Regulating Collusion

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Abstract

We attempt to provide a systemic view of the process of regulating collusion, including detection and prosecution, but also bargaining between firms and regulators via consent orders, the production of evidence, and containment measures that may be taken if collusion cannot be addressed in more direct means. In addition, we try to do justice to the peculiarities of the legal system: modeling the courts as they are, rather than as economists think they should be, is essential for economic analysis to improve the way collusion is regulated.

KEYWORDS: collusion, regulation, Twombly, burden of proof, safe tests, consent orders, AI collusion

1 Introduction

The theme of collusion shows up in a number of related but distinct academic fields, including game theory, mechanism design, industrial organization, and law and economics, as well as actual case law. Collusion admits related but different definitions across all these contexts in a way that makes productive discussions across fields delicate. At the same time, collusion is an exciting topic of inquiry because it connects in a uniquely relevant way several

fields, including very theoretical and very applied ones. In addition, as technology and case law evolve, an effective dialogue between theoretical and applied perspectives is needed to elaborate useful policy responses to an evolving challenge.

The goal of this review is to map out what we think are opportunities for productive dialogue across theory and empirics, in the context of a topical set of challenges. To this end we seek to provide a systemic view of the process of regulating collusion, including detection and prosecution, but also bargaining between firms and regulators via consent orders, the production of evidence, and containment measures that may be taken if collusion cannot be addressed in more direct means. In addition we try to do justice to the peculiarities of the legal system: correctly modeling the mechanics of the courts is a key input to understanding how to effect change in the way collusion is regulated. To this end we systematically include references to relevant case law, which we tend to view as choice data, expressing the preferences of judicial decision-makers.

The review is organized as follows. Section 2 provides some background information on recent practical concerns about collusion, including changing methods of collusion, and changing case law. We also provide an overview of the different processes involved in the regulation of collusion. Section 3 reviews different definitions and approaches to collusion from the perspective of mechanism design, industrial organization, and legal analysis. The remaining sections discuss issues arising in different stages of the process by which collusion is dealt with. Section 4 discusses the issue of detection, with some emphasis on the impact of Bell Atlantic v. Twombly (2007) and the role statistical screens play in prosecuting collusion. Section 5 discusses the prosecution of collusion, including burden of proof requirements, and challenges in successfully prosecuting collusion, as well as the potential for mechanisms to generate actionable evidence. Section 6 discusses regulatory steps that can be taken to prevent collusion from arising in the first place, with specific attention given to AI driven collusion. Section 7 discusses potential policy responses that can be pursued by regulators or stakeholders depending on the strength of the evidence available to them. Section 8 concludes

by highlighting several challenges that theory must overcome so that it can provide a more effective guide for regulators.

2 Background: An Evolving Challenge

This section sets the background for our review, namely the changing and growing set of challenges posed by market power and collusion, driven by changes in technology, the legal environment, and business practices. It also provides a brief overview of the regulatory process, including but not limited to prosecution of antitrust cases.

Evolving market-power. A growing body of work has argued that markups have significantly increased since the 1980s (De Loecker and Eeckhout, 2018, Grullon et al., 2019, De Loecker et al., 2020, Gutiérrez et al., 2018, Covarrubias et al., 2020, Philippon, 2019). The magnitudes are economically meaningful: De Loecker and Eeckhout (2018) suggests that markups have grown from roughly 20% to 60% over these 4 decades. Gutiérrez et al. (2018), Philippon (2019), Covarrubias et al. (2020) argue that this is especially true in the United States as opposed to Europe, while De Loecker and Eeckhout (2018) argue that this is a more global phenomenon.

This growth in markups has been accompanied by a growth in the market share of large firms charging high markups (Grullon et al., 2019, De Loecker et al., 2020, Autor et al., 2020), a significant increase of HHI across industries (Gutiérrez et al., 2018), a reduction in the share of profits going to labor (Autor et al., 2020), and a reduction in investment (Gutiérrez et al., 2018).

While the phenomenon is well documented, its causes are less clear. De Loecker et al. (2020) argue that increased overhead and fixed costs explain some, but not all of the increase in markups. Grullon et al. (2019) and Gutiérrez et al. (2018) point to reduced enforcement by antitrust authorities, and increased regulatory barriers. De Loecker et al. (2021) argue

that technology driven changes in entry costs, and in the distribution of firm productivity resulted in reduced competition.

Evolving regulatory context. This rise in the market-power of firms is mirrored by a durable shift in the way antitrust law has been applied.

Khan (2016) describes decades long changes in the way American antitrust law — built on the Sherman Act (1890), the Clayton Act (1914), the Federal Trade Commission Act (1914) and the Robinson-Patman Act (1936) — has been interpreted and applied. One question has been the extent to which corporate behavior constitutes *per se* violations of antitrust law, or whether a *rule of reason* criterion needs to be applied. In other terms, does antitrust ban specific corporate behaviors, or does it ban them only if they can be proven to be of harm to consumers. This change in interpretation corresponds to a significant difference in the burden of proof needed for successful prosecution: for instance, under *rule of reason* predatory pricing rarely runs afoul of antitrust legislation because its immediate impact is obviously to improve consumer welfare.

This tension between *per se* versus *rule of reason* approaches to antitrust, and the changing boundaries of behavior that is or is not accepted, is unavoidable, and likely a healthy aspect of regulation. It speaks to the complexities of both desirable and undesirable business practices and the real difficulties in distinguishing them, especially in changing environments. A similar tension arises in the context of patents and trade secrets. Patents and trade secrets are ex post restraints on competition, but they are necessary to support ex ante innovation and competition in markets with costly entry. The protection provided to patents and trade secrets is meant to achieve an acceptable compromise that may need to be adjusted as circumstances evolve. For instance, Alice Corp. v. CLS Bank International (2014) considerably limited the extent to which software implementations of algorithms could be patented.

Roughly speaking, during the first half of the twentieth century, antitrust law was frequently applied on a per se basis. In Addyston Pipe and Steel Co. v. U.S. (1899), the

US Supreme Court ruled that bid rigging by cartels was so egregious a behavior that it ran afoul of Section 1 of the Sherman Act in spite of claims by cartel members that the prices charged were in fact reasonable. Explicit collusion continues to be treated as a violation of the Sherman act on a per se basis, though the burden of proof set to hear cases has significantly increased in recent years. Some carve-outs were made for some collusive practices, in particular labor unions (in the Clayton Act of 1914). Similarly, employment contracts, which often include restrictions on contemporaneous employment, were clarified to be tolerable practice under antitrust law.

Still the per se approach led to controversial decisions, especially regarding price discrimination. While antitrust law recognizes the potential harm posed by predatory pricing – i.e. the practice consisting in pricing goods below marginal cost for a while, to induce competitors to leave a market – the fact that incumbents should lower their price in response to entry is not in itself evidence of foul play: it is precisely the point of competition. The issue is particularly salient in Utah Pie Co. v. Continental Baking Co. (1967). Following the entry of a local manufacturer of frozen pies in Salt Lake City, Utah, branches of national brands lowered their prices below their national average. While the majority opinion of the US Supreme Court found this behavior in violation of the Clayton Act, the dissenting opinion was that this decision ultimately harmed the competitiveness of markets: antitrust law was being used to reduce, rather than enhance competition.

The view that antitrust law was being used to stifle competition was powerfully articulated by the Chicago school of economics led by Milton Friedman and Aaron Director. They viewed predatory pricing and anti-competitive exclusive dealings as rare (if not mythical) and likely a much smaller hindrance on well functioning markets than over-regulation. Due to the Chicago school's impact on the field of Law and Economics, and its influence on the education of high level judges including Robert Bork, Antonin Scalia, and William Rehnquist, this view found its way in case law throughout the second half of the twentieth century. Bork (1978) in particular emphasized that the point of antitrust regulation was to

protect consumers, not competitors. This qualification severely limited the use of Antitrust laws to prevent corporate activities such as predatory pricing, and exclusive dealings that did not obviously lead to short term increases in prices to consumers. In Spectrum Sports v. Shirley McQuillan (1993), the US Supreme Court cited the words of Senator George Hoar, an author of the Sherman Act

> ... [a person] who merely by superior skill and intelligence...got the whole business because nobody could do it as well as he could was not a monopolist...(but was if) it involved something like the use of means which made it impossible for other persons to engage in fair competition."

to motivate the view that

> The purpose of the [Sherman] Act is not to protect businesses from the working of the market; it is to protect the public from the failure of the market. The law directs itself not against conduct which is competitive, even severely so, but against conduct which unfairly tends to destroy competition itself.

Most recently, Khan (2016) takes issue with *rule of reason* assessments that focus on short-term pricing behavior, and ignore long-term impacts on consumers. One case in point is Amazon.com. Over the last 25 years the company set low prices to expand market-share, and as a result, lost money over much of its history. Yet, it commands a high stock price, suggesting that the stock market expects the company to command higher margins in the future. In response, Khan (2016) suggests an increase in *per se* applications of antitrust law, focusing on industry structure as proxy for long-term competition, rather than short-term pricing behavior. The concerns delineated by Khan (2016) have caught the attention of regulators in Europe and the US, with Khan becoming chair of the Federal Trade Commission in 2021. The extent to which these concerns find their way in case law remains unclear, especially in view of the current conservative lean of the US Supreme Court.

Evolving case law. In parallel to these broad shifts in the way antitrust law has been interpreted, a number of cases pertaining specifically to collusion have also changed practice over the last fifteen years.

As we highlight in Section 3, court cases have placed great emphasis on whether there was an agreement or conspiracy to restrain competition to mark collusive behavior as illegal. In particular, and although it is not an explicit requirement in the law, evidence of overt communication between firms appears to be a prerequisite for successful prosecution.[1]

This is a high burden of proof. Short of a whistleblower or conspirator coming forward (such as in the case of the lysine cartel (United States v. Archer Daniels Midland Co., 1996)), publicly available information, such as unusual pricing patterns, rarely meet this standard. For this reason, a number of collusion lawsuits operate in two steps: first, circumstantial suggestive evidence of collusion based on data available to plaintiffs would be used to convince a court to hear the case, and open a process of discovery allowing plaintiffs access to private documents. In turn, the discovery process, as well as witness cross examination may then potentially yield sufficient evidence to establish conspiracy to fix prices.[2]

A recent case has threatened this two step approach by increasing the level of preliminary evidence needed for courts to even hear a case and open the discovery process. In Bell Atlantic v. Twombly (2007) the US Supreme Court raised the plausibility standard for cases to be heard in court. In particular, evidence of plausible agreement, rather than parallel conduct by firms (i.e. firms setting unusually similar pricing or contracting terms over time), is now required. This was followed up in different circumstances by Ashcroft v. Iqbal (2009) which increased the burden of evidence required for discrimination cases against the US government to be heard. Together Twombly and Iqbal have made it difficult for plaintiffs to access the discovery process. We emphasize that in evaluating possible responses to Twombly, it is

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[1]In the absence of evidence of overt communication, so-called plus factors may be used as evidence of illegal collusion (Kovacic et al., 2011).

[2]Kaplan (2001) describes a successful application of this two step approach in the context of re Nasdaq Market-Makers Antitrust Litigation (1996), a landmark case building on academic economic analysis by Christie and Schultz (1994).

useful to understand the rationale behind this choice: reducing the chilling effects, and legal costs associated with frivolous lawsuits treating discovery as a fishing expedition. We believe that statistical screens may overcome the challenge set by Twombly by taking seriously this concern.

This puts government regulators in a tricky position, especially since their own records can be accessed by the public through the Freedom Of Information Act (FOIA). For instance, the Securities and Exchange Commission's efforts to sue Ripple Lab, Inc (Securities and Exchange Commission v. Ripple Labs, Inc., 2020) are being thwarted by a FOIA request establishing possible conflict of interest on the part of SEC executives.

Evolving methods of collusion.   At the same time as the changing regulatory environment and case law have made it more difficult to prosecute collusion cases, methods that firms use to collude have also evolved.

Since successful prosecution of collusion currently requires evidence of communication, one development has been the use of alternative communication methods as a way to coordinate collusion.[3] One trend studied in Harrington (2022), has been the use of earnings calls to communicate collusive plans between competitors. Because firms' strategies are informative to investors it can be argued that they are a legitimate topic of discussion during earnings calls. Indeed, the US Supreme Court's ruling in Credit Suisse Securities v. Billing (2007) seems to imply that, since securities markets are regulated by the Securities and Exchange Commission, certain activities (like reasonable public communication) are exempt from antitrust regulation. Over the years the FTC has attempted to address the issue through consent orders, i.e. out-of-court settlements in which firms agree to refrain from certain behaviors without admission of guilt. Harrington (2022) provides a systematic discussion of

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[3]It is in a sense surprising that firms are not able to tacitly collude, but the costs of miscoordination are high. In addition, experimental work (Charness and Dufwenberg, 2006, Bochet et al., 2006, Blume and Ortmann, 2007, Cason et al., 2012) has highlighted the importance of communication channels in establishing cooperation. For this reason, new technology facilitating discrete communication, or pricing AIs better capable of tacit collusion than their human counterparts are real concerns.

what sort of communication serves purely collusive goals.

Another concerning evolution has been the rise in common ownership (Azar et al., 2018, Antón et al., 2018, Backus et al., 2021). Firms whose major shareholders also own their competitors face diminished incentives to compete. Even if no explicit conversation takes place, common ownership obviously blunts executives' incentives to engage in vigorous competition.

In addition to evolving business practices, there is concern that changing technology may support new modes of collusion. One possibility that has received growing attention is that of algorithmic collusion, in which AIs seeking to maximize profit simply reinvent collusion without being explicitly told to do so. Calvano et al. (2020b,a) provide suggestive simulations, while Harrington (2018) suggests possible fixes, exploiting the fact that having explicit code makes it in principle possible to assess an AI's propensity to collude. Of course the Volkswagen emissions scandal known as Dieselgate, in which cars' software was designed to induce low emissions in testing environments but not under normal use, along with the real difficulties of auditing complex software, often taking a black-box form, highlights some real implementation difficulties related to this approach. We make some suggestions in Section 6.

Regulation as a process. We conclude this background section by providing an abstracted out overview of the process by which collusion is regulated, illustrated by Figure 1. This roughly organizes the remaining sections of our review, and emphasizes co-dependencies between different subprocesses. For instance, prosecution affects regulators ability to settle effectively out of courts. This view also suggests a "process influence" rather than a mechanism design approach to improving the mechanics of regulation. At this stage, there are too many subprocesses, and their mechanics are not sufficiently well understood to permit a sensible overall optimization exercise. Instead, it may be possible to identify solvable issues or bottlenecks in the process and address them in a piece-wise manner.

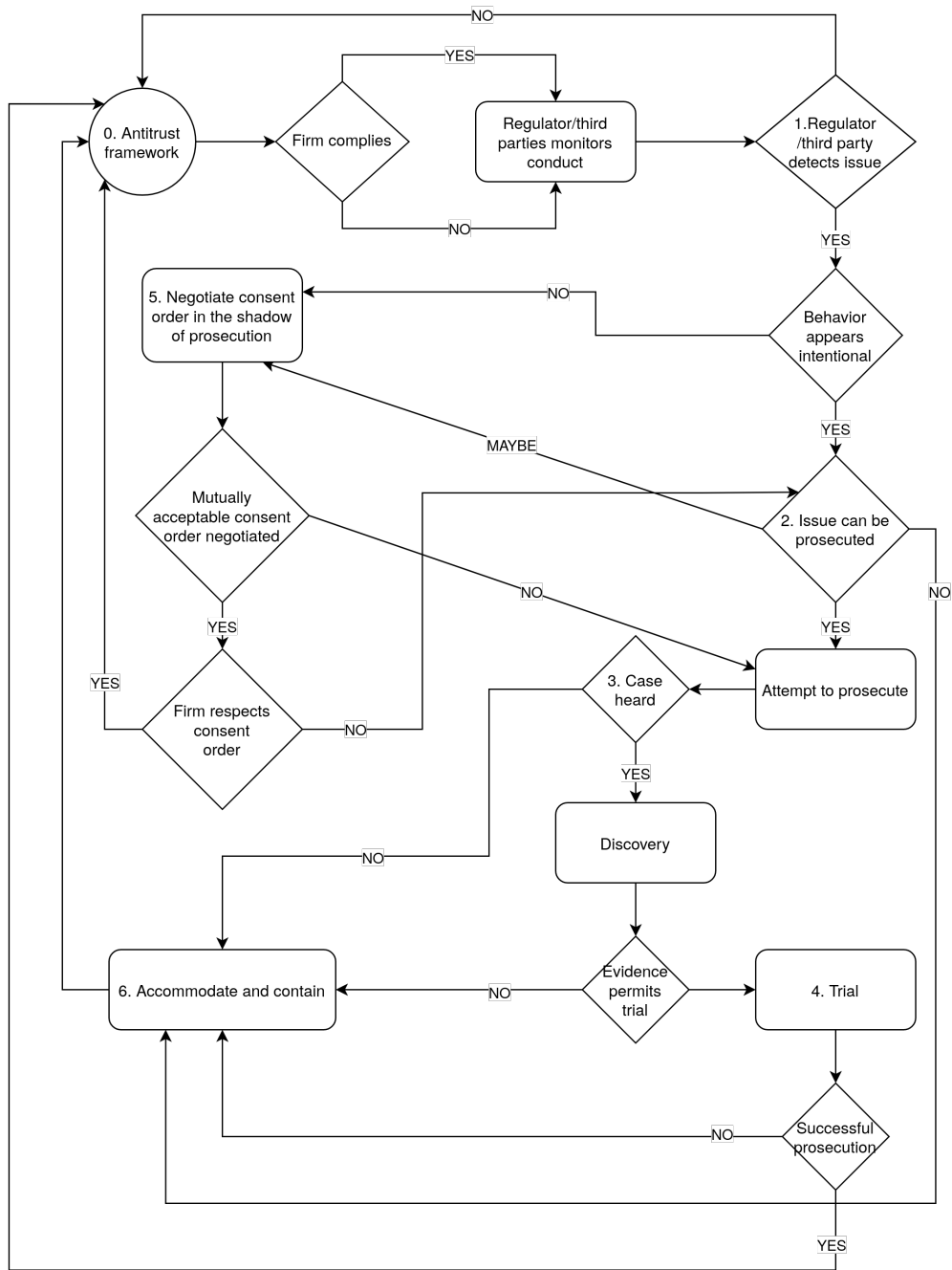Figure 1 highlights seven key subprocesses of regulation. Step 0 corresponds to the

Figure 1: Key steps in antitrust enforcement

underlying antitrust framework laid out by acts of congress, and case law. Because their language is vague, the antitrust framework must be interpreted by courts at a later stage. We find it useful to view this framework as implicitly providing choice data defining preferences which courts will seek to respect. This view is important to apply our historical antitrust framework to new circumstances (e.g. AI collusion).

In Step 1, regulatory entities as well as third-party stakeholders detect possible compliance issues either through the use of publicly available data, or through whistleblowers.[4] Depending on the nature of the behavior, regulators may either seek a negotiated solution (Step 5), or evaluate the possibility of prosecution (Step 2).

If no prosecution is possible, for instance if prices appear supra-competitive, but there is no evidence of conspiracy, then the regulator may take steps to improve competition through other means (Step 6), for instance, by providing incentives for entry.

If prosecution is possible but its outcome uncertain, the regulator may elect to negotiate in the shadow of prosecution (Step 5) and extract compromise concessions via a consent order settled out of courts, instead of pursuing a judicial route with an uncertain and more extreme outcome.

Prosecution itself proceeds in two steps. First, the plaintiff must convince the court to hear the case (Step 3). If the case is heard, then the discovery allows plaintiffs to collect evidence, leading to trial (Step 4). If the judge and jury rule in favor of plaintiffs damages are imposed on the defendants, and changes in conduct may be mandated. If the court judges against the plaintiffs, then accommodation and containment is the only remaining policy lever.

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[4]In fact, government entities and private plaintiffs may collaborate, forming what amounts to public-private partnerships (Kaplan, 2001).

3 Defining Collusion

3.1 Legal definition

The standards for collusion are set by Section 1 and Section 2 of the Sherman Act. Section 1 states

> Every contract, combination in the form of trust or otherwise, or conspiracy, in restraint of trade or commerce among the several States, or with foreign nations, is declared to be illegal.

Section 2 of the Sherman Act strengthens Section 1 by expanding the set of illicit offenses:

> Every person who shall monopolize, or attempt to monopolize, or combine or conspire with any other person or persons, to monopolize any part of the trade or commerce among the several States, or with foreign nations, shall be deemed guilty of a felony.

A central issue is the standard of proof needed to establish whether firms engaged in an unlawful conspiracy. In particular, is evidence of an express agreement (in the form of overt communication) a prerequisite to bring charges under the Sherman Act?

Interstate Circuit, Inc. v. United States (1939) is an early Supreme Court decision in which evidence of an express agreement did not appear to be a prerequisite for conviction. In this case, the government sued distributors of movies and movie theatre owners (which had a monopoly of first-run theaters in different cities in Texas and New Mexico) for price fixing. The case centered around a letter that the manager of the theatre owners sent to distributors. The letter stated that Interstate Circuit (one of the theater owners) would only continue showing the distributors' movies if they imposed restrictions on second-run theaters. Importantly, the letter that each distributor received named all of the distributors as addressees. Distributors ended up agreeing to the letter's demands. The court's ruling stated:

While the District Courts finding of an agreement of the distributors among themselves is supported by the evidence, we think that in the circumstances of this case such agreement for the imposition of the restrictions upon subsequent-run exhibitors was not a prerequisite to an unlawful conspiracy. It was enough that, knowing that concerted action was contemplated and invited, the distributors gave their adherence to the scheme and participated in it.

Hence, the ruling deemed one-sided communication in the form of an invitation to collude as sufficient grounds for a guilty verdict.

In American Tobacco Co. v. United States (1946), the dominant firms in the tobacco market were found to be in violation of Sections 1 and 2 the Sherman Act. The evidence in which the case was based was mostly circumstantial. For example, the three largest firms at the time (American, Liggett and Reynolds) charged essentially identical prices between 1928 and 1940, changing their prices in tandem throughout the period. There was no evidence of express agreement. The appellate court's ruling stated:

No formal agreement is necessary to constitute an unlawful conspiracy. Almost always, the crime is a matter of inference, deduced from the acts of the persons accused, which are done in pursuance of an apparent criminal purpose. [...] the essential agreement, combination and conspiracy in violation of the Sherman Act may be implied from, or found in a course of dealing or other circumstances, as well as through an exchange of words.

The Supreme Court's ruling further stated:[5]

It is not the form of the combination or the particular means used but the result to be achieved that the statute condemns.

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[5]The Supreme Court granted limited review centered on charges against the firms under Section 2 of the Sherman Act.

In practice, and in spite of these earlier rulings, in the more recent past court cases have placed greater emphasis on evidence of an express agreement, and in particular evidence of overt communication, to mark collusive behavior as illegal. As Judge Richard Posner observed (re Text Messaging Antitrust Litig., 2010), "Section 1 of the Sherman Act [...] does not require sellers to compete; it just forbids their agreeing or conspiring not to compete." Consequently, as Harrington (2018) notes, "Although many avenues have been pursued by plaintiffs to argue that firms' conduct could not have been reached independently, successful recipes for convincing a court of [a collusion] claim have almost always had a common ingredient: evidence of an overt act of communication."

At the same time, as Harrington (2018) notes, it is not clear whether this state of affairs reflects a deep rooted preference, or reflects law-makers' concern for disturbing the ordinary conduct of business through illegitimate, and overly punitive laws.

> As opined by Judge Stephen Breyer, the legality of these forms of collusion is undesirable but, in his view, unavoidable.

> "Courts have noted that the Sherman Act prohibits agreements, and they have almost uniformly held, at least in the pricing area, that such individual pricing decisions (even when each firm rests its own decisions upon its belief that competitors do the same) do not constitute an unlawful agreement under Section 1 of the Sherman Act... [T]hat is not because such pricing is desirable (it is not), but because it is close to impossible to devise a judicially enforceable remedy for "interdependent" pricing. How does one order a firm to set its prices without regard to the likely reactions of its competitors? The challenge lies in being able to define ex ante "interdependent" pricing that is intended to produce supracompetitive prices, and to be able to distinguish ex post such pricing from interdependence which is a natural consequence of competition."

Distinguishing the two explanations of case law (intrinsic preferences to act only if explicit

communication happened, or concern over false positives), is essential to evaluate the potential of possible responses to recent challenges, such as collusion through earnings calls, and collusion by pricing AIs.

3.2 Game theoretic definitions

While the legal definition of collusion emphasizes the way in which collusion comes about (i.e., an express agreement among firms), the game theoretic definitions of competition and collusion refer solely to firms' conduct, ignoring how that conduct was reached.

To fix ideas, consider an oligopoly market with firms $N = \{1, ..., n\}$, who compete in prices at periods $t = 0, 1, ...$ For each vector of prices $\mathbf{p} = (p_i)_{i \in N}$, let $d_i(\mathbf{p})$ denote firm i's demand. Firms' costs at time t are denoted by $\mathbf{c}_t = (c_{i,t})_{i \in N}$, and are drawn i.i.d. over time according to a joint distribution F_C.[6] Firms privately observe their costs each period. Firm i's flow profits given prices $\mathbf{p}$ and cost c_i are $\pi_i(\mathbf{p}, c_i) = d_i(\mathbf{p})(p_i - c_i)$. Firms discount future profits with common discount factor $\delta < 1$.

Assume that past prices are perfectly and publicly observed. Hence, the period-t public history, $h_t = (\mathbf{p}_s)_{s<t}$, records all past prices. A public strategy σ_i for firm i is a mapping $\sigma_i : h_t, c_{i,t} \mapsto p_{i,t}$. A perfect public Bayesian equilibrium $\sigma = (\sigma_i)_{i \in N}$ is a perfect Bayesian equilibrium in public strategies (Athey and Bagwell, 2008).

Chassang et al. (2022) and Ortner et al. (2022) introduce the following definitions:

Definition 1 (competitive firms). *Fix a strategy profile σ and a history $h_{i,t} = (h_t, c_{i,t})$ of firm i. Firm i is competitive at history $h_{i,t}$ if play at $h_{i,t}$ is stage-game optimal for firm i given the behavior of other firms; i.e. $\sigma_i(h_{i,t}) \in \arg\max_p \mathbb{E}_{\sigma_{-i}}[\pi_i((p, \mathbf{p}_{-i,t}), c_{i,t})|h_{i,t}].$*

Firm i is competitive if it plays competitively at all histories on the equilibrium path.

The industry is competitive if all firms $i \in N$ play competitively at all histories on the equilibrium path.

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[6]This allows for costs that are correlated among firms within each period. In addition, we could have costs that are serially correlated over time by allowing F_C to depend on a publicly observable state θ_t.

In words, a firm behaves competitively under strategy profile σ if it plays a static best response to the actions of its opponents. Note that, if the industry is competitive, it must be that all firms are playing a stage-game Nash equilibrium at all periods.

Definition 1 formalizes the idea of independent behavior by oligopolistic firms: a firm that behaves competitively chooses actions to maximize current profits, taking as given behavior by other firms. We note that Definition 1 does not rule out all forms of interdependent firm behavior, only those that cannot arise if firms compete. For instance, an increase in the costs of all firms will lead to uniformly higher prices, even under competition.

We stress that firms might fail to play a static best response to their opponents' actions for a variety of non-collusive reasons. Non-competitive behavior (i.e., behavior that does not satisfy Definition 1) is not necessarily collusive behavior. For instance, a firm that holds incorrect beliefs about the pricing strategy of its opponents' might look like it's failing to optimize. Similarly, trembles or mistakes in firm behavior would also lead sub-optimal prices.

So, what constitutes collusive behavior? A common definition, put forward by several scholars (e.g., Whinston, 2008, Kaplow, 2011a, Harrington, 2018), is that collusion occurs when firms coordinate on an equilibrium that allows them to sustain supra-competitive prices (i.e., prices that are higher than those that would prevail under competition). As emphasized by Harrington (2018), such collusive equilibria are rooted in a reward-punishment scheme, by which firms are rewarded in the future if they charge supra-competitive prices, and are punished if they defect and lower their prices.

As others have stressed (Whinston, 2008, Harrington, 2012), there is a gap between the legal definition of collusion and this game-theoretic definition. Indeed, tacit parallel behavior is collusive under the game-theoretic definition, but need not be unlawful. This gap gives rise to what Harrington refers to as the "conscious parallelism loophole" (Harrington, 2012), leaving plenty of room for firms to collude without the threat of prosecution.

Better understanding this gap between natural economic definitions and existing case law is also potentially quite valuable: it can help us understand the sort of econometric analysis

likely to be useful to courts, and can guide the design of evidentiary mechanisms seeking to produce evidence persuasive to courts. This is our first open question.

Open Question 1. *What decision problem rationalizes the observed case law? Why is evidence of communication important? Can other types of evidence be similarly persuasive?*

We suspect that models of social preferences in which decision-makers evaluate intent ex post have a role to play.[7] In particular, burdens of proof require decision-makers ex post belief over guilt to be sufficiently high. This will be affected by decision-makers priors, their ability to understand the evidence, and alternative competitive explanations for the data.

Competition and endogenous state variables.   Definition 1 allows for revealed preferences tests of competition under fairly general informational environments (see Chassang et al. (2022)). However, it ignores the fact that many natural oligopolistic environments feature endogenous payoff-relevant state variables. For instance, in some industries firms may become more efficient as they make more sales (learning-by-doing), while in other industries firms may face costs that are increasing in their backlog.

In such industries, revealed failures of stage-game optimization need not be evidence of non-competitive behavior. For instance, in markets in which learning by doing is important, competitive firms might price below cost to achieve future economies of scale. Hence, these settings demand a suitable extension of the definition of competitive behavior.

Kawai et al. (2021) propose a relatively broad definition of competition that still permits excluding some observed behavior using revealed preference arguments. Kawai et al. (2021) say that an equilibrium is competitive if it is Markov perfect, and firms' prices are enforced by continuation values that change continuously with current prices. This restriction on continuation values rules out reward-punishment equilibria in which firms are able to sustain supra-competitive prices by the threat of lower future payoffs.

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[7]See for instance Chassang and Zehnder (2016).

Although this approach is suitable for the limited purpose of Kawai et al. (2021), it remains somewhat ad hoc, and ultimately unsatisfactory. For this reason, extending definitions of competitive behavior to environments with endogenous state variables remains an important open question.

Open Question 2. *How should we define competitive play in games with endogenous payoff-relevant states? What are revealed preferences tests of competitive behavior under this extended definition?*

We discuss some plausible directions in Section 6, when discussing restrictions on value functions used by pricing AIs.

3.3   Limits of the reward and punishment view

We note that while the reward and punishment approach to defining collusion is very useful, it is not entirely free of issue. First, in some settings, there may be many stage game equilibria sustaining both low and high prices. Second, some industry conduct involving rewards and punishments need not be a source of efficiency loss.

One example of supra-competitive prices occurring in a one-shot setting is the Diamond paradox (Diamond, 1971): when consumers face strictly positive search costs, there may exist a static Nash equilibrium in which all firms charge the monopoly price, regardless of how many firms operate in the industry.

Examples of settings in which reward and punishment schemes can increase welfare include Board (2011) and Calzolari and Spagnolo (2017): there, reward-punishment schemes increase quality provision in settings in which a buyer procures repeatedly from a group of sellers. Similarly, reward-punishment schemes by buyers (i.e., a buyers' cartel) can lead to higher welfare in cartelized markets.

Whether we should care about these possible exceptions to the reward and punishment approach to collusion depends on how prevalent they are. These are also open questions.

Open Question 3. *Is there evidence of Diamond's paradox leading to supracompetitive prices?*

Open Question 4. *Is there evidence of welfare-enhancing collusion, leading, for instance, to higher quality?*

4 Detecting Collusion

As we highlight in Figure 1, detection of collusion plays an important role in the process of antitrust regulation. In the absence of direct evidence, antitrust agencies can use statistical screens to detect non-competitive behavior.

Although such statistical evidence tends not to be sufficient to win a case in a court of law, statistical screens have many uses. As we argue below, sufficiently strong statistical evidence can potentially be useful in convincing judges to proceed to discovery, even under the precedent of Bell Atlantic v. Twombly (2007). The evidence may be used to curb unwanted behavior through consent orders, or other policy steps.[8] In addition, regulators may strategically reveal information to encourage cartel members to apply to leniency programs, or accept the terms of a negotiated settlement.

In the last decades, an active academic literature has seek to develop statistical methods to detect non-competitive behavior.[9] Porter and Zona (1993, 1999) develop screens based on the comparison of bidding behavior by cartel members and non-cartel members. Bajari and Ye (2003) construct a test of competition for procurement auctions based on the idea that the bids of competitive firms are exchangeable under the independent private values assumption. Porter (1983), Ellison (1994), Chassang and Ortner (2019) build statistical screens to detect tacit collusion exploiting patterns of play predicted by the theory of repeated games. Conley and Decarolis (2016) and Kawai and Nakabayashi (2022) construct tests to detect collusive

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[8]For instance, antitrust authorities might consider this information when deciding on merger cases: statistical screens suggesting that the industry is collusive might tip the balance against allowing for mergers.

[9]For reviews of the literature, see Porter (2005) and Harrington (2008).

behavior in average-price auctions and in auctions with re-bidding.

While some of these approaches may be less effective as legal evidence due to the standards set by Bell Atlantic v. Twombly (2007), recent work has sought to deal with this challenge by using general revealed preference tests of non-competitive behavior; i.e. evidence that under all plausible models, firms are acting against their narrowly defined economic interests. Chassang et al. (2022) propose tests of non-competitive behavior in procurement auctions based on estimated counterfactual demand. Kawai et al. (2021) propose a test to detect collusive forms of bid-rotation and market segmentation. A key feature of the tests that these papers develop is that they are *safe*, in the sense that firms that behave competitively are guaranteed to pass with probability approaching 1, regardless of the underlying economic environment. Put differently, the tests developed in these papers are designed to fail firms whose behavior cannot be rationalized as competitive. This addresses concerns that excessively permissive statistical screens may lead to frivolous lawsuits, or have chilling effects on desirable pro-competitive behavior.

We believe that the statistical evidence coming from safe tests might be the type of evidence needed for plaintiffs to access the discovery process, following Bell Atlantic v. Twombly (2007). Because the behavior of firms that fail safe tests cannot be rationalized as competitive, such statistical evidence may convince judges that the likelihood of unlawful collusion is high enough to hear a case and allow for the discovery process.

Adaptation to statistical screens. As highlighted by Wollmann (2019) and Cunningham et al. (2021), firms typically adapt to the regulatory environment that they face. The case of screens of collusion is no different: in principle, firms can diminish the impact of screens by adapting their behavior. Moreover, as highlighted by Cyrenne (1999) and Harrington (2004), cartels could potentially use the threat of a regulatory crackdown to deter defectors and attain more collusive outcomes.

Against this backdrop, Ortner et al. (2022) show that screening for collusion with safe

tests can be effective even when cartels can adapt to the regulatory environment. In particular, they show that screening for collusion with safe tests does not hurt competitive industries, and does not create new collusive equilibria. Hence, safe tests don't increase firms' incentives to form cartels.

5 Prosecuting Collusion

Much of the regulation of collusion, including negotiated steps such as consent orders take place in the shadow of prosecution. Understanding this process, its constraints, and its degrees of freedom informs analysts on the nature of evidence likely to have an impact in court and suggests open questions of topical interest to stakeholders.

Burden of proof. Predictions from the standard economic theory of incentives do not provide a good predictive model of how courts decide on punishments. In ex ante optimal contracting models, optimal incentives depend on the likelihood ratio of observed evidence η conditional on desired and undesired actions B (beneficial) and H (harmful):

$$\frac{\mathsf{prob}(\eta|H)}{\mathsf{prob}(\eta|B)}. \tag{1}$$

As Kaplow (2011b) argues, much of the economic literature focuses on deterrence alone: there are only two actions available the bad one and the harmless one. However, in practice, courts are concerned with the "chilling effect" of the law: the dissuasion of beneficial practices (for instance aggressive pricing to build market share and compete effectively in the future). Realistically including potential chilling effects by allowing players to take one of three actions – the harmful one, a neutral one, and a beneficial one – modifies the optimal setting of evidence levels.

One notable property of optimal ex ante contracting is that the harmful action may occur with probability zero in equilibrium and yet some punishment may be necessary fol-

lowing suspicious looking evidence. This is not the way courts and juries operate. Different standards of evidence are expressed as a function of posterior beliefs, i.e. as a function of posterior odds ratio Λ

$$\Lambda = \frac{\mathsf{prob}(H|\eta)}{\mathsf{prob}(L|\eta)} = \frac{\mathsf{prob}(H)\mathsf{prob}(\eta|H)}{\mathsf{prob}(L)\mathsf{prob}(\eta|L)} \tag{2}$$

For instance, the criterion of "preponderance of evidence" frequently used in civil law requires that the harmful action be more likely than not, that is $\Lambda \geq 1$. A more demanding criterion, "clear and convincing evidence", sometimes used in higher stakes cases, would correspond to a larger cutoff (say, $\Lambda \geq 2$). Finally, "beyond reasonable doubt", used in criminal cases roughly corresponds to an even larger criterion (say, $\Lambda \geq 10$).[10]

Statistics (1) and (2) are obviously related – both are driven by the strength of evidence – but statistic (2) is also driven by the court's prior beliefs. As Chassang and Zehnder (2016) highlight, criterion (2) arises naturally if jury decisions express social preferences for equity: people should not be punished for bad outcomes if we know they had good intentions. As Chassang and Zehnder (2016) highlight, this way of generating rewards and punishments can induce desirable behavior, but it cannot entirely dissuade harmful behavior: if the harmful behavior does not occur in equilibrium, $\Lambda = 0$, so that no punishment is taken.

This last property reflects a real tension in policy-making: the Chicago school made the case that the per se approach to antitrust was likely excessive in view of relatively rare cases of tacit collusion and predatory pricing, however this may only have been true because of the more stringent application of antitrust law prevalent at the time. In a dynamic way, this may lead to time varying stringency in enforcement: weak enforcement leading to more crime, leading to stringent enforcement, leading to less crime, leading to weak enforcement, and so on. In this respect, Khan (2016) may reflect a necessary swing of the pendulum.

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[10]These thresholds roughly correspond to the assessments of judges in the Eastern District of New York surveyed by Judge Weinstein, as reported in McCauliff (1982). We note that there is variation in the views that judges have regarding the burden of proof needed under each of these criteria.

We note that the fact that equilibrium enforcement ends up tolerating some misbehavior need not be a flaw in the way the law operates, for reasons related to Kaplow (2011b)'s concerns over chilling effects. Consider a model in which the baseline rate of opportunities for misbehavior (or its attractiveness) changes over time. If misbehavior is fully deterred, we cannot measure its counterfactual frequency. For this reason, highly deterrent laws prevent the accumulation of evidence that they are unnecessary. A criterion along the lines of (2) ensures that only necessary laws are active.

Damages. Antitrust allows for a variety of penalties, associated with different degrees of misbehavior and different burdens of proof. Damages, and burden of proof depend on the civil or criminal nature of the case, and whether the facts suggest a per se or rule of reason violation.

The Sherman and Clayton acts are largely enforced in civil courts, in which case the burden of proof on the plaintiffs is in theory "preponderance of evidence" (i.e. guilt is more likely than not) but in fact turns out to be closer to "clear and convincing evidence" (two to one odds). In principle, penalties follow the rule of treble damages, but as Lande (2005) argues, the rule is difficult to implement in practice. First, counterfactual losses difficult to evaluate. Second, time discounting is rarely taken into account, so that a cartel operating for many years does not pay interest on the damages it has caused. For this reason, Lande (2005) argues that treble ex post damages correspond to roughly simple damages at the time of misbehavior. Given that the likelihood of detection is less than one, this suggests that incentives to behave are relatively weak. In addition, executives need not fully perceive the risks of collusion. Resolving this question empirically seems of first order importance.

Open Question 5. *What are the risk-benefit tradeoffs of engaging in collusion? How do firm executives evaluate the risk-benefit tradeoffs of engaging in collusion? In what circumstances are firms most likely to be driven to collude?*

A variety of methods could be used to elucidate these questions. One intriguing possibility

would be to conduct suitably anonymous surveys of firm executives.

In addition to civil lawsuits, antitrust can lead to criminal prosecutions. In the words of the FTC:

> Although most enforcement actions are civil, the Sherman Act is also a criminal law, and individuals and businesses that violate it may be prosecuted by the Department of Justice. Criminal prosecutions are typically limited to intentional and clear violations such as when competitors fix prices or rig bids. The Sherman Act imposes criminal penalties of up to $100 million for a corporation and $1 million for an individual, along with up to 10 years in prison. Under federal law, the maximum fine may be increased to twice the amount the conspirators gained from the illegal acts or twice the money lost by the victims of the crime, if either of those amounts is over $100 million.

In this case, the standard of proof is "beyond reasonable doubt". In all cases, the defendants are presumed to be innocent, and the burden of proof falls on the plaintiffs.

The nature of facts to be established depends on the nature of misbehavior. Clear violations of the Sherman Act, including recorded price fixing and bid rigging, are per se violations, and are punishable regardless of their impact on consumer welfare. Other actions, including contractual restraints, fall under the rule of reason framework, and require establishing harm. Rule of reason arguments are typically more difficult to make for plaintiffs than per se arguments. In rare cases, defendants whose actions would normally fall under the per se regime can move their case to be evaluated under a rule of reason basis, if they can persuade the court of a plausible pro competitive basis for their actions. The burden of proof necessary to effect this change of regime falls on the defendant under a "clear and convincing evidence standard" (Rosch, 2009). This is known as the quick look or truncated rule of reason.

Evidence. Court proceedings admit a variety of evidence: hard evidence supplied by whistleblowers, statements made during cross examinations, as well as arguments made by economic experts. However as Rosch (2009) asserts,

> the [. . .] fundamental problem with many economic analyses is that they are too complex and therefore are incomprehensible. Based on my own experience, that is especially true of simulation studies and regression analyses that involve complex formulae requiring an economists knowledge of statistics.
>
> By contrast, there seemed to be agreement that direct evidence of the effects of a transaction or practice in the form of a party's own statements or documents is superior to those formulae in terms of their probative value. That also seemed to be true of the explanation by an economist of his or her assumptions and conclusions. Everyone seemed to agree that federal judges, as well as members of the European courts, are generally not Ph.D. economists, and that this kind of evidence is more likely to be probative when there is judicial review of prosecutorial challenges. Indeed, it does not appear that complex economic analysis has carried the day in many (if any) appeals in the United States or Europe.

This assessment is a difficult one for economists to accept. While it is possible that the comfort of judges and juries with technical arguments will rise over time, a more productive reaction is perhaps to draw implications about the sort of analysis that may end up being most influential. We can see two possible directions.

Open Question 6. *How can we make complex arguments more persuasive? How can we formulate economic models in ways that are persuasive to decision-makers?*

This is a general problem for economists – most policy questions that voters express views on are complex. There is reason to be hopeful in the context of antitrust: judges are in all likelihood a relatively more attentive and sophisticated audience. We note that other fields

of economics are engaging with related questions. For instance, Duflo (2020) discusses at length the process by which research findings find their way into policy. Vivalt and Coville (2021) highlights biases in the way policy makers learn from randomized controlled trials.

Part of the solution may be related to the way models are written. Courts may be cautious when models make assumptions whose impact on inferences are not obvious. One possible response, explored by Chassang et al. (2022) and Kawai et al. (2021) is to draw inferences under general environments. In practice, it may also be simpler for third-parties to subjectively evaluate the robustness of simple models, especially framed as expressive stories, than complex ones.

Second, the way statistical tests are expressed may be more or less intuitive. Finding expressive approximations may be hugely valuable. One example of successful communication is the SSNIP test for market definition: a market is sufficiently broadly defined if a monopoly would profitably implement a small significant non-transitory increase in price (typically 5% over 12 months). This is not a well grounded economic definition for a market, but it offers a good enough and intuitive solution.

The other direction is whether statistical information can be used to encourage cartel members to inform on one another.

Open Question 7. *Can we leverage statistical analysis to increase the revelation of hard information by informed parties as part of an evidentiary mechanism?*

Kaplan (2001) provides an evocative account of similar strategic use of information in the context of re Nasdaq Market-Makers Antitrust Litigation (1996). This approach may be particularly effective in the context of leniency negotiations.

Leniency and related design questions. The Department of Justice created its leniency program in 1978, and then revised it in Department of Justice (1993). In addition, the 2004 Antitrust Criminal Penalty Enhancement & Reform Act extended leniency provisions to civil suits. In both cases, guilty parties coming forward first can under certain conditions be

protected from criminal penalties (i.e. jail time and fines against individuals), and see civil damages reduced to single damages rather than treble damages. Leniency can be awarded under two scenarios laid out by the DOJ, whose main features are as follows:

- Scenario A: the firm bringing evidence is the first one, and the DOJ did not suspect wrongdoing;

- Scenario B: the firm bringing evidence is the first one, the DOJ had initiated a case, but did not have hard evidence.

Intuitively, leniency turns evidence provision into a coordination game in which providing evidence is the risk-dominant action (Harsanyi et al., 1988): if other firms are not providing evidence, not providing evidence is a best response; but if there is a risk that other firms will provide evidence, then doing so first yields a large payoff gain. In contrast, without leniency, not providing evidence would be a weakly dominant action.

Because leniency programs lead to hard evidence, they are particularly well suited to generate information that is actionable in court. In the words of the DOJ:

> The Antitrust Division's Leniency Program is its most important investigative tool for detecting cartel activity. Corporations and individuals who report their cartel activity and cooperate in the Divisions investigation of the cartel reported can avoid criminal conviction, fines, and prison sentences if they meet the requirements of the program.

The success of leniency programs should be perceived as an encouragement to study this approach in more detail. Spagnolo (2006) provides a survey of the literature. More recently Scarborough (2022) identifies a number of issues with recent evolutions in the DOJ's leniency policy, highlighting that seemingly more effective rules (for instance requiring that reports be prompt) can in practice reduce incentives to come forward by making eligibility to the leniency program uncertain.

We believe that the study of leniency programs under uncertainty, and their interaction with potential soft evidence (e.g. in the form of economic analysis) available to third-party stakeholders such as the DOJ is an attractive area for future research.

Open Question 8. *Can the DOJ iteratively leverage soft evidence to get a cartel to unravel? Is it optimal for the DOJ to keep its information secret? How much should it reveal, when, and to whom?*

6   Regulating Collusion

We think of regulation as a set of upfront steps taken to prevent collusion from happening in the first place. Naturally, regulation is made possible by detection, and the threat of possible prosecution, even if prosecution (ideally) remains off of the equilibrium path.

6.1   Structural regulation

Khan (2016) argues that *per se* structural approaches to antitrust may be necessary to address concerns that apparent short-term aggressive pricing may lead to future market power. This is especially true if market power is hard to detect and prosecute ex post: then, it is not sufficient to remedy market power issues if and when they show up; instead, it is important to prevent them in advance. The argument for structural approaches to antitrust also applies to collusion because the high burden of proof makes it difficult to prosecute once it has occurred.

One structural approach to regulating collusion is to incorporate the risk for collusion in merger analysis. Most merger analysis is performed under either static models, or Markov models that rule out collusive behavior. As a result, they ignore the fact that reducing the number of participants can facilitate the formation of cartels, either by facilitating coordination, or by facilitating the enforcement of cartel discipline.

Open Question 9. *What is an operational framework for merger analysis that takes into account the impact of mergers on collusion?*

While there has been work highlighting the impact of mergers on the possibility of collusion (Nocke and White, 2007, Ivaldi et al., 2007), building an operational merger framework would require evaluating the impact of mergers on the likelihood of collusion, and the degree of collusion. This is ultimately a question of probabilistic equilibrium selection in repeated games. It requires an empirical answer.

Another strategy is to encourage entry (Starc and Wollmann, 2022). Because entrants are not yet part of the cartel, coordinating with them is more difficult. In addition, entrants diminish the pie available to cartel members, reducing incentives to maintain cartel discipline. Depending on the context, different strategies may be used to encourage entry. In the context of procurement auctions, Chassang and Ortner (2019) argue using data from Japan that minimum prices can both increase entry and destabilize cartels. In other markets, targeted subsidies for entry in specific industries may be desirable. Brunnermeier et al. (2022) recently argued that this approach could be useful in regulating oil prices.

Because some of these structural remedies to collusion can be expensive (e.g. subsidies for entry) it may be that they are used as policy responses only once collusion has been detected and no cost effective remedy can be found. We note that states and cities routinely offer targeted incentives for entry in the form of tax rebates to new firms.

6.2 Regulating by negotiating

A key trade-off between negotiated solutions and taking cases to courts is that trials create precedents that affect long-term outcomes. However court decisions can be unpredictable, so that going to trial is effectively a lottery over long term policy. For this reason, while the evidence is not overwhelmingly strong, it may be optimal for regulators to negotiate.

Consent orders, or consent decrees are agreements settling disputes between parties with-

out admission of guilt. A court of justice is included as part of the agreement and serves to monitor and enforce the agreement. As part of the agreement, the firms will agree to certain behavior restrictions.

Consent decrees have been used to settle cases since early in the history of US Antitrust. In Swift & Co. v. United States (1905) the US Supreme Court issued a consent order enjoining meatpacking firms, members of a beef cartel, to stop coordinating on pricing and entry decisions. The nature of the dispute was whether federal antitrust law applied to the defendants' practices. Under the settlement, the meatpackers accepted to follow the rules set out by the court without recognizing that they were in fact conspiring to restrain trade. Importantly, consent decrees do not require guilt to be established since the defendant consents to its terms. As a result consent decrees are largely final, in contrast with judgments that can be appealed. For this reason when the defendants attempted to get the terms of the decree dismissed in Swift & Co. v. United States (1928) on the ground that there was no instance of conspiracy in the first place, their case was thrown out: consent orders are not predicated on one party's illegal behavior.

The FTC routinely uses consent orders, for instance in several of the cases discussed in Harrington (2018), such as Valassis Communications, Inc. (2006) and U-Haul International, Inc. (2010).

Negotiated consent orders can serve the process of regulation in two ways.

- They allow more flexibility in the remedies than damages estimated by courts, including merely stopping behavior, divesting assets (Harrington, 2017) ...

- They reduce risk for both firms and regulators. Court decisions are risky and might lead to extreme outcomes. Consent orders in the shadow of prosecution may benefit both firms and the FTC. This is a good way for the FTC to obtain partial satisfaction when it is very uncertain that courts would judge in its favor.

In a manner similar to Kamenica and Gentzkow (2011), there maybe an optimal time

for the FTC to seek a consent order depending on the information received: before discovery; after discovery but before judgement; after some but not all aspects of the judgment have been clarified.

A concern however, is that consent orders may end up having little effect on actual collusion: a cartel may agree to stop communicating via earnings calls, but once coordinated, they may continue to operate under tacit collusion.[11] In addition, the availability of consent orders may increase the ex ante returns to collusion.

Open Question 10. *How effective are consent orders at curbing collusion once it has taken place? What is the impact of consent orders on ex ante incentives to collude and actual collusion decisions?*

Open Question 11. *What is the optimal use of consent orders vs. prosecution as a function of the discovery process?*

6.3   Regulating by informing

As we highlight in Section 5, intent (i.e. a party's knowledge of the consequences of their acts) is essential in obtaining a conviction. Mandated information may play a role in this setting by not only ensuring that firms know the consequences of their actions, but that courts know that firms know.

One way to achieve this may be to mandate firms in seemingly non competitive industries may to undergo third party audits evaluating their business practices for antitrust compliance. Similarly, firms operating in certain problematic markets may be required to get liability insurance for collusive practices. This incentivizes good behavior, and also increases the probability that firms will take the threat of prosecution seriously: information helps establish intent.[12]

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[11]In fact, any drop in prices may end up serving as evidence of collusion.

[12]A counterpart of this reasoning is that firms may also systematically avoid information establishing their own awareness that they are participating in a conspiracy. This suggests that internal compliance enforcement is likely difficult.

This approach can be formalized using the game tree illustrated Figure 2. Imagine that a firm chooses between two behaviors L and R, whose payoffs to the firm are always M (for L) and H (for R), with $M < H$, but whose social consequences depend on the state of nature L or R. Action L is always safe, and leads to a social payoff M in all states. Action R is risky and leads to a social payoff L in state L, but H in state R, with $L < M$. In the event that the firm causes social damage (L) a court may decide to impose a fine $K > 0$ such that $H - K < M$.

In the uninformed case, the firm does not know the state. In the informed case, the firm does, because it receives an audit report making a behavioral recommendation.

If we model juries as having social preferences over realized payoffs (Chassang and Zehnder, 2016), the jury's decision to impose a fine will not depend on which game tree is used. In contrast if a model capturing intent is used, for instance a model of social preferences over ex ante prospects, then the court will be more likely to rule against an informed firm than an uninformed one.

The difficulty of establishing intent, and the value of third party audit is particularly important when the legality of actions itself is uncertain. One prominent example is the use of AI pricing, and associated liability should AIs collude.

6.4 Regulating pricing AIs

A growing set of concerns relates to the use of artificial intelligences (AI) to make pricing decisions. Crucially, as Harrington (2012, 2018) notes, if AIs turn out to be better than humans at tacit collusion, or if collusion by AIs is considered as tacit per se, then these instances of collusion will be difficult to prosecute under the current application of US antitrust law.[13] Assad et al. (2020) provides evidence that the adoption of pricing algorithms led to collusive price increases among German gas stations. Calvano et al. (2020b,a) as well

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[13]A possible countervailing use of AI is to speed up the discovery process by evaluating large written and audio archives for incriminating content.
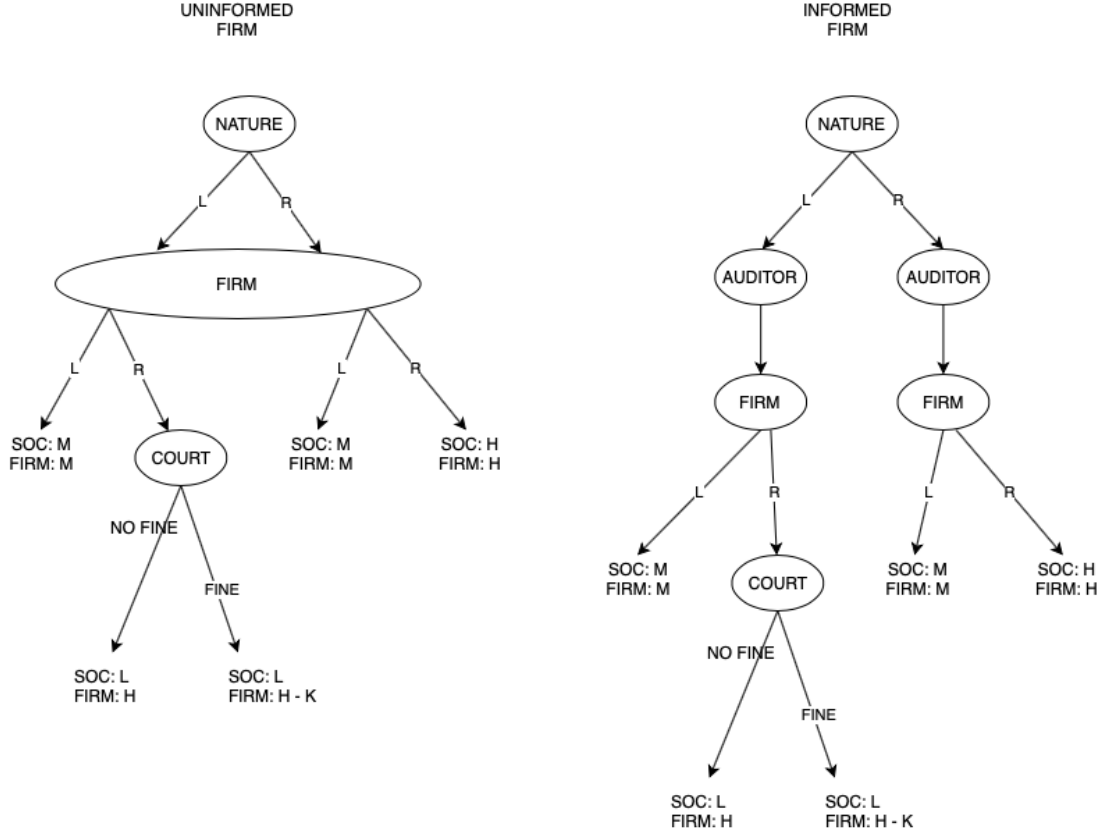
Figure 2: Explicit intent and liability

as Asker et al. (2021) investigate via simulations aspects of pricing algorithms that can lead to supra-competitive prices. They emphasize the importance of associating pricing decisions with intertemporal continuation values as in Q-learning, as well as the importance of properly defining counterfactual profit outcomes for pricing decisions not taken. Besides this evidence, it seems clear that a court-ruling exonerating firms maintaining supra-competitive prices through the use of pricing AIs prone to collusion would considerably expand the already-problematic "parallel conduct loophole". For this reason, it is essential that scholars help formulate a framework to deal with such cases before a damaging precedent is established.

Harrington (2018) lays out a possible approach to deal with AI collusion that builds on the more open legal definition of unlawful collusion described in Section 3: the reason judges

have focused on communication is that it is one unambiguous marker of conspiracy, for which there can be evidence with positive probability. In contrast, intentions to collude remaining in people's head are inaccessible. The key observation made by Harrington (2018) is that contrary to thoughts, AIs strategic dynamic responses on and off the path of play are in principle accessible to courts: the code can be read and simulated in realistic situations. For this reason, under Justice Breyer's more open interpretation of antitrust case law it may be possible to offer concrete procedures allowing courts to address collusion between AIs. This leads Harrington (2018) to propose a research program seeking to define criteria for AIs to be acceptable, as well as define liability in a manner that imposes the least hindrances on competing firms, while effectively punishing colluding ones.

In this section, we flesh out a few concrete steps towards Harrington (2018).

Ensuring no regrets with pricing wrappers. In the context of procurement auctions, Chassang et al. (2022) formulate a general inference program detecting failures of competitive behavior built on the observation that under competitive behavior firms should not be experiencing significant regrets with respect to their pricing strategies. It turns out that this criterion can be used to ensure that pricing AIs do not lead to collusive outcomes without significantly restricting the ability of competitive firms to use AI to improve pricing.

Consider a firm i using a pricing AI ϕ taking as inputs observed covariates $(X_{i,t})_{t\in\mathbb{N}}$. In every period t, $\phi(X_{i,t}) \in \mathbb{R}$ is a pricing recommendation which we denote by p_t^{req}. Given the pricing choices made by other firms, we denote by $d_{i,t}(p)$ firm i's residual demand when it sets price p. For simplicity we assume that firm i's cost $c_{i,t}$ takes values in a finite set $C \subset \mathbb{R}_+$. Similarly, we assume that possible prices take values in a finite set $P \subset \mathbb{R}_+$. Firm i's profit following pricing decision p in period t is denoted by

$$\pi_{i,t}(p) = d_{i,t}(p) \times (p - c_{i,t}).$$

We propose to discipline the behavior of the AI by requiring the firm to encapsulate it within a pricing wrapper that satisfies the two following goals: (i) it ensures that the firm follows the AI's recommendation if they increase flow profits; (ii) it ensures that pricing deviates from the AI's recommendations if targeted deviations can increase flow profits.

Concretely, let $h_t^0 = (\pi_{i,s}, c_{i,s}, p_{i,s}, p_t^{req})_{s<t}$ denote the history of profits, costs, pricing choices, and AI recommendations. Note that the history only records on path profits, and need not include counterfactual profits. A pricing wrapper is a function

$$\sigma : h_t^0 \to \Delta(P)$$

which associates histories to implemented prices. Note that the wrapper gets to use recommended prices p_t^{req} as inputs (though it does not need to observe covariates $X_{i,t}$).

In each period T, we define the following set of regrets:

$$\forall p, p' \in P^2, c \in C, \quad \mathcal{R}_{i,T}^{c,p \to p'} \equiv \frac{1}{T} \sum_{t=0}^{T} \left(\pi_{i,t}(p') - \pi_{i,t}(p) \right) \times \mathbf{1}_{c_t, p_{i,t}=c,p} \tag{3}$$

$$\forall p \in P, c \in C, \quad \mathcal{R}_{i,T}^{c,p \to req} \equiv \frac{1}{T} \sum_{t=0}^{T} \left(\pi_{i,t}(p_{i,t}^{req}) - \pi_{i,t}(p) \right) \times \mathbf{1}_{c_t, p_{i,t}=c,p} \tag{4}$$

These are internal regrets capturing the average payoff-gains from conditional deviations in price decisions. Remarkably there exist prior-free wrappers σ such that with probability approaching 1 as T grows large, all these regrets approach zero with probability 1 (Hart and Mas-Colell, 2000, Cesa-Bianchi and Lugosi, 2006). Note that this is the case even though counterfactual demand, and therefore the actual true regrets are not directly observed, but instead must be estimated through experimentation.

Wrapping up pricing AI ϕ within a no-regret strategy σ has two benefits:

(i) An implication of Hart and Mas-Colell (2000) is that whenever these regrets are small, then the joint distribution of prices approaches a correlated equilibrium

of the one-shot pricing game with privately observed costs. This guarantees that pricing algorithms wrapped within a no-regret strategy cannot effectively collude using dynamic rewards.

(ii) Whenever the pricing decisions recommended by the AI improves over all policies that are fixed conditional on costs, then the wrapper will end up choosing the AI recommended decision most of the time.

This has multiple advantages from a regulatory perspective:

- it doesn't require understanding pricing algorithm ϕ or simulating it; no algorithmic pre-approval is necessary;

- it doesn't force firms to deviate from their intended pricing strategy unless there is evidence that they are failing to optimize flow profits; the costs of applying this restriction to competitive industries are vanishing;

- it guarantees that AIs cannot collude.

We note that these are asymptotic results, so that more work is needed to establish the viability of this approach in plausible environments.

Open Question 12. *Do no-regret wrappers address the possibility of collusion in plausible simulated environments? Do they affect competitive AIs? Over what time scale? Which markets can they be realistically applied to?*

Restrictions on values. The no-regret approach identifies competition with maximizing short-run profits. One practical difficulty is that in many settings desirable competitive behavior will involve intertemporal considerations. For instance, for products with increasing gains from scale, or learning by doing, it may be valuable to keep prices below flow-profit maximizing prices to build market share and experience. Inversely if backlog increases future production costs, it may be optimal to price above flow-profit maximizing prices.

This means that a firm's legitimate competitive goal may involve solving:

$$\max_{p_{i,t}} \mathbb{E}\left[\pi_{i,t}(p_{i,t}, p_{-i,t}) + \delta V_{i,t}(d_{i,t}, p_{i,t}, p_{-i,t})\right] \tag{5}$$

where $V_{i,t}$ captures firm i's continuation value conditional on its demand, its price, and the prices $p_{-i,t}$ chosen by others.

It is well understood that if value function $V_{i,t}$ is flexible enough, it can encode reward and punishment schemes capable of supporting collusion. As we already highlighted in Section 3, this presents a challenge for economic theory: defining collusion using Harrington (2018) dynamic reward and punishment criterion, becomes trickier in environments where production costs depend on past production and pricing decisions. As a result, it becomes trickier to distinguish collusive price choices from dynamically optimal choices even when firms are not colluding.

We think that carefully thinking through restrictions on value functions that respect firms' legitimate cost dynamics, while also limiting the potential for collusion is a practically useful, and theoretically intriguing question for future research.

Kawai et al. (2021) offers an example of what a theory of reasonable restrictions on value functions might look like. In the context of procurement auctions, Kawai et al. (2021) show that under the assumption that $V_{i,t}(d_{i,t}, p_{i,t}, p_{-i,t})$ is Lipschitz-continuous in both $p_{i,t}$ and $p_{-i,t}$, then it is possible to derive testable predictions on the joint distribution of bidders' submitted prices and covariates. In particular, firm covariates must be continuous conditional on bids. This allows Kawai et al. (2021) to differentiate pricing behavior driven by dynamic costs of backlog from collusion using bid rotation.

Two observations may prove useful going forward:

- At least theoretically, one benchmark may be to consider value functions that can be sustained as limits of value functions in finite horizon games, provided that one shot collusion games don't have multiple equilibria. Provided the analyst is able to impose

some constraints on costs (say from an engineering understanding of the problem), then this would lead to restrictions on acceptable value function.

- Oblivious equilibrium (Weintraub et al., 2008, Benkard et al., 2015) is used to compute industry equilibrium in settings with many firms. In industries with many firms, keeping track of a vector of individual states within each firms' dynamic is both computationally infeasible and strategically implausible. Oblivious equilibrium considers dynamics in which each firm approximates the industry state and assumes it follows an exogenous process. This is a solution concept that assumes realistic but imperfect rationality from firms. In addition, by taking as exogenous the behavior of other firms, it generates a class of value functions that exclude collusion.

Open Question 13. *Does oblivious equilibrium adequately capture firms' unilateral profit optimization problem?*

One state variable that is both practically relevant and problematic as a way to encode collusion is market share. In particular, many of the earnings calls/public communication cases described in Harrington (2022) involve strategies along the following lines:

> We will continue to keep prices high, under the constraint that our market share does not decline.

This very naturally induces a collusive strategy in which firms threaten price wars in the event that others take advantage of high prices to steal market share. At the same time, it is plausible that maintaining scale is an important dynamic consideration for manufacturing.

Open Question 14. *How can we extend the idea of no-regret wrappers in settings with legitimate continuation values?*

7   Policy Responses: Accommodation and Containment

Successful prosecution is perhaps the most salient way in which regulators can address and punish instances of collusion. However, in the event that prosecution fails, or seems unlikely to succeed, regulators and stakeholders have a number of policy levers available that can reduce the impact of collusion, or make life more difficult for cartels.

Encourage entry.   The most obvious policy response is to take steps to encourage entry. As Starc and Wollmann (2022) argue in the context of generic drug manufacturing, the entry of new competitors is an effective remedy against collusion: coordination with new entrants is more difficult; it requires sharing existing profits with a growing number of cartel members, making collusion harder to sustain.

Different mechanisms may be used to encourage entry. In the context of procurement auctions, Chassang and Ortner (2019) argue that setting minimum price guarantees encourage entry and weakens collusion. Minimum prices ensure that cartel members cannot effectively dissuade entry by threatening price wars. As a result, they reduce the financial risk of entering new markets.

Brunnermeier et al. (2022) make a related case in the context of energy price regulation. Specifically, they argue for advance purchase commitments extended to marginal entrants in the energy production, storage, and transport markets. This idea can be applied in a number of contexts. For instance, in response to the dismissal of Bell Atlantic v. Twombly (2007), the state of California may have provided short term-subsidies for the entry of new mobile operators.

An additional strategy to increase entry may be to require redundancy of supply for government procurement. This can also be viewed as a measure to increase the resilience of government to shocks.

We note that other than encouraging entry, several aspects of market design can affect firms propensity to collude. Harrington Jr (2011) builds on the example of v. General

Electric Co. (1977) to argue that posted pricing schemes with prohibitions on discounts support collusive behavior. See Ivaldi et al. (2007) and Marshall and Marx (2009) for related discussions.

Allow countervailing market power. It is well understood that in the presence of a cartel, trade becomes a bargaining problem, so that it may be beneficial for other parties to organize to increase their own bargaining power. In the context of standard purchase auctions, Graham and Marshall (1987) and McAfee and McMillan (1992) show that the optimal response to the presence of a cartel is to increase reserve prices, matching the optimal take-it-or-leave-it offer if the cartel operates as a unitary decision maker.[14]

This idea is reflected in practice. Labor unions are an obvious response to monopsony power by firms. Grocery retailers, as well as hospitals often form purchasing groups, or sign up with group purchasing organizations to increase their bargaining power, and secure better prices. From a theoretical perspective, bulk purchasing, especially if done on a bilateral basis rather than through observable pricing increases cartel members' temptation to defect.

The difficulty is that in principle, antitrust law also applies to purchasing groups and distinguishing legitimate versus illegal purchasing groups is difficult (Carstensen, 2010). Labor unions had to be explicitly excluded from antitrust law by the Clayton Act. The stamp buyers' cartel studied in Asker (2010) is a well known example of an illegal buyers' cartel. And indeed, the US Supreme Court has ruled against buyers cartels in the event that they created serious restraints on trade. For instance in Eastern States Retail Lumber Dealers' Ass'n v. U.S. (1914) the US Supreme Court ruled against a group of lumber buyers seeking to leverage their market power to exclude other buyers from the market. In contrast, purchasing groups are tolerated on a rule of reason basis when they have a pro competitive impact, for instance if large orders help organize supply logistics.

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[14]However, because they restrain trade, tight reserve prices can potentially leave buyers worse off (Iossa et al., 2022).

Open Question 15. *What is a good framework to evaluate the welfare impact of buyer groups in competitive and non-competitive environments?*

One especially useful institutional innovation would be for regulators and courts to setup an expedited safe harbor process for purchasing groups facing plausibly cartelized sellers, in which buyers would obtain a ruling clarifying conditions under which they may group purchases without running afoul of antitrust law. OIG Advisory Opinion No. 18-07 (2018) provides an example of safe harbor ruling in the context of medical group purchases.

Frequent moderate responses. Enforcing antitrust law through high-stakes lawsuits involves rare (due to the high burden of proof) but large (at least in principle) punishments, following a scheme à la Becker (1968). An advantage of discretionary policy responses (including perhaps consent orders) is that they can allow more frequent, smaller scale responses to misbehavior.

Indeed, there is evidence that frequent moderate penalties are more effective in changing behavior than rare large punishments (Teodorescu et al., 2021). The likelihood of rare events is hard to evaluate, and limited liability may lead decision makers to underweigh large negative risks. In contrast frequent moderate penalties are much more likely to impact decision makers' bottom line in a rapid and effective way. In addition rapid feedback improves learning, whether by human or artificial decision makers.

Moderate penalties may take a variety of forms: repeated mildly intrusive oversight, repeated threats of lawsuits, market interventions, minor divestments and fines. An advantage of using small penalties is that under a principle of proportionality, they might be assigned using lower standards of proofs, hopefully speeding up regulatory reaction times.

Open Question 16. *Is the "frequent moderate punishments" approach to policy enforcement, as opposed to the "large rare punishment" approach, effective in the case of firms?*

8 Conclusion

Changes in technology, business practices, and case law have made the regulation of collusion more difficult: Bell Atlantic v. Twombly (2007) has made access to discovery challenging, new ways of communicating allow firms to coordinate in ways that do not lead to actionable evidence, the increased use of AIs in pricing raises concerns over growing tacit collusion.

We highlight two perspectives that are useful in evaluating potential responses to these challenges. The first is a revealed preference approach to case law that hopes that, by improving our model of courts, we can also improve the persuasiveness of statistical methods, and the effectiveness of our evidentiary processes. The second is a process view of regulation in which prosecution is only one of many steps. It is a complement to some steps, such as consent order negotiations, and a substitute to others, for instance ex post policy accommodations such as subsidies for entry.

Within this broader view of the process of regulation, we make a few concrete proposals. First we suggest that safe tests, which do not fault competitive behavior under broad ranges of environments, may offer a way to access the discovery process on the basis of economic data consistent with Bell Atlantic v. Twombly (2007). We suggest that no-regret wrappers may be an effective, and unobtrusive way to address pricing AIs' potential for tacit collusion. We argue that economic evidence may be used to enhance the effectiveness of evidentiary mechanisms offering leniency in exchange for hard evidence. Finally, we wonder whether an approach to regulation based on frequent moderate interventions, accessible at a low burden of proof, may not prove more effective than the system of rare large punishments offered by the legal system.

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