Protecting Consumers from High Prices Due to AI

Emilio Calvano, Giacomo Calzolari, Vincenzo Denicolò, Joseph E. Harrington, Jr.
and Sergio Pastorello

Introduction

Collusion is when firms coordinate on the prices they charge to consumers. In almost all countries, collusion is unlawful. At present, there is a backdoor through which firms could collude using Artificial Intelligence. AI-enabled collusion has occurred in the virtual world and, should it occur in the real world, society is defenseless against it. We describe the source of the problem and call for a program to develop a solution.

What is algorithmic collusion and why is it a concern?

The efficacy of the market system is rooted in competition. In striving to attract the business of customers, firms are led to charge lower prices and deliver better products and services. Nothing more fundamentally undermines this process than when firms agree not to compete. Collusion is universally condemned by economists and policymakers, regardless of their political ideology.

Collusion typically involves firms' employees with price-setting authority communicating and coordinating to set prices exceeding those which would have occurred under competition. Given that the price-setting task has been increasingly delegated to algorithms in recent years,[1] this operational change has the potential for altering how collusion manifests itself. "Algorithmic collusion" is when the algorithms themselves coordinate on setting higher prices, all of which is done without human intervention, oversight, or even knowledge.[2]

Though the use of pricing algorithms has a long history - airline companies, for instance, have been using revenue management software for decades - concerns regarding algorithmic collusion have only recently arisen for two reasons.

First, pricing algorithms have evolved from rule-based programs to rely more on AI systems that learn autonomously through active experimentation. Once programming in a goal such as profit maximization, there is no human input during the learning process. The enhanced sophistication of learning algorithms makes it more likely that AI will discover profit-enhancing collusive pricing

[1] This is true both in online marketplaces such as Amazon (Chen et al., 2016) and in more traditional sectors such as for instance gas stations (Assad et al., 2020).

[2] Algorithmic collusion is to be distinguished from firms' employees initiating collusion and then conducting it with the assistance of algorithms, such as occurred in recent U.S. and UK cases against sellers of wall posters on Amazon Marketplace.

schemes, just as they have succeeded in discovering winning strategies in complex board games such as chess and Go.[3]

Second, a feature of Big Data in online markets is that competitors' prices are available to a firm, and in real time. Such information is essential to the implementation of collusive pricing rules. In order for firms to coordinate their prices, those prices must be observed by each other. Furthermore, effective collusion requires the prospect of a firm punishing another firm with aggressive pricing should it lower price to capture more market share. It is the anticipation of such a response that induces a firm to price at a high level. Thus, the emergence and persistence of collusion is facilitated by high frequency price data, which is now often available online.

Algorithmic collusion is no longer an abstract possibility. Recent research has shown its spontaneous emergence in computer-simulated markets. Using a common method of reinforcement learning in the context of a well-accepted economic model of a market, algorithms learned to initiate and sustain collusion.[4] Collusion arose with no human intervention other than instructing the AI-enabled learning algorithm to maximize profit.

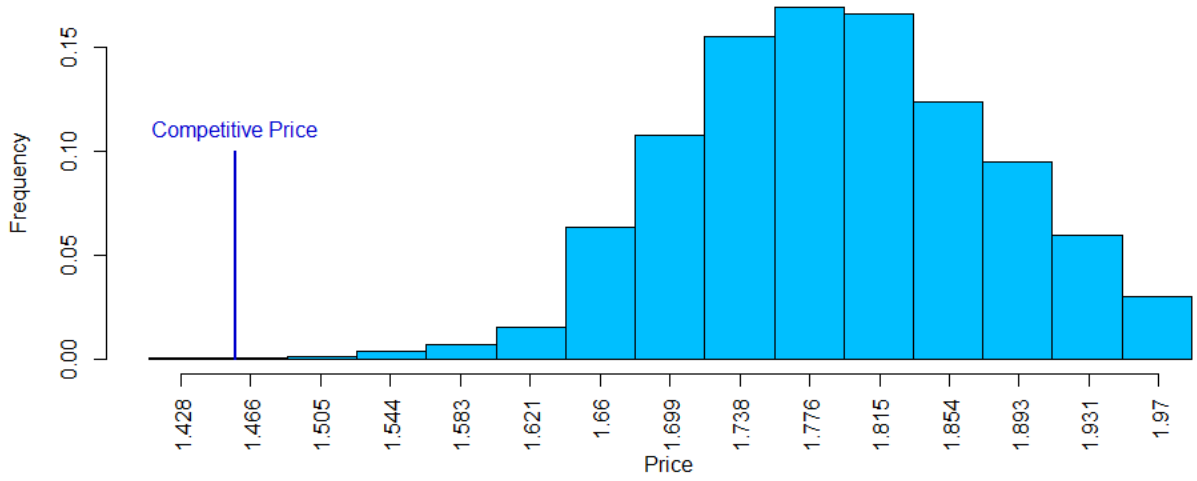

Figure 1. The distribution of prices charged by reinforcement-learning price algorithms in the virtual market created in Calvano et al. (2020). The price that would maximize the firms' joint profit is just above 1.9. The algorithms routinely learned to collude.

Figure 1 plots the distribution of the prices charged by the algorithms in a virtual market over a large number of simulations. Only rarely did the algorithms converge to the competitive price. While the extent of collusion varies, prices were almost always substantially above the competitive level. Algorithmic collusion was a common occurrence.

[3] See Silver et al. (2018).
[4] Calvano et al. (2020) and Klein (2019).

Can algorithmic collusion emerge in real markets?

Starting in 2017 and 2018, concerns regarding the possibility of algorithmic collusion have been raised by government authorities including the U.S. Federal Trade Commission,[5] the United Kingdom's Competition & Markets Authority,[6] the European Commission, and the OECD.[7] At the same time, some economists find these concerns unwarranted.[8] They liken algorithmic collusion to tacit collusion, which is when firms' employees coordinate without direct communication by instead signalling with their prices. Given that tacit collusion is believed to be uncommon, they extrapolate when claiming all forms of collusion without communication – whether conducted by humans or computer programs – are rare.

It may be true that, without communication, collusion by human subjects in a laboratory setting occurs infrequently, even for simple market environments.[9] However, algorithmic collusion in a (virtual) laboratory setting is very common, and for significantly more complex market environments. Given the learning processes of humans and AI are distinct, it is not surprising that the outcomes that emerge should differ. We see no sound basis upon which to predict that algorithmic collusion would be sufficiently rare that it should be dismissed as a relevant concern.

Underscoring this point as well as heightening concerns, there is evidence of algorithmic collusion in Germany's retail gasoline markets. A recent study[10] finds the delegation of pricing to algorithms was associated with a 20-30 percent increase of stations' average price-cost margin. Though the evidence is indirect - because the authors of the study could not directly observe the timing of adoption of the pricing algorithms and thus must infer it from other data - their findings are consistent with that found in computer-simulated markets.

Why is society defenseless against algorithmic collusion?

Should algorithmic collusion emerge in a market and be discovered, society is currently defenseless to stop it. The problem lies in how the law prohibiting collusion is written and how jurisprudence has interpreted that law. Though it is higher prices that harm consumers, the illegality of collusion resides in the process which produces those higher prices, not the higher prices themselves. What is unlawful is firms having a "meeting of minds,"[11] a "concurrence of wills,"[12] or "a conscious commitment"[13] that they will not compete. Unless courts are prepared to conclude that AI has a

[5] "The Competition and Consumer Protection Issues of Algorithms, Artificial Intelligence, and Predictive Analytics," Hearing on Competition and Consumer Protection in the 21st Century, U.S. Federal Trade Commission, November 13-14, 2018 https://www.ftc.gov/news-events/events-calendar/ftc-hearing-7-competition-consumer-protection-21st-century

[6] "Pricing Algorithms: Economic working paper on the use of algorithms to facilitate collusion and personalised pricing," U.K. Competition & Markets Authority, October 2018. https://www.gov.uk/government/publications/pricing-algorithms-research-collusion-and-personalised-pricing.

[7] See "Algorithms and Collusion – Note from the European Union" 2017 and "Algorithms and Collusion," OECD Roundtable, June 2017 http://www.oecd.org/competition/algorithms-and-collusion.htm.

[8] Kühn and Tadelis (2018) and Schwalbe (2019).

[9] Potters and Suetens (2013).

[10] Assad et al. (2020).

[11] *American Tobacco Co. v. United States* 328 U.S. 781, (1946).

[12] *Bayer AG v Commission of the European Communities* , Judgment of the Court of First Instance of 26 October 2000.

[13] *Monsanto Co. v. Spray-Rite Serv.*, 465 U.S. 752, (1984).

"mind" or a "will" or is "conscious" then there can be no "meeting of minds" with algorithmic collusion.[14] In short, if algorithmic collusion occurs and is discovered by the authorities, it is not a violation of antitrust or competition law. Society would then have no recourse and consumers would be forced to continue to suffer the harm from higher prices.

What can society do about it?

Meeting the challenge of algorithmic collusion requires the combined efforts of computer scientists, economists, and legal scholars. Legal scholars need to interpret existing laws or design new laws to make algorithmic collusion illegal so, once found, it can be shut down. Computer scientists and economists need to solve the challenges of detecting algorithmic collusion and preventing learning algorithms from adopting collusive pricing rules.

From a legal perspective, the focus must go beyond "state of mind" and the communication practices that facilitate collusion. As is well established in economics, collusion is the sustaining of high prices by the threat of a punishment, such as retaliatory low prices, should a firm deviate from those high prices.[15] Collusion can be thought of as an implicit arrangement whereby a firm prices high if the rival firm does so and prices low if the rival firm does not do so. Prohibition of firms using pricing rules that embody that "if then" statement is the path to prohibiting algorithmic collusion.

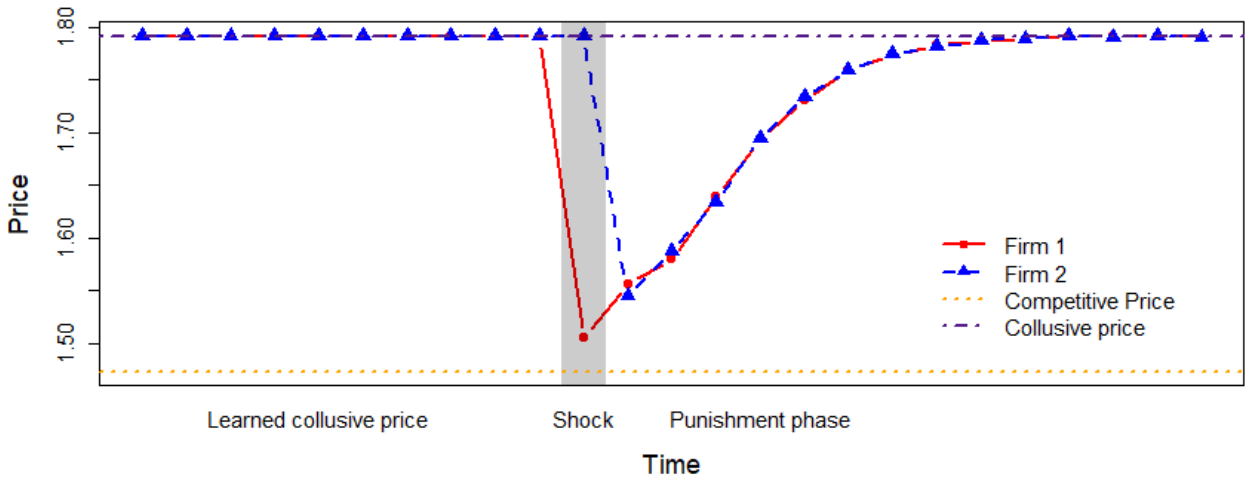

Figure 2. After the two algorithms have learned their way to collusive prices, an attempt to "cheat" so as to gain market share is simulated by exogenously forcing one of the two algorithms to cut its price. From the "shock" period onwards, the algorithm regains control of the pricing. The deviation is punished by the other algorithm, so firms enter into a price war that lasts for several periods and then gradually ends as the algorithms return to pricing at a collusive level.

Underlying the high prices that emerged in the computer-simulated markets reported in Figure 1 is exactly this collusive property of retaliation against undercutting of high prices. Part of the price path from one of those simulations is shown in Figure 2 where one can see that the pricing algorithms settled on prices well above the competitive level. To determine whether the pricing

[14] Ezrachi and Stucke (2017) and Harrington (2018).
[15] Harrington (2017).

algorithms have learned this collusive property, the programmer overrode Firm 1's pricing algorithm by forcing it to set a lower price ("shock"). As shown in Figure 2, both firms' pricing algorithms immediately engaged in a temporary price war, where lower prices were charged with prices then gradually returning to the collusive level. Having learned that undercutting the other firm's price brings forth a price war (with the associated low profits), the algorithms evolved to setting high prices.

It is exactly this collusive property that is the key to identifying and preventing algorithmic collusion. When prices reach suspiciously high levels or there is a change in prices that could be associated with collusion, the authorities could audit firms' pricing algorithms to test for the collusive property. Furthermore, it may be possible to constrain learning algorithms to avoid adopting pricing strategies that embody this property. Firms that delegate pricing decisions to algorithms could be required to regularly test their pricing rules for this property in order to ensure that it is not present.

These are some of the avenues that can be pursued for preventing or shutting down algorithmic collusion. The challenge is to achieve this goal without giving up the gains in terms of economic efficiency from pricing algorithms such as the quicker response to changing market conditions.

Concluding remarks

Suppose a designer of a computer program suddenly learned there was a backdoor that compromised the program's security. Would it be sensible to leave the program vulnerable and hope that no one would ever find it? Or would prudence call for creating a fix? Currently, there is a backdoor through which algorithmic collusion can infiltrate markets. As authorities prepare to take action,[16] it is vital that computer scientists, economists, and legal scholars work together to create a fix and thereby protect consumers from the potential harm of high prices.

Authors

Emilio Calvano is Professor of Economics at the University of Bologna and Research Fellow at CEPR, London; e-mail emilio.calvano@unibo.it

Giacomo Calzolari is Professor of Economics at the European University Institute, Florence, and Research Fellow at CEPR; e-mail giacomo.calzolari@eui.eu

Vincenzo Denicolò is Professor of Economics at the University of Bologna and Research Fellow at CEPR, London; e-mail vincenzo.denicolo@unibo.it

[16] On June 3, 2020, the European Commission announced the need for a "new competition tool" which, among other goals, would tackle "the structural lack of competition" due to the "increasingly prevalent algorithm-based technological solutions" that may induce collusion. European Commission, Inception impact assessment – Ares (2020) 2877634.

Joseph E. Harrington, Jr. is the Patrick T. Harker Professor of Business Economics and Public Policy at Wharton; e-mail harrij@wharton.upenn.edu

Sergio Pastorello is Professor of Econometrics at the University of Bologna; e-mail sergio.pastorello@unibo.it

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