Antitrust in High-Speed: Colluding Through Algorithms and Other Technologies

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What is a price-setting algorithm?

A price-setting algorithm is a software program for determining the price of a product or service. It takes data on the market environment – such as cost, demand, and inventories – and assigns a price. Algorithms are programmed to serve a company's objective, such as maximizing profit or revenue or building market share.

Algorithms vary in terms of the extent of human intervention, which will prove to be a factor relevant to the legality of algorithmic pricing in the context of section 1 of the Sherman Act. A price-setting algorithm could be as simple as providing a fixed markup over cost where the human agent sets the markup, and the algorithm automatically adjusts price to changes in cost. An algorithm with more discretion might use data (prices, quantities, etc.) to estimate the product's demand, and then search to find the price that maximizes expected revenue based on that estimated demand. In that case, the human agent is setting the objective of the algorithm – expected revenue maximization – and some broad parameters to the algorithm but not the particular pricing rule, which is left to the algorithm to figure out.

It is useful to think of a pricing algorithm as composed of a pricing rule and a learning algorithm. A pricing rule sets price based on market characteristics such as cost, demand, and inventory. A learning algorithm selects among pricing rules to find the best pricing rule, where what is "best" is defined by the human programmer. For example, a pricing rule may have price be a fixed markup over cost. A learning algorithm would learn what is the best markup based on past rules and how they performed. Where human agents previously engaged in such learning, it can now be automated with a software program.

What are the efficiency benefits of price-setting algorithms?

The potential efficiency benefits of a learning algorithm and the automated pricing rule that it selects can come from two possible sources.

First, a learning algorithm can make the company more informed about how price affects profit, and that allows the company to better identify profit-maximizing prices. In other words, a learning algorithm uses *past* data to better predict the relationship between price and profit. Some learning algorithms are composed of two modules; an estimation module that makes predictions about demand conditional on current market conditions, and an optimization module that selects prices based on that estimated

demand. These learning algorithms build in price experimentation in order to enhance learning and, more generally, dynamically optimize.

Second, an automated pricing algorithm can allow price to be better tailored to current market conditions by rapidly adjusting price to take account of changes in market conditions and personalizing price to a consumer's traits. In other words, it uses *current* data to more effectively set price given the environment. This second efficiency is made possible by big data.[1] With automated pricing, prices can adjust as soon as new information is received, which means price can quickly adapt to changes in sales, inventories, rival companies' prices, and any other variable that is monitored at a high-frequency level. Another benefit from automated pricing and big data is that it can personalize prices to a customer's traits or to a class of customers; that is, engage in more refined price discrimination. This information could be the time of day that a consumer is on a website, the consumer's clickstream activity or past purchases, and demographic information (which the company may have if the consumer is registered with the website).

In sum, the potential efficiencies of a price-setting algorithm are better estimates of a company's environment and finding prices more suitable to current market conditions.

How can price-setting algorithms promote collusion?

Consider representatives of competitors communicating in order to coordinate their conduct so as unreasonably restrain trade. Rather than coordinate on a particular price, they may coordinate on their pricing algorithms. Such a case occurred in 2015 with the Antitrust Division's prosecution of two online sellers of posters. The possibility of coordinating pricing algorithms, as opposed to prices, makes collusion more likely because it becomes more attractive. First, collusion is more profitable because the collusive price can better adjust to market conditions when companies have coordinated on pricing algorithms. This is potentially valuable as a number of studies have shown that collusion can cause prices to be less responsive to variables such as cost. Second, collusion is more effective because the implementation of common pricing algorithms enhances monitoring as each company knows exactly the price that the other company should be charging.

Algorithms can promote collusion even when employees of competing companies are not actively engaged in coordinating their conduct. One way this can occur is when companies outsource pricing to a third party, and that third party actively engages in collusion. Big data and the use of sophisticated algorithms can provide an efficiency rationale for outsourcing pricing because a third party may have more data and better algorithms. However, outsourcing encourages coordination in at least two ways. First, a third party could develop a pricing algorithm which, if all companies adopted it, would lead to collusion. It could then aggressively market it to those competitors with the marketing promise that profits will go up. Second, a third party is contracted by competitors to set prices, and then does so in order to maximize a joint objective such as industry profit or revenue.

While there are instances in which a third party sets prices for competitors, there is not, to my knowledge, evidence that those prices are set in a coordinated manner. Online platforms routinely involve the setting

[1] Big data refers to massive data sets that can be analyzed to find patterns, trends, and associations in human behavior and other phenomena. Data is "big" in volume (number of observations), variety (heterogeneity in variables), and velocity (time frequency of data).

(or recommending) of prices for sellers on the platform where some of those sellers are competitors. Currently, there is a private litigation suit against Uber accusing it of unlawful collusion because it sets the prices of all competing Uber drivers in an area. Airbnb does not set the prices of its property owners but, through its Smart Pricing option, can recommend prices. If the price-setting algorithm at a platform is programmed to maximize, say, total revenue for the sellers in a market then supracompetitive prices are likely to result.

Another example of outsourcing with the risk of collusion is occurring at sponsored search auctions.[2] The setting has companies bidding for their ads to appear in response to a search query at a search engine. For example, Dell and Samsung compete by submitting bids to appear alongside Google's search output to the word "computer". Many companies have outsourced bidding to a digital marketing agency (DMA). There is an efficiency rationale for doing so as a DMA is likely to have more data and better algorithms for determining which keywords to bid upon and how much to bid. However, there is a genuine risk of collusion because some of these DMAs have competitors as clients. For example, one DMA is contracted to set the bids for Dell and Samsung as well as several other PC manufacturers.

Even when pricing is performed internally and employees act independently, algorithms can cause companies to collude. Consider a scenario in which managers at competing companies independently decide to adopt learning algorithms for the purpose or pricing. Unbeknownst (and unforeseen) by the managers, the learning algorithms end up adopting collusive pricing rules. Through the objective of finding more profitable pricing rules and intensively using data and experimenting, collusion has emerged. For example, an algorithm may come to match, rather than undercut, a rival company's price. That could then cause the algorithm to raise price, for it knows – based on past data – that the price increase will be matched. To my knowledge, collusion by autonomous agents without human intervention has not occurred in an actual market; nor has it occurred in a simulated market that is descriptively realistic. However, it has occurred in simple simulated markets. Given the rapid progress of AI, it would be foolish to dismiss collusion by learning algorithms in actual markets in the near future (if it is not already occurring).

Is it an antitrust violation?

As just reviewed, there are a variety of paths by which price-setting algorithms may play a role in collusion. But is the collusion unlawful?

If employees of competing companies coordinate on pricing algorithms, as opposed to prices, illegality is clear. Indeed, there is nothing substantively new for coordination on basing point pricing rules was successfully prosecuted decades ago.

More intriguing is the legality of a third party setting the prices of competitors, as with online platforms and DMAs. For online platforms such as Uber, the BMI case is relevant because, before condemning the platform setting sellers' prices, one should ask whether it is technologically feasible for it to delegate pricing to sellers. That matter is open to debate with Uber, though is clearly feasible with Airbnb where

[2] Francesco Decarolis, Maris Goldmanis, and Antonio Penta, "Marketing Agencies and Collusive Bidding in Online Ad Auctions." NBER Working Paper No. 23962, October 2017.

sellers currently do set price. Still, might not the recommended prices from Smart Pricing be a facilitating practice that promotes coordination? Suppose Smart Pricing informs a property owner when its price is below the market average but not when it is above the market average (controlling for the property's characteristics). Would that not induce those companies with below average prices to raise their prices? That is starting to sound collusive.

Perhaps there needs to be guidelines for third parties so that they avoid setting prices for competitors that might serve a common objective. Should platforms be advised to set prices to equate supply and demand, and avoid maximizing aggregate revenue for sellers? Or when a third party like a DMA sets bids for competitors like Dell and Samsung, should there be a firewall between the unit that sets Dell's price and the unit that sets Samsung's price?

The most intriguing case is when human agents act independently and it is the learning algorithms that are responsible for collusion. Section 1 jurisprudence defines liability as having an agreement, which has been interpreted as a mutual understanding among competitors to restrict competition. Required evidence is an overt act of communication to create or sustain that mutual understanding. If there is any communication (broadly defined) between these learning algorithms, it is occurring through prices or other legitimate market data, which the court has found to fall short of satisfying evidentiary standards. (I would argue it is comparable to conscious parallelism.) As there is no overt act of communication, a requisite element of evidentiary standards is absent. Furthermore, it would seem that companies are not liable. The companies' employees independently adopted these learning algorithms and the presumption is that they lacked awareness that their adoption would produce collusion.

In principle, algorithmic collusion could prove as harmful and as common as unlawful collusion. One proposed legal approach is to prohibit certain properties of pricing algorithms as a facilitating practice.[3] It is time that we develop and investigate methods for detecting and prosecuting algorithmic collusion "so that when science fiction becomes reality, we're ready to deal with it." [4]

[3] Joseph E. Harrington, Jr. "Developing Competition Law for Collusion by Autonomous Price-Setting Agents," August 2017. Available at SSRN: https://ssrn.com/abstract=3037818 or http://dx.doi.org/10.2139/ssrn.3037818

[4] "[W]hen we look at the challenges for cartel enforcement in the future, one of the biggest things we need to deal with is the risk that automated systems could lead to more effective cartels. ... It's true that the idea of automated systems getting together and reaching a meeting of minds is still science fiction. ... But we do need to keep a close eye on how algorithms are developing ... so that when science fiction becomes reality, we're ready to deal with it." Margarethe Vestager, "Algorithms and Competition," Remarks by the European Commissioner for Competition at the Bundeskarellamt 18th Conference on Competition, Berlin, March 16, 2017.