the filing for firms that withdraw, but increases threefold for firms that proceed with the IPO. Furthermore, firms that withdraw are much more likely to have experienced negative NASDAQ fluctuations in the two months after the filing (while such fluctuations before the filing are insignificantly different).

5.2.2 Empirical Strategy

Comparing the propensity to be involved in an antitrust lawsuit for firms that proceed with their IPO to those that withdraw their filing has the advantage that it allows for a comparison of firms in similar stages in their lifecycle. The baseline specification is

$$Y_i^{post} = \alpha_1 + \beta_1 IPO_i + \gamma_1 Y_i^{pre} + \delta_1 X_i' + \nu_k + \mu_t + \varepsilon_{i1}, \tag{4}$$

where Y_i^{post} and Y_i^{pre} are binary variables taking the value of one if the firm is involved in an antitrust lawsuit in the four years after and before the IPO filing, respectively; IPO_i is the variable of interest, indicating whether the firm goes through with its IPO. If

[13] The coverage of this database for lawsuits prior to 1990 is sparse.

[14] An antitrust claimant must demonstrate antitrust injury, i.e., harm to competition (not just harm unique to the claimant) and antitrust standing, i.e., that the claimant's injury is "inextricably intertwined" with the alleged conduct.

public ownership has an effect on collusion, β_1 should be positive and significantly different from zero. We include industry fixed effects at the two digit SIC level, IPO filing year fixed effects, and control variables X that account for size (*Log total assets*, adjusted to inflation), revenues (*Sales/assets*), and profitability (*Net income/assets*).

Since the decision to withdraw an IPO can be related to unobserved factors related to collusion, the estimation of β_1 in (4) may be biased. Thus, we adopt Bernstein's (2015) instrument for the IPO completion choice using $NASDAQ$ as an instrument defined as the two months return of the NASDAQ since the start of the book-building phase. We then estimate the following first-stage regression

$$IPO_i = \alpha_2 + \beta_2 NASDAQ_i + \gamma_2 Y_i^{pre} + \delta_2 X_i' + \nu_k + \mu_t + \varepsilon_{i2}. \tag{5}$$

The second stage is then

$$Y_i^{post} = \alpha_3 + \beta_3 \widehat{IPO}_i + \gamma_3 Y_i^{pre} + \delta_3 X_i' + \nu_k + \mu_t + \varepsilon_{i3}, \tag{6}$$

where $\widehat{IPO}$ are the predicted values from (5). If $NASDAQ$ is a valid instrument, β_3 captures the causal effect of an IPO on the propensity of being involved in an antitrust lawsuit.

Finally, to account for the fact that IPO is a binary variable, we follow the three-stage procedure outlined in Wooldridge (2002, p. 623, procedure 18.1). In the first stage, we estimate a probit of the determinants that an IPO proceeds in analogy to (4). In the second stage, we regress IPO on the fitted values from the first stage, Y_i^{pre}, and X. In the third stage, we regress Y_i^{post} on the fitted values from the second stage, Y_i^{pre}, and X.[15]

5.2.3 Results

Columns (1) and (2) of Table II show the estimates of an OLS and a probit model of the determinants that an IPO proceeds. These regressions serve as the first stages in model (5) and the three-stage procedure outlined, above respectively. The results show that fluctuations in the NASDAQ in the two moths after the IPO filing strongly affect the likelihood of withdrawal. Moreover, Table III in the Appendix shows that $NASDAQ$ is likely to be uncorrelated with the residuals in equation (4), implying that the exclusion restriction is also likely to be satisfied. Hence, as in Bernstein (2015), $NASDAQ$ appears to be a valid instrument for the likelihood that the IPO is completed.

INSERT TABLE II

[15] For an explanation of the procedure, see also Adams et al. (2009).

Column (3) of Table II presents the estimates of the potentially endogenous OLS model (4) and shows that there is a positive association between firms that proceed with their IPO and the likelihood of an antitrust lawsuit following the IPO filing. Column (4) shows a positive correlation between $NASDAQ$ and being involved in an antitrust lawsuit, arguably through the impact of the instrument on whether or not the IPO proceeds.

Our main novel empirical finding is contained in columns (5) and (6) that present the results of the 2SLS estimation and the subsequently outlined three-stage procedure. The results show a strong impact of the instrumented IPO variable on the likelihood of an antitrust lawsuit. The coefficients state that the likelihood of being involved in an antitrust lawsuit increases by about 10%, which is not only statistically, but also economically significant given that the unconditional likelihood of such a lawsuit for firms that withdraw their IPOs is 1%. It is interesting to note that the coefficient estimates imply that the simple OLS result in column (3) underestimate the probability of a lawsuit. In unreported regressions, we show that all these results are robust to considering antitrust lawsuits in the three and five year windows around the IPO filing.

Overall, our empirical findings give strong support to Implication 1 that public ownership helps to facilitate collusion.

6 Conclusion

We develop a model in which firms choose public over private ownership when they want to tacitly collude on a technology to retain high margins. Though neither public nor private ownership confers direct insights into a firm's actions, under public ownership firms' cash flows are public information, and signals inferred from these cash flows are informative and common knowledge. This makes punishments for deviations a credible threat and facilitates tacit collusion. Thus, firms will choose public ownership when their technology is becoming commoditized and they seek to retain high profits.

Not all firms benefit from public ownership, however. Being able to collude on an existing technology is a double-edge sword if an innovator seeks to develop a new technology, as then the temptation to abandon its development in case of early difficulties is high. In such cases, firms could be faced with a time inconsistency problem, and private ownership might be better. It helps to commit to the long-term pursuit of innovation and improves incentives.

Taking these results as a starting point, we derive a number of novel implications about a firm's choice between public and private ownership. We find that there is a U-shaped relationship between the new technology's expected profitability and the attractiveness of public ownership. If the profitability is low, the option to collude on the incumbent's technology is very valuable, and public ownership dominates. However, if the new technology's expected profitability is higher, being able to commit not to abandon it in the face of early difficulties becomes more valuable. In this case, private ownership dominates. However, if the new technology is sufficiently profitable that it is never abandoned, public ownership dominates again. This is particularly true if the incumbent could also attempt to develop the new technology, as then being able to collude in case both firms are successful becomes important.

Our analysis highlights also three further aspects. First, though collusion can also be achieved through equity stakes, such type of collusion is not a substitute to public ownership, as it can have additional positive or negative effects on innovation incentives. Second, size matters too. Since large incumbents would not bother to respond to small rivals, small innovators will tend to abandon the development of new technologies faster even under private ownership, as they can free ride on the high margins of the incumbent technology. This could create incentives to remain small to avoid the need to collude. Third, collusion would be difficult to achieve through voluntary reporting, as firms would have ex post incentives to add noise to their reports.

Since the result that public ownership facilitates collusion is key for our analysis, we offer empirical support for this result by explicitly taking into account the endogeneity of the going public decision. Comparing firms that complete with firms that withdraw their IPO filings (for arguably exogenous reasons) we show that firms that proceed with their IPOs are 10 percentage points more like to be involved in an antitrust lawsuit in the four years following their IPO. Given that over 90% of these lawsuits are brought by affected private parties (that do not need to rely on public firms' reporting to realize that they are affected by anticompetitive behavior), these findings offer support for our insight that public ownership facilitates collusion.

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Appendix

Proof of Proposition 2. Define y_C to be the innovator's two-period payoff when both firms use the incumbent technology and collude, and let y_{NC} be expected payoff when they do not collude. There is a trade-off between public and private ownership when the continuation decision differs for $\theta = \theta_B$. Suppose, therefore, that $\theta_G x_{FM} > y_C > \theta_B x_{FM} > y_{NC}$ (note that there can be no single-period collusion on the new technology in period two). We treat the remaining cases at the end of the proof. In what follows, we consider in turn public (collusion) and private (non-collusion) ownership. Observe that, since θ is not contractible, whenever the new technology is abandoned, the R&D team must receive the same wage, independent of θ.

Public ownership and collusion at $t = 0.5$. The innovator takes the ex post efficient decision to abandon the new technology and collude with the incumbent after observing θ_B if $y_C - w_A > \theta_B (x_{FM} - w)$. Since $\theta_B x_{FM} < y_C$, a sufficient condition is that $\theta_B w \geq w_A$. Suppose for now that this is satisfied (below we show that it is, as $w_A = 0$). The innovator maximizes[16]

$$\begin{aligned}&(1 - p_B - \tau_B - p_G - \tau_G)(y_C - w_A) + (p_B + \tau_B)(y_C - w_A)\\&+ (p_G + \tau_G)\theta_G (x_{FM} - w)\end{aligned}$$

subject to the R&D team's incentive constraint

$$-(\tau_G + \tau_B) w_A + \tau_B w_A + \tau_G \theta_G w \geq c. \tag{7}$$

It is optimal to set $w_A = 0$, implying that $\theta_G w = \frac{c}{\tau_G}$. Hence, the innovator's expected payoff is

$$(1 - p_B - \tau_B - p_G - \tau_G) y_C + (p_B + \tau_B) y_C + (p_G + \tau_G)\theta_G x_{FM} - \frac{(p_G + \tau_G)}{\tau_G} c. \tag{8}$$

Private ownership and non-collusion at $t = 0.5$. The innovator takes the ex post efficient decision to continue the new technology after observing θ_B if $y_{NC} - w_A < \theta_B (x_{FM} - w)$. This requires that $\theta_B x_{FM} - y_{NC} > \theta_B w - w_A$. Suppose for now that this is satisfied (below we check when this is the case). The R&D team's incentive constraint is

$$-(\tau_G + \tau_B) w_A + (\tau_B \theta_B + \tau_G \theta_G) w \geq c. \tag{9}$$

[16] Note that it is without loss that the R&D team is paid only in period one.

It is optimal to set $w_A = 0$, implying that $w = \frac{c}{\tau_G \theta_G + \tau_B \theta_B}$, and the innovator's expected payoff is

$$\begin{aligned} & (1 - p_B - \tau_B - p_G - \tau_G)\, y_{NC} + (p_B + \tau_B)\, \theta_B x_{FM} \\ & + (p_G + \tau_G)\, \theta_G x_{FM} - \frac{(p_G + \tau_G)\, \theta_G + (p_B + \tau_B)\, \theta_B}{\tau_G \theta_G + \tau_B \theta_B} c. \end{aligned} \tag{10}$$

Recall that continuation after observing θ_B requires

$$\theta_B x_{FM} - y_{NC} > \theta_B w = \frac{\theta_B c}{\tau_G \theta_G + \tau_B \theta_B} \tag{11}$$

(i.e., y_{NC} is sufficiently low). Suppose that the inequality in (11) is not satisfied. Then the innovator does not have the right incentives at $t = 0.5$ to take the efficient continuation decision. This creates scope for renegotiations, in which the R&D team extracts γ of the additionally generated surplus. Denoting the R&D team's payoff in that case with w_R, we have

$$w_R = w_A + \gamma(\theta_B x_{FM} - y_{NC}).$$

Hence, at the contracting stage $t = 0$, the R&D team's incentive constraint is

$$-\,(\tau_G + \tau_B)\, w_A + \tau_B\, (w_A + \gamma\, (\theta_B x_{FM} - y_{NC})) + \tau_G \theta_G w \geq c. \tag{12}$$

It is optimal to set $w_A = 0$ and $w = \frac{c - \tau_B \gamma (\theta_B x_{FM} - y_{NC})}{\tau_G \theta_G}$.[17] The innovator's expected payoff is

$$\begin{aligned} & (1 - p_B - \tau_B - p_G - \tau_G)\, y_{NC} + (p_B + \tau_B)\, (\theta_B x_{FM} - \gamma\, (\theta_B x_{FM} - y_{NC})) \\ & + (p_G + \tau_G) \left(\theta_G x_{FM} - \theta_G \frac{c - \tau_B \gamma\, (\theta_B x_{FM} - y_{NC})}{\tau_G \theta_G} \right) \\ = \; & (1 - p_B - \tau_B - p_G - \tau_G)\, y_{NC} + (p_B + \tau_B)\, \theta_B x_{FM} \\ & + (p_G + \tau_G)\, \theta_G x_{FM} + \gamma\, (\theta_B x_{FM} - y_{NC}) \left(\frac{\tau_B}{\tau_G} p_G - p_B \right) - \frac{(p_G + \tau_G)}{\tau_G} c. \end{aligned} \tag{13}$$

Subtracting now the innovator's payoff under non-collusion from that under collusion,

---

[17] Note that $\theta_B x_{FM} - \theta_B w$ is indeed negative (and renegotiations in $t = 0.5$ are needed) as

$$\begin{aligned} \theta_B x_{FM} - y_{NC} - \theta_B \frac{c - \gamma \tau_B\, (\theta_B x_{FM} - y_{NC})}{\tau \theta_G} \quad & = \quad \frac{1}{\theta_G} \left((\theta_B x - y_{NC}) - \frac{\theta_B c}{\tau_G \theta_G + \theta_B \tau_B \gamma} \right) \\ & \leq \quad \frac{1}{\theta_G} \left((\theta_B x - y_{NC}) - \frac{\theta_B c}{\tau_G \theta_G + \theta_B \tau_B} \right) < 0. \end{aligned}$$

we obtain

$$(1-p_B-\tau_B-p_G-\tau_G)(y_C-y_{NC})+(p_B+\tau_B)(y_C-\theta_B x_{FM})-c\theta_B\frac{\frac{\tau_B}{\tau_G}p_G-p_B}{\tau_G\theta_G+\tau_B\theta_B} \quad (14)$$

if there are no renegotiations under non-collusion, and

$$(1-p_B-\tau_B-p_G-\tau_G)(y_C-y_{NC})+(p_B+\tau_B)(y_C-\theta_B x_{FM})-\gamma(\theta_B x_{FM}-y_{NC})\left(\frac{\tau_B}{\tau_G}p_G-p_B\right) \quad (15)$$

if there are renegotiations. Hence, as long as $\frac{\tau_B}{\tau_G}p_G > p_B$, the R&D team's compensation is lower under non-collusion than under collusion, regardless of whether or not (11) is satisfied. Furthermore, both (14) and (15) decrease in p_B, p_G, and $\frac{\tau_B}{\tau_G}$. In particular, there is a threshold $\widehat{p}_G$, such that non-collusion is better for the innovator for all $p_G > \widehat{p}_G$. This threshold decreases (i.e., non-collusion is more attractive) in $\frac{\tau_B}{\tau_G}$, p_B, and x_{FM}.

Finally, note that if $\theta_B x_{FM} > y_C$, the continuation decision is the same under public and private ownership, and public ownership dominates. If $y_C > \theta_G x_{FM} > y_{NC}$, public ownership dominates again, but the innovation is never undertaken under public ownership. **Q.E.D.**

Proof of Proposition 3. Observe, first, that the innovator's gross expected payoff is x_{FM} if only it successfully develops the new technology, 0 if it is unsuccessful in developing the new technology, and $y_O = 2x_O$, if both firms successfully develop the new technology, where $O \in \{C, NC\}$ stands for whether or not the two firms collude. At $t = 0.5$, it is optimal to abandon the new technology if $(1-\rho)\theta x_{FM}+\rho\theta y_O < (1-\rho)y_O$ or equivalently if

$$\theta x_{FM}+\frac{\rho}{1-\rho}\theta y_O < y_O. \quad (16)$$

Hence, the abandonment threshold is higher than without competition. In particular, since $\frac{\rho}{1-\rho}$ increases in ρ, abandonment is never optimal if ρ is sufficiently high. (In this case, private ownership would have no advantage, and public ownership would be always preferable.)

In what follows, we consider the case in which for θ_B, condition (16) holds for y_C, but not for y_{NC}, such that abandonment in state θ_B is optimal under public, but not under private ownership (in all other cases, public ownership dominates). We denote with w_{comp} the R&D team's wage in case both firms successfully develop the new technology.

Public ownership and collusion at $t = 0.5$. The R&D team's incentive constraint is

$$-\left(\tau_B+\tau_G\right)w_A+\tau_B w_A+\tau_G\left(\left(1-\rho\right)\theta_G w+\rho\theta_G w_{comp}\right)\geq c$$

It is optimal to set $w_A = 0$, implying that $\theta_G\left(1-\rho\right)w+\rho w_{comp} = \frac{c}{\tau_G}$. Hence, the innovator's expected payoff is

$$\begin{aligned}&\left(1-p_B-\tau_B-p_G-\tau_G\right)\left(1-\rho\right)y_C+\left(p_B+\tau_B\right)\left(1-\rho\right)y_C\\&+\left(p_G+\tau_G\right)\left(\left(1-\rho\right)\theta_G x_{FM}+\rho\theta_G y_{NC}\right)-\frac{\left(p_G+\tau_G\right)}{\tau_G}c.\end{aligned}$$

Private ownership and non-collusion at $t = 0.5$. Suppose, first, that the innovator takes the ex post efficient continuation decision without renegotiations (below we check when this is the case). The R&D team's incentive constraint is

$$-\left(\tau_G+\tau_B\right)\left(1-\rho\right)w_A+\left(\tau_G\theta_G+\tau_B\theta_B\right)\left(\left(1-\rho\right)w+\rho w_{comp}\right)\geq c$$

It is optimal to set $w_A = 0$, implying that $\left(1-\rho\right)w+\rho w_{comp} = \frac{c}{\tau_G\theta_G+\tau_B\theta_B}$, and the innovator's expected payoff is

$$\begin{aligned}&\left(1-p_B-\tau_B-p_G-\tau_G\right)\left(1-\rho\right)y_C+\left(p_B+\tau_B\right)\left(\left(1-\rho\right)\theta_B x_{FM}+\rho\theta_B y_{NC}\right)\\&+\left(p_G+\tau_G\right)\left(\left(1-\rho\right)\theta_G x_{FM}+\rho\theta_G y_{NC}\right)-\frac{\left(\left(p_G+\tau_G\right)\theta_G+\left(p_B+\tau_B\right)\theta_B\right)}{\tau_G\theta_G+\tau_B\theta_B}c.\end{aligned}$$

Recall that continuation after observing θ_B requires that

$$\left(1-\rho\right)\theta_B x_{FM}+\rho\theta_B y_{NC}-\left(1-\rho\right)y_{NC}>\frac{\theta_B c}{\tau_G\theta_G+\tau_B\theta_B}. \tag{17}$$

Suppose that the inequality in (17) is not satisfied. Then the innovator does not have the right incentives at $t = 0.5$ to take the efficient decision to continue. This creates scope for renegotiations, in which the R&D team extracts γ of the additionally generated surplus $w_R := w_A+\gamma\left(\left(1-\rho\right)\theta_B x_{FM}+\rho\theta_B y_{NC}-\left(1-\rho\right)y_{NC}\right)$. Hence, at the contracting stage $t = 0$, the R&D team's incentive constraint is

$$-\left(\tau_G+\tau_B\right)\left(1-\rho\right)w_A+\tau_B w_R+\tau_G\left(\left(1-\rho\right)\theta_G w+\rho\theta_G w_{comp}\right)\geq c$$

Hence, it is optimal to set $w_A = 0$ and $\left(1-\rho\right)w+\rho w_{comp} = \frac{c-\tau_B w_R}{\tau_G\theta_G}$.[18] The innovator's

[18] It is straightforward to verify that for this wage, there are, indeed, renegotiations at $t = 0.5$.

expected payoff is

$$
\begin{aligned}
&(1-p_B-\tau_B-p_G-\tau_G)(1-\rho)\,y_C+(p_B+\tau_B)\left((1-\rho)\,\theta_B x_{FM}+\rho\theta_B y_{NC}\right)\\
&+(p_G+\tau_G)\left((1-\rho)\,\theta_G x_{FM}+\rho\theta_G y_{NC}\right)+\left(\frac{\tau_B}{\tau_G}p_G-p_B\right)w_R-\frac{(p_G+\tau_G)}{\tau_G\theta_G}c
\end{aligned}
$$

Subtracting the innovator's payoff under non-collusion from that under collusion, we obtain

$$
\begin{aligned}
&(1-p_B-\tau_B-p_G-\tau_G)(1-\rho)(y_C-y_{NC})\\
&+(p_B+\tau_B)\left((1-\rho)\,y_C-(1-\rho)\,\theta_B x_{FM}-\rho\theta_B y_{NC}\right)\\
&+(p_G+\tau_G)\,\rho\theta_G(y_C-y_{NC})-c\theta_B\frac{\frac{\tau_B}{\tau_G}p_G-p_B}{\tau_G\theta_G+\tau_B\theta_B}
\end{aligned}
\tag{18}
$$

if there are no renegotiations under non-collusion, and

$$
\begin{aligned}
&(1-p_B-\tau_B-p_G-\tau_G)(1-\rho)(y_C-y_{NC})\\
&+(p_B+\tau_B)\left((1-\rho)\,y_C-(1-\rho)\,\theta_B x_{FM}-\rho\theta_B y_{NC}\right)\\
&+(p_G+\tau_G)\,\rho\theta_G(y_C-y_{NC})-\left(\frac{\tau_B}{\tau_G}p_G-p_B\right)w_R
\end{aligned}
\tag{19}
$$

if there are renegotiations. The result follows from (18) and (19). **Q.E.D.**

Proof of Corollary 2. If p_G is very low, neither firm starts the new technology's development and public ownership dominates. If p_G is very high, both firms start the new technology's development and never abandon it (see (16)). Finally, to deal with all remaining cases, suppose that p_G is high enough that the innovator starts developing the new technology, but that this technology is abandoned if the innovator observes θ_B under private, but not under public ownership. The difference in payoffs between public and private ownership is a convex function of p_G. To see this, use that $\frac{\partial\rho}{\partial p_G}=\theta_G$ and take the second derivative of (18) with respect to p_G to obtain

$$
2\theta_G(\theta_G+1)(y_C-y_{NC})\,.
$$

The second derivative of (19) with respect to p_G is the same. Thus, the attractiveness of public ownership is a convex function of p_G. Together, all of this implies a U-shaped relationship between p_G and the attractiveness of public ownership. **Q.E.D.**

Proof of Proposition 4. (i) Let ρ^{Innov} be the likelihood that the innovator successfully develops the new technology. Furthermore, let V^{Inc} be the incumbent's expected payoff when starting the new technology's development, and $V^{Innov,no\ comp}$ and $V^{Innov,comp}$ be the innovator's expected payoffs depending on whether it is competing with the incumbent for the new technology. The incumbent starts the new technology's development if

$$(1-\beta)V^{Inc}+\beta V^{Inov,comp}-k\geq(1-\beta)\left(1-\rho^{Innov}\right)y_C+\beta V^{Innov,no\ comp} \quad (20)$$

Consider as a benchmark the case in which $\beta=0$ and the incumbent is just indifferent. Since $V^{Innov,no\ comp}>V^{Inov,comp}$, this implies that we must have $V^{Inc}>\left(1-\rho^{Innov}\right)y_C$. But differentiating both sides of (20) with respect to β, this implies that increasing β, makes condition (20) more difficult to satisfy.

(ii) If the incumbent firm buys a controlling stake in the innovator, it dictates that the innovator continues the new technology also if the signal realization is θ_B. This is because the incumbent is guaranteed the monopoly profit on the incumbent technology if the new one fails, so it faces no opportunity cost from continuation. Hence, motivating the R&D requires satisfying the incentive constraint

$$-\left(\tau_G+\tau_B\right)w_A+\left(\tau_B\theta_B+\tau_G\theta_G\right)w\geq c.$$

As shown in Proposition 2, this leads to a lower compensation cost than if the new technology is abandoned in case of θ_B. Moreover, absent competition, the incumbent's profit in case of success are higher, increasing the likelihood that the new technology's development is initiated. **Q.E.D.**

Proof of Proposition 5. (i) Suppose that both firms adopt the same technology in periods one and two and that Assumption 2 is not satisfied for the incumbent. Since $2x_C-bx_{NC}>K$ and $x_C-m>x_{NC}$, playing C in both periods is a dominant strategy for the incumbent regardless of the action taken by the innovator.

(ii) If the innovator is large, it is one of four cases applies: It is public and innovates alone; It is private and innovates alone; it is private and competes with the incumbent on innovation; it is public and competes with the incumbent on innovation.

In the first region, the innovator abandons the new technology following signal θ_B regardless of whether it is large or small. Hence, the cost of motivating the R&D team is the same, and remaining small is preferable (cf. 8) if

$$\begin{aligned}
& \left(1-p_B-\tau_B-p_G-\tau_G\right) 2bx_{NC}+\left(p_B+\tau_B\right) 2bx_{NC}+\left(p_G+\tau_G\right) \theta_G x_{FM}-\frac{\left(p_G+\tau_G\right)}{\tau_G} c \\
> & \left(1-p_B-\tau_B-p_G-\tau_G\right) 2\varphi x_C+\left(p_B+\tau_B\right) 2\varphi x_C+\left(p_G+\tau_G\right) \theta_G \varphi x_{FM}-\frac{\left(p_G+\tau_G\right)}{\tau_G} c,
\end{aligned} \tag{21}$$

that is if φ is sufficiently small relative to b. We omit the argument for the remaining regions, as it is analogous.[19]

Finally, note that if m is sufficiently small, the incumbent might prefer that the innovator remains small despite stealing market share. The incumbent can influence this decision by choosing private ownership or not buying an equity stake in the innovator. To see this, observe that in these cases, we have to replace x_C with x_{NC} in the right-hand-side of inequality (21), which makes remaining small more attractive. **Q.E.D.**

[19] For example, in the second region, the innovator's compensation cost is higher when it is small, as it continues developing the new technology if large (and private), but not if it is small. Remaining small is, thus, profitable if (see (14)):

$$\left(1-p_B-\tau_B-p_G-\tau_G\right)\left(2bx_{NC}-2\varphi x_{NC}\right)+\left(p_B+\tau_B\right)\left(2bx_{NC}-\theta_B \varphi x_{FM}\right) \geq c\theta_B \frac{\frac{\tau_B}{\tau_G} p_G-p_B}{\tau_G \theta_G+\tau_B \theta_B},$$

or respecitvely

$$\left(1-p_B-\tau_B-p_G-\tau_G\right)\left(2bx_{NC}-2\varphi x_{NC}\right)+\left(p_B+\tau_B\right)\left(2bx_{NC}-\theta_B \varphi x_{FM}\right) \geq \gamma\left(\theta_B x_{FM}-y_{NC}\right)\left(\frac{\tau_B}{\tau_G} p_G-p_B\right)$$

giving again a critical value for φ.

Table 1: **Summary Statistics.** This table compares the sample of firms that complete their IPO filings with the sample of firms that withdraws their filings. *AT case after/before filing*, which is a dummy variable equal to one if there is an antitrust case in the four years after/before the filing. *Postfiling NASDAQ returns* is a the two months NASDAQ returns following the IPO filing, *Prefiling NASDAQ return* is the three month return prior to the filing, *Log total assets* is the natural log of total assets, adjusted to inflation, *Net income/assets* and Sales/assets are the ratios of net income and sales to total assets, winsorized at one percent, *AT case prior filing* is a dummy equal to one if there was an antitrust case in the four years before the IPO filing. *, **, and *** indicate that the differences in means are statistically significant at the 10%, 5%, and 1% level, respectively.

	Completed			Withdrawn			
	Mean	Median	SD	Mean	Median	SD	Difference
AT case before IPO filing	0.007	0.000	0.084	0.005	0.000	0.068	0.002
AT case after IPO filing	0.022	0.000	0.147	0.007	0.000	0.081	0.015***
Total asssets	166.026	26.157	775.169	167.336	22.395	753.838	-1.310
Net income/assets	-0.264	-0.033	0.710	-0.374	-0.057	0.928	0.110***
Sales/assets	1.122	0.901	1.113	1.208	0.756	1.372	-0.086**
Postfiling NASDAQ returns	0.025	0.031	0.093	-0.018	-0.005	0.121	0.043***
Prefiling NASDAQ returns	0.055	0.048	0.111	0.050	0.041	0.138	0.005

Table 2: **Going Public and Antitrust Lawsuits.** This table reports the effect of an IPO on the likelihood of an antitrust lawsuit in the four years after the IPO filing. In models (1) and (2), the dependent variable is IPO, which is a dummy variable, equal to one if the firm does not withdraw its IPO. Model (1) presents the estimates from an OLS, while model (2) the estimates from a probit regression. In models (3)–(6), the dependent variable is $AT\ case\ after\ filing$, which is a dummy variable equal to one if there is an antitrust case in the four years after the filing. Models (3) and (4) show OLS estimates, model (5) presents the second stage of the 2SLS estimates, and model (6) presents the third stage of the Wooldridge's three-stage procedure (18.1). Variable definitions are as in Table I. All regressions include filing year and industry fixed effects at the two digit SIC level. Robust t-statistics are reported in the parantheses. *, **, and *** indicate that the coefficient is statistically significant at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	IPO	IPO	AT case after filing	AT case after filing	AT case after filing	AT case after filing
IPO			0.023***		0.140**	0.093***
			(3.433)		(2.280)	(2.831)
NASDAQ returns	0.011	0.073	0.234***	0.233***	0.232***	0.242***
	(0.123)	(0.212)	(7.382)	(7.369)	(2.606)	(2.638)
AT case before filing	0.461***	1.515***		0.065**		
	(5.994)	(5.508)		(2.294)		
Log total assets	0.039***	0.145***	0.010***	0.011***	0.005*	0.007***
	(7.495)	(7.389)	(5.159)	(5.713)	(1.777)	(3.199)
Net income/assets	-0.009	-0.041	-0.010**	-0.010**	-0.008**	-0.009***
	(-0.750)	(-0.966)	(-2.273)	(-2.271)	(-2.480)	(-2.812)
Sales/assets	-0.019***	-0.075***	0.001	0.001	0.004	0.003
	(-2.709)	(-2.864)	(0.466)	(0.360)	(1.177)	(0.978)
Constant	0.664**	4.421	-0.056	-0.044	-0.213***	-0.173***
	(2.336)	(0.057)	(-0.534)	(-0.424)	(-3.153)	(-3.393)
Filing year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3139	3090	3139	3139	3139	3090
R^2	0.189		0.078	0.076	.	0.044
Pseudo R^2		0.187				

Table 3: **NASDAQ Drops and Placebo Test**. Panel A of this table compares firms that experience a two month post filing Nasdaq return in the bottom 10% and top 90% of the filing year, and the bottom 25% and top 75%, respectively. Variable definitions are as in Table I. *, **, and *** indicate that the differences in means are statistically significant at the 10%, 5%, and 1% level, respectively. Panel B reports placebo tests for the validity of the instrumental variable exclusion restriction. The dependent variable is *AT case after filing* that takes the value of one if there was an antitrust case in the four years after the IPO filing. *Nasdaq returns* is defined as in Table I. *Nasdaq* 1 *year post/pre filing* are defined as the NASDAQ one-year return following/preceding the IPO filing. The models are estimated using OLS, and robust t-statistics are presented in parantheses. *, **, and *** indicate that the coefficient is statistically significant at the 10%, 5%, and 1% level, respectively.

Panel A: NASDAQ Drops and Firm Characteristics	(1) Bottom 10%	(2) Top 90%	(3) Difference	(4) Botton 25%	(5) Top 75%	(6) Difference
AT case before IPO filing	0.000	0.007	-0.007*	0.007	0.007	0.000
AT case after IPO filing	0.016	0.029	-0.013	0.016	0.025	-0.009*
Total asssets	121.498	103.311	18.187	192.183	173.760	18.423
Net income/assets	-0.314	-0.326	0.012	-0.289	-0.315	0.026
Sales/assets	1.171	1.115	0.056	1.156	1.111	0.045

Panel B: Placebo test	(1)	(2)	(3)	(4)	(5)
Dependent variable	AT case after filing	AT case after filing	AT case after filing	AT case after filing	AT case after filing
NASDAQ returns	0.066**			0.066**	0.065**
	(2.463)			(2.507)	(2.361)
NASDAQ 1 year post filing		-0.011		-0.001	
		(-0.549)		(-0.057)	
NASDAQ 1 year pre filing			0.011		0.005
			(1.014)		(0.409)
Control variables	Yes	Yes	Yes	Yes	Yes
Filing year FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
Observations	3139	3139	3139	3139	3139
R^2	0.059	0.058	0.058	0.059	0.059