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Article

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INTRODUCTION

Disruptive innovation can turn users into newly-minted economists. Consider the controversial practice of "surge pricing" enabled by the ride-sharing service Uber.[1] Confronted on occasions such as New Year's Eve by prices six to seven times as much as normal, users tend to ask for an explanation. On the one hand, surge pricing resembles basic market economics—many people want a ride, market demand pushes the price up, and those higher prices attract more drivers until the price falls to a new level.[2] But as Uber's own marketing recognizes, this is a market whose price signals act within a proprietary

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1. *See* Eric Posner, *Why Uber Will—and Should—Be Regulated*, SLATE (Jan. 5, 2015, 2:49 PM), http://www.slate.com/articles/news_and_politics/view_from_chicago/2015/01/uber_surge_pricing_federal_regulation_over_taxis_and_car_ride_services.single.html (endorsing arguments for regulation of surge pricing, Uber's term for raising prices at times of higher demand); Ilya Somin, *Surge Pricing and Political Ignorance*, WASH. POST: VOLOKH CONSPIRACY (Dec. 31, 2014), https://www.washingtonpost.com/news/volokh-conspiracy/wp/2014/12/31/surge-pricing-and-political-ignorance (opposing regulation, but fearing that "without at least a basic understanding of economics, consumers won't realize that surge pricing increases the quantity and quality of available goods"); *see also* Yves Faguy, *The Uber Cartel*, CBA NATIONAL (Jan. 5, 2015), http://www.nationalmagazine.ca/Blog/January-2015/The-Uber-cartel.aspx (discussing surge pricing and noting the possible relevance of Canadian competition law).

2. *See* Jacob Saulwick, *Is Cab App Just an Uber Cartel?*, SYDNEY MORNING HERALD (Jan. 10, 2015), http://www.smh.com.au/business/is-cab-app-just-an-uber-cartel-20150108-12ktd5.

black box: "Dynamic pricing *algorithmically* increases prices to encourage more drivers to come onto the platform and increase supply."[3] As Uber's CEO has stated: "[W]e are not setting the price, the market is setting the price. . . . [W]e have algorithms to determine what that market is."[4] By this account, the market is both an independent force of nature that determines price, but also paradoxically a result constructed at least in part by a proprietary algorithm.[5]

Some have observed that the drivers are independent contractors, who "could in theory" compete against each other, but who instead have agreed to have their prices coordinated and set by the algorithm of a company that gets a twenty percent slice of the fare.[6] Whether this is paradigm-shifting, disruptive technology or a harmful, twenty-first-century, techno-cartel depends in part on the workings of that algorithm. Competition law does not yet have a good sense of how to appraise this situation; how to begin this inquiry is the focus of this Article.

How will antitrust law work when decisions are no longer made by humans but instead by machines? Antitrust's archetypal villains—price-fixing bosses in a smoke-filled room—may be coming to the end of their road.[7] The increasing power of computers has become a game changer. Their rising power, plus the growing ubiquity of the Internet, and increasingly sophisticated data-mining techniques have driven a rapid shift of pricing decisions away from human-decision makers in favor of algorithms—defined as step-by-step procedures for solving

3. *Id.* (emphasis added); *see also* Matt Stoller, *How Uber Creates an Algorithmic Monopoly To Extract Rents*, NAKED CAPITALISM (Apr. 11, 2014), http://www.nakedcapitalism.com/2014/04/matt-stoller-how-uber-creates-an-algorithmic-monopoly.html.

4. Stoller, *supra* note 3 ("[Uber's] algorithm is not regulated nor is it transparent, so neither the buyer nor the seller has any credible information. This isn't a market, it's a monopoly. It's a special type of monopoly, an algorithmic monopoly. It may mimic market-style pricing, or it may not. That's up to Uber.").

5. *Id.*

6. Saulwick, *supra* note 2.

7. *See, e.g.*, Transcript of Record of Defendant's Testimony vol. 12, at 4889, United States v. U.S. Steel Corp., 251 U.S. 417 (1920) (No. 6) (testimony of Elbert H. Gary) (describing the famous "Gary dinners," a series of social events and meetings early in the 20th century, convened to encourage executives of rival steelmakers to tell each other "frankly and freely what they were doing, how much business they were doing, what prices they were charging, . . . and . . . all information concerning their business" in order to stabilize prices).

problems, especially by a computer.[8] Increasingly the software programs that apply these algorithms, functioning as "robo-sellers," can make pricing decisions autonomously.[9]

"Can robo-sellers really raise prices?," a skeptical reader might wonder. The simple answer: they already have done so. In 2011, one could find a classic, twenty-year-old, developmental biology textbook on fruit flies available on Amazon for the astonishing price of $23.7 million.[10] That particular "market price" was set through the interaction of two different sellers' programmed algorithms. The first algorithm automatically set the price of the first book for 1.27059 times the price of the second book—which belonged to the other seller in the marketplace.[11] The second algorithm automatically set the price of the second book at 0.9983 times the price of the first book.[12] Because the two equations $x = 1.27059 * y$ and $y = 0.9983 * x$ cannot be reconciled for positive numbers, the result was an upward spiral in which each algorithm's price hike was subsequently responded to by a price hike from the other, and vice versa.[13] From April 8 to 18, 2011, the offer prices of the two books rose in tandem into the millions of dollars.[14]

8. *Algorithm*, MERRIAM-WEBSTER DICTIONARY, http://www.merriam-webster.com/dictionary/algorithm (last visited Mar. 15, 2016).

9. *See, e.g.*, John Bible, *The Science of Retail: How To Counterbalance Instinct with Data-Driven Insight*, ORACLE RETAIL (2014), http://www.oracle.com/us/industries/retail/view-point-science-fashion-br-2225302.pdf (stating that traditional "retailers are still in the early stages of using their data in truly scientific ways . . . to turn rich troves of data into dollars by better demand measurement and management" by "explor[ing] every facet of price elasticity" and adding that "[e]ven with new products that have no history, the algorithms can examine the performance of similar products to discover the patterns needed to support initial pricing decisions and to chart a likely model for lifecycle pricing"); Natalie Burg, *Your Company Can See the Future with Predictive Analytics*, FORBES (Mar. 26, 2014, 9:39 AM), http://www.forbes.com/sites/sungardas/2014/03/26/your-company-can-see-the-future-with-predictive-analytics-2 (stating that "predictive analytics utilizes 'a variety of statistical, modeling, data mining, and machine learning techniques to study recent and historical data, thereby allowing analysts to make predictions about the future'" and "can be used to automatically vary pricing over time based on purchasing trends").

10. *See* CHRISTOPHER STEINER, AUTOMATE THIS: HOW ALGORITHMS CAME TO RULE OUR WORLD 1 (2012).

11. *See* John D. Sutter, *Amazon Seller Lists Book at $23,698,655.93—Plus Shipping*, CNN (Apr. 25, 2011), http://www.cnn.com/2011/TECH/web/04/25/amazon.price.algorithm/index.htm.

12. *Id.*

13. *Id.*

14. *Id.*

The fruit-fly textbook example appears to have been the product of mistake rather than any conscious anticompetitive intent.[15] By contrast, suspicions about Uber's algorithm go to whether it has been designed to exploit consumers—such concerns echo calls in other areas for "algorithmic neutrality" to prevent economically or socially harmful distortions.[16] Given the textbook example, whether or not their creators intend, robo-sellers can combine algorithmic pricing with autonomous decisionmaking to charge consumers higher prices.

Algorithmic pricing continues to grow hand-in-hand with the increasing ability of autonomously operating software-based agents. Pablo Picasso believed that the computers of his era were "useless" since "[t]hey c[ould] only give you answers."[17] But times have changed; since then, computers with machine-learning capabilities have bested humans at chess and "Jeopardy!"[18]—and, thanks to Google, safe driving.[19] Their increasing ability and autonomy makes them an essential, inescapable presence in twenty-first-century business.

Computers, "big data," and algorithmic processes have altered how people learn[20] and love[21]—and, of course, how we

15. As one expert on machine learning noted, "[t]he expansion of API [applications programming interfaces—specifications detailing how and encouraging one program to interact with another] usage in marketplaces means: . . . [a]ny PhD with an idea can create a startup to add value to a marketplace . . . [and] [a]ny idiot with a questionable algorithm can screw things up for everyone." Marshall Kirkpatrick, *When Bots Go Mad*, READWRITE (Feb. 25, 2012), http://readwrite.com/2012/02/25/when_bots_go_mad.

16. *See infra* notes 37–38 and accompanying text (discussing Google and the claimed need for "algorithmic neutrality" in search algorithms).

17. William Fifield, *Pablo Picasso—A Composite Interview*, 32 PARIS REV. 37, 62 (1964).

18. *See* David Ferrucci et al., *Building Watson: An Overview of the DeepQA Project*, AI MAGAZINE (Fall 2010), http://www.aaai.org/Magazine/Watson/Watson.php.

19. *See The Self-Driving Car Logs More Miles on New Wheels*, GOOGLE OFFICIAL BLOG (Aug. 7, 2012), http://googleblog.blogspot.hu/2012/08/the-self-driving-car-logs-more-miles-on.html. *But see Fatality Facts*, INS. INST. FOR HIGHWAY SAFETY, http://www.iihs.org/iihs/topics/t/general-statistics/fatalityfacts/overview-of-fatality-facts (last visited Mar. 15, 2016) (reporting 10.8 deaths per 100,000 people and 1.14 deaths per 100 million vehicle miles traveled in the United States due to accidents in 2012); *FARS Encyclopedia*, NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., http://www-fars.nhtsa.dot.gov/Main/index.aspx (last visited Mar. 15, 2016) (recording 29,867 fatal crashes for human drivers in 2011).

20. *See* James E. Cabral et al., *Using Technology To Enhance Access to Justice*, 26 HARV. J.L. & TECH. 241, 255–56 (noting that independent institutions such as the Khan Academy have begun offering free online courses in science and technology); Maciej H. Kotowski et al., *Audits As Signals*, 81 U.

shop. Sellers use dynamic-pricing algorithms to gauge supply and demand and set prices not only for books and air tickets online, but increasingly, for consumer electronics, groceries, and other tangible goods in brick-and-mortar stores.[22] An industry has rapidly sprung up to provide software-embedded mathematical models that digest mass-collected data to monitor market conditions and make pricing decisions.[23]

This Article offers the first descriptive and normative study of this change and its critically important implications for antitrust law.[24] This Article has two goals: First, it provides a descriptive picture of the sea change in commerce that is taking place due to the spread of algorithm-driven dynamic pricing. Second, using that snapshot as a base, this Article strives to identify and analyze the broader normative consequences for consumer welfare and antitrust law. To be sure, such an effort to describe and predict the course of a quickly evolving business world must be preliminary at best.[25] But it must be examined, as the change entailed has become too significant and wide-ranging to avoid discussion.[26]

CHI. L. REV. 179, 200 (2014) (noting universities' use of massive open online courses (MOOCs)).

21. *See* AMY WEBB, DATA, A LOVE STORY: HOW I GAMED ONLINE DATING TO MEET MY MATCH 71–84 (2013) (reviewing data-driven, algorithmic, dating sites).

22. *See, e.g.*, Stephanie Clifford, *Shopper Alert: Price May Drop for You Alone*, N.Y. TIMES (Aug. 9, 2012), http://www.nytimes.com/2012/08/10/business/supermarkets-try-customizing-prices-for-shoppers.html; Tucker Cummings, *Everything You Need To Know About Dynamic Pricing*, CHRISTIAN SCI. MONITOR (Nov. 4, 2013), http://www.csmonitor.com/Business/Saving-Money/2013/1104/Everything-you-need-to-know-about-dynamic-pricing ("Best Buy is . . . committed to a dynamic pricing strategy . . . .").

23. *See infra* Part I.

24. This Article uses "antitrust law" and the broader, but similar, "competition law" interchangeably.

25. Indeed, this problem has long been recognized to be inherent in any study of a fast-moving legal issue. *See, e.g.*, Charles A. Reich, *The New Property*, 73 YALE L.J. 733, 733 (1964).

26. Some commentators express concern about antitrust enforcement in fast-moving digital industries on the grounds that the probability and costs of errors may be high. *See, e.g.*, Geoffrey Manne & Joshua D. Wright, *Google and the Limits of Antitrust: The Case Against the Case Against Google*, 34 HARV. J.L. & PUB. POL'Y 171, 178, 213–44 (2011) (arguing for cautious application of antitrust against Google since a "false positive" might chill "innovation and competition"). Others point out that "the features that distinguish" such markets from "conventional" industries "do not all weigh in favor of biasing policy toward underenforcement, the social costs of which could be at least as high as those of overenforcement." Howard A. Shelanski, *Information, Innovation, and Competition Policy for the Internet*, 161 U. PENN. L. REV. 1663, 1667–68

This Article sets forth this tale and study in four parts. Part I paints the overall landscape. It situates the in-progress transformation of sellers, buyers, and price-setting within a broader social context in which algorithm-laded software is playing bigger and more important roles. Part I describes how the rise of the era of algorithms has already changed certain industries' behavior as well as consumer expectations. It then explains how as this era blossoms, it is morphing sellers into robo-sellers—producing a faster, broader, more-networked and increasingly non-human world-spanning bazaar.

Part II addresses a key risk posed by the robo-seller. The paradigmatic harm of collusion among competitors may grow and become more threatening. Perhaps worse still, robo-sellers may increase the risk that, in some cases, real-world oligopolists will operationalize their individual theoretical incentives to achieve Nash equilibrium prices above the competitive level, thereby harming consumers. The Sherman Act contains a gap in its coverage under which oligopolists that can achieve price coordination interdependently, without communication or facilitating practices, generally escape antitrust enforcement,[27] even when their actions yield supracompetitive pricing that harms consumers. Antitrust law has famously struggled with this issue for half a century—and robo-sellers will likely make this gap even more problematic. Classic models of oligopoly have identified key features that make a cartel hard to sustain, and current antitrust enforcement attempts to harness some of these features in order to preemptively undercut cartel formation. Time lags between defection from a cartel and its discovery make that defection more profitable and undermine collusion. Noise, errors, and complexity make "accidental," but still fatal, defection from a cartel more likely. Finally, human sellers have hyperbolic discount rates that make sellers prefer to cheat on their partners in collusion even while they sacrifice future cartel profits. Robo-sellers will "solve" some of these issues for oligopolists, making higher prices that injure consumers more likely.

(2013); *see also* Michal S. Gal & Daniel L. Rubinfeld, *The Hidden Costs of Free Goods: Implications for Antirust Enforcement* (N.Y.U., Working Paper No. 14-44, 2015), http://papers.ssrn.com/sol3/papers.cfm? abstract_id=2529425 (rejecting "the position . . . that free goods" commonly found in the digital ecosystem "should not come under antitrust scrutiny").

27 *See, e.g.*, Donald F. Turner, The Definition of Agreement Under the Sherman Act: Conscious Parallelism and Refusals To Deal, 75 HARV. L. REV. 655, 671 (1962).

Part III broadens the perspective to include the impact of robo-selling on monopolists and more overt cartel behavior. In particular, it addresses the implications of the robo-seller on cases in which price coordination requires communication or facilitating practices in order for firms to come to an anticompetitive "agreement." In these cases, usually analyzed as a Prisoner's Dilemma in which the Nash equilibrium is to "cheat" on the cartel, an agreement is required to avoid the inferior (from the price-fixers' perspective) outcome. Under standard models of oligopoly, even where sellers have individual incentives to price supracompetitively, they can do better by achieving an agreement, tacitly or overtly; in some cases, competing firms can only achieve supracompetitive pricing in this way. In considering how antitrust law should respond, Part III identifies a key creature that is relatively unexamined due to its longstanding ubiquity, until now, in antitrust law: the human seller. Longstanding debates in antitrust focus on the role of intent in finding a Section 2 offense involving monopoly,[28] enforcers' goal of sowing fear and distrust among potential Section 1 price-fixing violators,[29] and the need for agreement in proving a Section 1 price-fixing offense.[30] Part III then explains how the shift from human price-setting to robo-sellers requires a rethink of competition law. Specifically, antitrust relies on anthropomorphic concepts of intent, fear, distrust, and agreement with which it will prove hard to categorize or incentivize the robo-seller. Competition law will have to reconsider its embedded assumption of personhood in those it seeks to punish and deter.

Part IV discusses possible solutions. First, it focuses on key systemic issues that will complicate antitrust's rendezvous with the robo-seller. It explores two important normative consequences. First, it asks how likely it is that robo-sellers could be

28. *See infra* Part III.A.

29. Christopher R. Leslie, *Predatory Pricing and Recoupment*, 113 COLUM. L. REV. 1695 (2013).

30. *See* RICHARD A. POSNER, ANTITRUST LAW: AN ECONOMIC PERSPECTIVE 40 (1976) (describing the difficulty of deterring "tacit collusion" when it does "not involve explicit, detectable acts of agreement or communication"); Louis Kaplow, *On the Meaning of Horizontal Agreements in Competition Law*, 99 CAL. L. REV. 683 (2011); William H. Page, *A Neo-Chicago Approach to Concerted Action*, 78 ANTITRUST L.J. 173, 173 (2012); Turner, *supra* note 27 (arguing that oligopolists who anticipate "the probable reactions of competitors in setting their basic prices, without more in the way of 'agreement' than is found in 'conscious parallelism,' should not be held unlawful conspirators under the Sherman Act").

successfully regulated. The complexity of the algorithms involved and their interaction makes this potentially a daunting regulatory challenge. Additionally, it warns of underestimating the benefits of the robo-seller. Even if, as this Article explains, both independent Nash equilibrium coordinated pricing and collusion become more likely with robo-sellers, they may nonetheless be so efficient such that the benefits of robo-selling outweigh its harms. In more formal terms, using algorithms, software, and big data to do key business functions such as market intelligence, information gathering, strategic management, and sales may reduce marginal cost even while they make price coordination—and pricing to consumers above marginal cost—more likely.[31] Part IV then turns to address several possible solutions, including banning robo-sellers, subjecting them to traditional antitrust processes under the rule of reason, or seeking antitrust's potential evolution within a wider context of how law will deal with autonomous agents more broadly. Specifically, the more general argument that the law should recognize that autonomous software agents are evolving beyond their original role as the mere tools of their principals is not an easy fit for antitrust. The evolving, shifting treatment has been justified deontologically based on autonomous agents' incipient ability to reason.[32] Joining such a solution is not an easy move for antitrust, which by contrast is relentlessly instrumental in its focus; for example, consumer welfare and the fear of false positives have become articles of faith in antitrust.[33] The best, but imperfect, solution may be to incorporate an evolving approach to robo-sellers as a reasonable expansion of the Federal Trade Commission's (FTC's) ongoing regulatory program targeting the competition and consumer protection aspects of pri-

31. There are conflicting viewpoints on how to treat such a circumstance. Some commentators view any welfare transfer from consumers to producers as in conflict with antitrust law's original intent and continuing goal, regardless of any offsetting, overall, social welfare benefits. *See* Robert H. Lande, *Proving the Obvious: The Antitrust Laws Were Passed To Protect Consumers (Not Just To Increase Efficiency)*, 50 HASTINGS L.J. 959, 963 (1999) (discussing the "wealth transfer thesis").

32. *See* SAMIR CHOPRA & LAURENCE F. WHITE, A LEGAL THEORY FOR AUTONOMOUS ARTIFICIAL AGENTS 171–72 (2011) (suggesting that Locke's definition of "person" is consistent with ascribing legal personhood and moral responsibility to artificial agents).

33. Borrowed from medicine and the sciences, the term "false positives" refers to erroneous punishment of efficiency-enhancing conduct. *See, e.g.*, Verizon Commc'ns Inc. v. Law Offices of Curtis V. Trinko, LLP, 540 U.S. 398, 414 (2004).

vacy. Looking further into the future, regulators may need to develop the ability to test and probe the effects of algorithmic sales on consumers; agencies may need to conduct their own "algorithmic enforcement." Significant regulatory efficiencies may stem from the overlap between the technologies involved and the concerns for consumers that they raise.

I. THE AGE OF THE ALGORITHM

Our digital age relies on the increasing power and influence of computers, interconnection, especially via the Internet, and massive collection and analysis of data. Technological progress has made our computing devices speedier, smaller, less expensive, and, increasingly, mobile. Increasingly, it has also put such computing power in contact with the common consumer. Recent versions of the Xbox gaming console have more computing power than the flight computer of the Space Shuttle Atlantis;[34] the Voyager 1 unmanned probe reached interstellar space in 2013 despite having less memory than an iPhone 5.[35] Such breathtaking improvement has made computers of all kinds increasingly ubiquitous in the twenty-first-century world. This power has enabled the rise of sophisticated algorithms to model and predict our world—with great impact on society at large and on business in particular.

A. ALGORITHMS IN DAILY LIFE

The age of the algorithm results from the synergy of mathematics, computer power, and the Internet. All three combine to empower the collection and analysis of massive amounts of data, and to make possible more empirically-driven decisionmaking. Before, people might have knowingly relied on imperfect predictions or "gut" feeling to handle complex problems of prediction in the absence of data and models. But increasingly, they can turn to a set of powerful new tools.

These tools are increasingly ubiquitous. For almost a decade, "to Google" has been a dictionary verb.[36] Its search results

34. HUNTSVILLE TIMES, *Space Shuttle Fast Facts: Xbox 360 Has More Power than Flight Computer, Orbiter Has 2.5 Million Parts*, AL.COM (July 8, 2011, 7:01 AM), http://blog.al.com/space-news/2011/07/space_shuttle_fast_facts_xbox.html.

35. Amanda Wills, *Voyager 1 Got to Deep Space on Less Memory than Your iPhone 5*, MASHABLE (Sept. 12, 2013), http://mashable.com/2013/09/12/voyager-1-iphone-5.

36. *See* Candace Lombardi, *Google Joins Xerox As a Verb*, CNET (July 6, 2006), http://cnet.com/newsgoogle-joins-xerox-as-a-verb (reporting "Google" be-

have long been the product of an algorithm, PageRank, that drives its results by steering Web-search traffic to sites that the algorithm concludes that users believe to be most relevant.[37] In addition to collecting and crunching data on which sites users click on after doing particular searches, the algorithm also gives more credibility to sites linked to by other sites and hubs it concludes are influential.

The application of algorithmic autonomous decisionmaking has already moved beyond cyberspace, and has done so at a pace that was unanticipated, even by well-informed experts. A decade ago experts asserted that driverless cars were technologically infeasible, to little controversy.[38] Recently, to much media coverage, Google has piloted versions of such vehicles that rely on data collection via sensors as well as software that applies algorithmic processes; such cars already drive more safely than the average human.[39] However, all of this attention to Google has somewhat obscured the speed with which traditional automakers are deploying similar technology: Nissan intends to market such a vehicle by 2020, Ford and GM have similar plans, and Daimler-Benz already has a Mercedes concept car rolling autonomously down German autobahns.[40] But with

ing added to Merriam-Webster's dictionary as a verb).

37. For a clear, concise and entertaining description of the PageRank algorithm, see STEVEN STROGATZ, THE JOY OF X: A GUIDED TOUR OF MATH, FROM ONE TO INFINITY 191–98 (2013). *See also* AMY N. LANGVILLE & CARL D. MEYER, GOOGLE'S PAGERANK AND BEYOND: THE SCIENCE OF SEARCH ENGINE RANKINGS 31–45 (2006) (explaining the mathematics of Google's PageRank system). Certain tweaks to the algorithm over time have raised concerns about the neutrality or fairness of Google's algorithmic process to competitors as well as downstream web businesses. *See* United States v. Google, Inc., No. CV 12-04177 SI, 2012 WL 5833994, at *4–6 (N.D. Cal. Nov. 16, 2012) (granting an injunction regulating actions by Google); *see also* Frank Pasquale & Oren Bracha, *Federal Search Commission? Access, Fairness, and Accountability in the Law of Search*, 93 CORNELL L. REV. 1149 (2008) (questioning if search engines should be regulated like personal data collectors).

38. *See* FRANK LEVY & RICHARD J. MURNANE, THE NEW DIVISION OF LABOR: HOW COMPUTERS ARE CREATING THE NEXT JOB MARKET 28–30 (Princeton U. Press 2004) ("[A] truck driver [possesses] the schema to recognize what [she is] confronting. But articulating this knowledge and embedding it in software for all but highly structured situations are at present enormously difficult tasks. . . . Computers cannot easily substitute for humans [in driving and similar tasks].").

39. *See* Radhika Sanghani, *Google Driverless Cars are "Safer" than Human Drivers*, TELEGRAPH (Oct. 29, 2013, 1:00 PM), http://www.telegraph.co.uk/technology/google/10411238/Googles-driverless-cars-are-safer-than-human-drivers.html (reporting a study making the comparison with data).

40. *See* Alexis Madrigal, *By the Time Your Car Goes Driverless, You Won't Know the Difference*, NPR: ALL TECH CONSIDERED (Mar. 20, 2014, 9:23 AM),

this technology comes the policy question of whether the algorithm should be designed to do something individually rational, such as save a single passenger's life, even if it is socially inferior, such as killing ten pedestrians in the process.[41] This type of ethical and legal question will likely occur in other fields that confront algorithmic processing, including antitrust law.[42]

On another dimension, algorithmic processes have altered the ways in which people conduct their affairs in realms that are usually seen to be less cold-bloodedly rational than Internet searching or driving.[43] Online dating systems, such as eHarmony, have grown in scope and influence even as they have evolved in sophistication.[44] These services' algorithms have garnered greater autonomy in matching customers, particularly as they have learned that they can be more successful by matching their customers based on data collected about them rather than by solely focusing on what their customers actually say they are looking for in a partner.[45] Algorithmic processes have similarly penetrated into health care spheres that traditionally mix uneasily with commerce.[46] The process by which available donor organs come to be matched with those who need transplants has become increasingly automated.[47] If

http://www.npr.org/blogs/alltechconsidered/2014/03/04/285740673/by-the-time-your-car-goes-driverless-you-wont-know-the-difference (describing recent developments in driverless cars).

41. *See* Eric Limer, *Should Your Driverless Car Kill You to Save Two People?*, GIZMODO (May 12, 2014), http://gizmodo.com/should-your-driverless-car-kill-you-to-save-two-other-p-1575246184 (questioning whether a driverless car should sacrifice its driver in a crash to save more lives).

42. *See infra* Part IV.

43. *But see* RICHARD A. POSNER, SEX AND REASON 146–80 (1994) (discussing economic rationality and human sexual behavior); Richard A. Posner, *The Regulation of the Market in Adoptions*, 67 B.U. L. REV. 59 (1987) (discussing economic rationality and babyselling).

44. *See* DAN SLATER, LOVE IN THE TIME OF ALGORITHMS: WHAT TECHNOLOGY DOES TO MEETING AND MATING 86–87 (2013) (describing the complex process of matchmaking on eHarmony).

45. *See* David DiSalvo, *Why the Future of Online Dating Relies on Ignoring You*, FORBES (Dec. 7, 2013, 3:09 PM), http://www.forbes.com/sites/daviddisalvo/2013/12/07/why-the-future-of-online-dating-relies-on-ignoring-you (arguing that dating websites should use algorithms instead of personal submissions to determine ideal matches).

46. *See* Vinod Khosla, *Do We Need Doctors or Algorithms*, TECH CRUNCH (Jan. 10, 2012), http://techcrunch.com/2012/01/10/doctors-or-algorithms (advocating for increased use of algorithms to aid in more efficient healthcare and diagnoses).

47. *See* STEINER, *supra* note 10, at 149–51 (discussing use of algorithms to make matches for transplants); *see also* Henry Hansmann, *The Economics and Ethics of Markets for Human Organs,* 14 J. HEALTH POL. POL'Y L. 57 (consid-

Americans increasingly delegate driving, love, and life-and-death decisions to automated algorithms, few areas can remain off-limits.

B. THE RISE OF THE MACHINES—SEND IN THE ROBO-SELLERS

Where driving, love, and life mix as ingredients, one might cook up shopping. Algorithmic processes already meld into software that autonomously makes pricing and output decisions based on market conditions, and then make offers to consumers.[48] Indeed, this capability has become commonplace in some non-physical markets. Already, finance and the travel industry make ample use of software that algorithmically adjusts prices based on supply and demand data. Relatedly, existing software tools alter prices to consumers based on information about changes in demand. Increasingly, decisions on the sales of physical products are delegated to algorithm-driven robo-sellers.

Initially, algorithmic pricing and automated trading emerged as a seismic force in finance.[49] The ability of computers to gather, digest, and act has fundamentally transformed finance from a human-dominated business to one co-inhabited by humans and computers in synergy, in a kind of "cyborg finance."[50] Aided by SEC regulations that fostered technological change,[51] finance-industry participants have deployed incredibly powerful and speedy computers that analyze and make trades using complex mathematical models.[52]

ering impacts of market and nonmarket incentives for organ donation).

48. *See, e.g.*, Barney Jopson, *Amazon "Robo-Pricing" Sparks Fears,* FIN. TIMES (Jul. 8, 2012, 5:43 PM), http://www.ft.com/intl/cms/s/0/26c5bb7a-c12f-11e1-8179-00144feabdc0.html; SLATER, *supra* note 44.

49. For a description of the rise of algorithmic trading in finance—and a harsh critique of its misuse, see MICHAEL LEWIS, FLASH BOYS: A WALL STREET REVOLT (2014). *See also* SAL AMUK & JOSEPH SALUZZI, BROKEN MARKETS: HOW HIGH FREQUENCY TRADING AND PREDATORY PRACTICES ON WALL STREET ARE DESTROYING INVESTOR CONFIDENCE AND YOUR PORTFOLIO 141–50 (2012) (describing how algorithms are used in trading stocks today); SCOTT PATTERSON, DARK POOLS: THE RISE OF THE MACHINE TRADERS AND THE RIGGING OF THE U.S. STOCK MARKET (2013) (describing the practice and future of using algorithms in stock trading).

50. *See* Tom C.W. Lin, *The New Investor*, 60 UCLA L. REV. 678, 687 (2013) (stating that "[m]odern finance is cyborg finance" as "the key players are part human and part machine").

51. *Id.* at 688 (describing how Reg ATS and Reg NMS permitted new trading systems and the development of electronic communications networks linking existing previously separate markets).

52. *See* SCOTT PATTERSON, THE QUANTS: HOW A NEW BREED OF MATH

The entry of algorithm-driven software into the financial industry has raised concerns about its safety and impact on the investing public. Notably, the May 6, 2010 "Flash Crash," in which $1 trillion in market value vanished in less than an hour, raised doubts about algorithm-driven automated trading, as SEC and CFTC inquiries concluded that such traders played a significant role.[53] More broadly, however, concerns have arisen that automated trading exposes the investing public to new, large-scale risks, including the possibility of harder-to-detect insider trading, the potential for asymmetries of speed to unlevel the securities playing field against smaller investors, and the weakness of existing disclosure regimes in the new context.[54]

The tools employed in finance have migrated into the sales of non-financial products. Initially, these tools made their appearance on online retail sites, such as Amazon.[55] Just as they did with financial markets, such tools drove an increasingly high rate of price variability in response to massive rapid competitive data collection.[56] For example, in November 2012, during the lead-up to the holiday season, Amazon made 2.5 million price changes per day utilizing such technologies; brick-and-mortar retailers such as Wal-Mart operating more traditionally only made about 50,000 price changes during that entire month.[57] The promise of such technology is to steal away customers from rivals by responding more nimbly to changes in supply and demand—the epitome of competition.

However, as in the financial industry, the implementation of algorithm-based trading in other markets has had its hiccups. In addition to the previously-mentioned problems with $23 million dollar biology textbooks, Amazon has had to battle the creation of "dummy" accounts formed only to try to trick

WHIZZES CONQUERED WALL STREET AND NEARLY DESTROYED IT 36–38 (2010) (describing the strategy of convertible bond arbitrage).

53. CFTC & SEC, FINDINGS REGARDING THE MARKET EVENTS OF MAY 6, 2010, 1 (2010).

54. For an overview of these concerns, see LEWIS, *supra* note 49. *See also* Lin, *supra* note 50, at 720–21 (discussing the use of technology in finance).

55. *See* Jopson, *supra* note 48 (discussing use of financial-industry derived algorithms on Amazon and other online retailers).

56. *Id*. (noting that "[h]igh-speed trading tools pioneered in the stock market are increasingly driving price movements on Amazon as sellers use them to undercut" each other).

57. Tom Ryan, *Amazon's Price Changing Machine*, RETAILWIRE (Dec. 19, 2013), http://www.retailwire.com/discussion/17222/amazons-price-changing-machine.

other algorithms into mispricing goods on the site.[58] United Airlines has famously had to deal with algorithms that mistakenly priced and offered consumers airfares as low as $5.[59] Such errors appear to be the exception rather than the rule, however, and the adoption of such technology continues apace.

At the same time, so-called "dynamic pricing" has also spread beyond its initial beachhead in the sale of travel and utilities. The term "dynamic pricing" has recently come to overlap with, and at times include, the sort of algorithmic-based trading that emerged in the financial sector. Initially, however, it denoted pricing based on proxies for competitive intelligence about demand, such as time of day, season, or weather. For example, airlines increase the price of tickets to Colorado ski destinations based on the availability of snow, and electrical utilities charge less per kilowatt-hour during nighttime, when air conditioning is used less.[60] Some vending machines already possess sensors by which they adjust beverage prices based on the outside temperature.[61]

In these early manifestations, dynamic pricing merely used crude stand-ins—time, temperature, season—to make ballpark estimates of changes in demand. However, with greater data collection and high-powered data analysis, the possibility of measuring demand more precisely has emerged. As a result, the term dynamic pricing has come to also include algorithmic pricing in which directly collected competitive data on supply and demand is used to drive automated pricing decisions.[62]

58. *See* Jopson, *supra* note 55 (describing dummy accounts).

59. *See* Hugo Martin, *Glitch Causes United to Sell Tickets for as Little as $2.50*, L.A. TIMES (Sept. 12, 2013), http://www.latimes.com/business/money/la-fi-mo-glitch-causes-united-to-sells-tickets-for-as-little-as-250-20130912,0,488189.story (noting the glitch appears to have been the product of how United's pricing algorithm dealt with fuel surcharges); Nick Vivion, *Exploiting Air Fare Glitches: The Moral, the Righteous and the Opportunistic*, TNOOZ (Dec. 9, 2013), http://www.tnooz.com/article/exploiting-fare-glitches-moral-righteous-opportunistic (presenting arguments for and against conducting extensive fare searches).

60. *See* Lisa Magloff, *Dynamic Pricing Strategy*, HOUS. CHRON, http://smallbusiness.chron.com/dynamic-pricing-strategy-5117.html (last visited Mar. 15, 2016) (describing the concept of dynamic pricing).

61. *See* Evgeny Morozov, *Requiem for Our Wonderfully Inefficient World*, SLATE (Apr. 23, 2013), http://www.slate.com/articles/technology/future_tense/2013/04/senor_based_dynamic_pricing_may_be_efficient_but_it_could_create_inequality.html.

62. Examples include IBM's DemandTec Price Optimization software. *See IBM Price Optimization*, IBM, http://www-03.ibm.com/software/products/en/price-optimization (last visited Mar. 15, 2016).

Notwithstanding the terminology, this development is a natural—and critical—progression that can provide important benefits to producers and consumers in more efficiently matching supply with demand.

Software tools already exist to help firms optimize their prices to achieve sales, volume, profit, and price objectives.[63] Increasingly sophisticated software solutions model and forecast the interdependence between supply and demand to predict market prices for commodities, and in turn propose—and execute—pricing strategies.[64] At the same time, the nascent field of demand chain optimization—the flip side of the more familiar field of supply chain management—is trying to use software and mathematical algorithms to proactively manage the pull of consumer demand and its effects on a firm and its suppliers.

Firms already, right now, cede pricing decisions to algorithm-laden software tools that monitor supply and demand. No longer are robo-sellers deployed only to sell services and intangible products. Increasingly, they are being used to sell physical-world products, such as cereal and cameras, both online and in concert with brick-and-mortar stores. Consider a description of how retailers use the Mercent software platform:

> [O]nce we have the information from the retailer's line of business software systems, we layer in our own real-time Web analytics. That tracks where shoppers are coming from . . . what they're buying, and most recently we've added to that data mix real-time monitoring of product availability and pricing so that our clients can use the Mercent platform to keep tabs on what's happening in the [broader] market. And the rate at which we're able to collect that competitive intelligence, match competitor products against our clients' own catalog, and then ultimately determine a new price point for the SKU [stock keeping unit, denoting a distinct product and its attributes for inventory management], is currently at about 2 million products per hour.[65]

63. *Id.*

64. *See, e.g.*, PROS PRICING SOLUTION SUITE, http://microsoft-sapphire.com/orlando/resources/Partners/PROS/PROS_Pricing_Solution_Suite.pdf (last visited Mar. 15, 2016) (describing software solution that claims to "[c]reate the right price for each customer and product by setting science-based optimized pricing strategies and automating price list management"); *see also* Heather Clancy, *This Analytics Software Keeps the Price Right, in Near Real Time*, FORTUNE (Sept. 24, 2015), http://fortune.com/2015/09/24/pros-pricing-software (describing software sold by firms such as Zilliant, Vendavo as well as PROS, that "can analyze historic pricing and, through analysis, come up with better pricing for managing margin").

65. Steven Cherry, *Dynamic Pricing: "How Much" Is Not a Simple Question*, IEEE SPECTRUM (Oct. 15, 2012, 12:36 PM), http://spectrum.ieee.org/podcast/telecom/internet/dynamic-pricing-how-much-is-not-a-simple-question.

Delegating competitive intelligence gathering and pricing to a robo-seller creates the ability to collect and crunch competitive data and respond more quickly than is humanly possible. Brick-and-mortar stores, such as Best Buy and Macy's, already use algorithmic processes to react to fast changes in price driven by their customers' use of competing online sellers.[66]

In short, competitive response and pricing decisions are increasingly being transferred away from humans to algorithm-driven software. Tools formerly—and famously—deployed first in the financial sector are migrating into the real economy of goods and services in which virtually all Americans participate. This process can be expected to continue and accelerate. Were these tools merely to provide speed and accuracy, but not otherwise alter market outcomes, they would not be a source of antitrust concern. However, as we have seen in the financial markets, the possibility of market distortion exists—technological tools have been used to capture consumer surplus for producers in the context of securities trading.[67] As these tools migrate into the goods and services market, similar injury to consumer welfare, arguably antitrust's heartland, may also loom.

The possibility of implementing such algorithmic pricing has provided a significant boost to efforts to collect and use all sorts of demand-relevant data in order to more effectively sell to consumers. These efforts have drawn criticism, particularly from consumer advocates. Some worry about the privacy implications of turning data about all sorts of individual choices and acts—including those not explicitly involving commerce, such as how and when one drives, brushes ones teeth, or goes to bed—into, effectively, a class of saleable information assets.[68] Others contend that sellers will be able not merely to better calculate a demand curve for their products, but will actually be able to gauge *an individual's* demand, so as to increase profits through increasingly powerful price discrimination.[69] Those

66. Cummings, *supra* note 22; *see Macy's Peers into the Hearts of Consumers with Predictive Analytics*, RETAIL INFO SYSTEMS NEWS, (May 19, 2014), http://risnews.edgl.com/retail-news/Macy-s-Peers-Into-the-Hearts-of-Customers-with-Predictive-Analytics-92848 (describing Macy's use of algorithms).

67. *See* LEWIS*, supra* note 49, at 37–43 (discussing these distortions).

68. *See* Evgeny Morozov, *Silicon Valley Is Turning Our Lives into an Asset Class*, FIN. TIMES (Mar. 14, 2014, 3:38 PM), http://www.ft.com/intl/cms/s/0/9d2a73fe-a54a-11e3-8070-00144feab7de.html (describing how companies make commodities out of personal habits).

69. *See infra* notes 189–91 and accompanying text; *see also* Douglas M. Kochelek, *Data Mining and Antitrust*, 22 HARV. J.L. & TECH. 515, 521–23

concerns may be important, but have not traditionally been central to antitrust enforcers' focus.[70] Most relevantly for this Article, though, is the potential for data collection and algorithmic pricing to lead to conduct that, while profitable for a firm, is harmful to consumer welfare,[71] and difficult to address with existing antitrust law approaches.

II. ROBO-SELLERS, ACCURACY, SPEED, AND OLIGOPOLY

The increasing prevalence of oligopolies in the American economy, and the seeming impotence of antitrust and federal regulatory policy to deal with their overweening political influence and their market power over consumers, have become matters of popular concern well beyond merely antitrust, economic, or legal circles. In recent years, Professor Tim Wu has written about this issue in *The New Yorker*;[72] similarly, *The Atlantic* has asked whether "more mergers" and "fewer players" spells "the end of competitive capitalism?"[73] Other commentators in the popular press have reached beyond antitrust's standard microeconomic and innovation concerns to ar-

(2009) ("If a monopoly firm could determine and charge the value that each individual customer placed on the good and could maintain the price discrimination scheme, then that firm could . . . charge each consumer the maximum value he would be willing to pay."); Morozov, *supra* note 61 (describing dynamic pricing in technology; *see also* Andrew Odlyzko, *Privacy, Economics and Price Discrimination on the Internet*, DIGITAL TECH. CTR., http://www.dtc.umn.edu/~odlyzko/doc/privacy.economics.pdf (last visited Mar. 15, 2016) (noting the tension between price discrimination and privacy online).

70. *But see* Pamela Jones Harbour, *A Tale of Two Marks, and Other Antitrust Concerns*, 20 LOY. CONSUMER L. REV. 32, 42–47 (2007) (criticizing the outcome in *Leegin*, in which the Court declined to uphold per se illegality of vertical minimal price fixing); J. Thomas Rosch, *The Common Law of Section 2: Is It Still Alive and Well?*, 15 GEO. MASON L. REV. 1163 (2008) (discussing the Chicago School in Supreme Court antitrust jurisprudence); Peter Swire & Yianni Lagos, *Why the Right to Data Portability Likely Reduces Consumer Welfare: Antitrust and Privacy Critique*, 72 MD. L. REV. 335 (2013) (discussing the "lock-in" problem with the right to data portability).

71. *See* John B. Kirkwood & Robert H. Lande, *The Fundamental Goal of Antitrust: Protecting Consumers, Not Increasing Efficiency*, 84 NOTRE DAME L. REV. 191, 191–201 (2008) (describing the concepts of consumer welfare and efficiency.

72. Tim Wu, *The Oligopoly Problem,* NEW YORKER (Apr. 15, 2013), http://www.newyorker.com/tech/elements/the-oligopoly-problem (describing modern-day oligopolies).

73. Jordan Weissman, *The Return of the Monopoly*, ATLANTIC (Mar. 20, 2013), http://www.theatlantic.com/magazine/archive/2013/04/the-chartist/309271.

gue that contemporary oligopolies pose real risks to our political and economic system, asserting related engendering of the 2007–08 Financial Meltdown and the ensuing "Great Recession."[74]

To the extent that the effects of increased oligopoly fall through the cracks of antitrust law, the advent of the robo-seller may widen those cracks into chasms. For several reasons, the robo-seller should increase the power of oligopolists to charge supracompetitive prices: the increased accuracy in detecting changes in price, greater speed in pricing response, and reduced irrationality in discount rates all should make the robo-seller a more skillful oligopolist than its human counterpart in competitive intelligence and sales. Leading scholars have long appreciated antitrust law's weakness in dealing with oligopoly; the robo-seller is poised to strike powerfully at this weakness, to the detriment of consumers. Moreover, the robo-seller should also enhance the ability of oligopolists to create durable cartels.

A. THE EXISTING CRACK IN THE SHERMAN ACT

Black-letter antitrust law makes clear that Section 1 of the Sherman Act prohibits anticompetitive "agreements."[75] For many judges, lawyers, and other interested observers, that is the end of the story. Given the archetypal application of Section 1's text to price-fixing and restrictions on output, that conclusion is not completely unjustified; generally, interdependent parallel conduct, without more, has not been held to satisfy Section 1's "agreement" language.[76]

However, economists and leading antitrust law experts concur that, if we are concerned with anticompetitive pricing, the agreement requirement creates "a fairly wide crack" in U.S.

74. *See, e.g.*, BARRY C. LYNN, CORNERED: THE NEW MONOPOLY CAPITALISM AND THE ECONOMICS OF DESTRUCTION 248 (2010) (decrying increased concentration of markets and arguing that "no longer . . . can [we] fix the physical flaws in our financial and industrial systems without first resolving the basic flaws in our political economy," which the author argues are interlinked); Zephyr Teachout, *The Madisonian Impulse Behind Antitrust Law*, NATION (May 18, 2009), http://www.thenation.com/blog/madisonian-impulse-behind-antitrust-law (arguing Americans are growing used to monopolies).

75. 15 U.S.C. § 1 (2014).

76. *See* PHILLIP E. AREEDA & HERBERT HOVENKAMP, ANTITRUST LAW: AN ANALYSIS OF ANTITRUST PRINCIPLES AND THEIR APPLICATION ¶ 1428 (2d ed. 2001) (stating that "mere interdependent parallelism has not been held to constitute agreement" but continuing on to discuss the arguments for doing so).

antitrust law for socially harmful conduct to fall through.[77] As Louis Kaplow has observed, "what economics teaches about why we should be concerned about price fixing not only fails to support reasoning offered in favor of a heightened agreement requirement, but also cuts against it because the cases exonerated . . . are those that involve the greatest rather than the least social harm."[78]

Indeed, this is a debate that goes back half a century to arguments by Judge Richard Posner and Donald Turner; it has been rekindled by others more recently. Posner advocated a very broad interpretation of Section 1's language that would reach interdependent pricing by oligopolists, even where they do not make an agreement in the common sense of the term:

> [A] seller communicates his 'offer' by restricting output, and the offer is 'accepted' by the actions of his rivals in restricting their outputs as well. . . . Businessmen should have no difficulty, moreover, in determining when they are behaving noncompetitively. Tacit collusion is not an unconscious state. If the sales division of a company recommends that it offer a wider variety of products in order to exploit consumer demand more effectively, and the financial division recommends against that course on the ground that it will make it more difficult for the industry to maintain 'healthy' prices, top management can be in no doubt of the significance of its actions if it adopts the financial division's recommendation.[79]

As a result, Posner argued for the application of the Sherman Act to firms that priced interdependently, even where they did not communicate or signal their intent to each other apart from observing each other's price decisions.[80]

Likewise, Turner agreed that the term "agreement" could not be limited only to conventional understandings of an explicit agreement—requiring proof of price-fixing contract formation would eviscerate Section 1, and at any rate was only one of several possible interpretations of the agreement language in the statutory text.[81] However, Turner thought that an approach like Posner's was a bridge too far. First, Turner concluded that punishing businesspeople for such behavior was problematic,

77. HERBERT HOVENKAMP, FEDERAL ANTITRUST POLICY: THE LAW OF COMPETITION AND ITS PRACTICE 157 (2003).

78. Kaplow, *supra* note 30, at 689.

79. Richard A. Posner, *Oligopoly and the Antitrust Laws: A Suggested Approach*, 21 STAN. L. REV. 1562, 1576–92 (1969).

80. *Id.*

81. *See* Turner, *supra* note 30, at 664–65 (suggesting through comparison between explicit and non-spoken communication that the former is sufficient but not necessary for an inference of agreement required for a Section 1 violation).

since, as in a competitive industry, they were simply rationally optimizing their prices given market realities.[82] Additionally, Turner thought that courts were ill-equipped to regulate and remedy the pricing decisions that such an interpretation would identify as illegal.[83]

The Posner-Turner discussion has been recently rekindled. Although Posner himself has recently walked back from his original argument,[84] Louis Kaplow has picked up Posner's baton and continued the run.[85] Kaplow has cast doubt on notions of "agreement" required for Section 1 liability "other than interdependence" of decisionmaking.[86] He has further criticized courts' reliance on "communications" for defining "agreement" and determining liability as an approach that is "hard to make operational" and "unconnected with the modern theory of oligopoly."[87] He argues that, given well-accepted models of oligopoly, "the cases exonerated on the ground that they involve mere interdependence are those that involve the greatest rather than the least social harm."[88] Despite these critiques, courts continue to impose an agreement requirement in a manner that often requires proof of direct communication or proxies for it, and this approach continues to have strong defenders.[89]

82. *Id.* at 666 ("[E]ach seller in [an oligopolistic supracompetitive pricing situation], in refraining from price competition, is not agreeing with his competitors but simply throwing their probable decisions into his price calculus as impersonal market facts. . . . [I]t seems questionable to call the behavior of oligopolists in setting their prices unlawful when the behavior in essence is identical to that of sellers in a competitive industry.").

83. *See id.* at 669–70.

84. *See, e.g.*, *In re* Text Messaging Antitrust Litigation, 782 F.3d 867, 874 (7th Cir. 2015) ("Harvard Law School Professor Louis Kaplow . . . argues that tacit collusion should be deemed a violation of the Sherman Act. That of course is not the law, and probably shouldn't be."); *see also* Richard Posner, *Review of Kaplow*, Competition Policy and Price Fixing, 79 ANTITRUST L.J. 761, 763 (2014) (book review) ("I now think that I didn't sufficiently appreciate the force of Turner's doubts about the feasibility of an antitrust remedy for tacit collusion.").

85. *See* Kaplow, *supra* note 30, at 797, 815 (criticizing reliance on "communications" to determine liability and casting doubt on notions of "agreement" required for Section 1 liability "other than interdependence"); *see also* LOUIS KAPLOW, COMPETITION POLICY AND PRICE FIXING (2013).

86. Kaplow, *supra* note 30, at 815.

87. *Id.* at 685.

88. *Id.* at 689.

89. *See, e.g.*, Page, *supra* note 30, at 200 ("[T]he lessons of game theory, experimental economics, real-world cartels, and dispositions of price-fixing cases over the past four decades support refocusing the analysis and investigation of concerted action on the role of communication."). *But see* Jon Fougner,

All things being equal, the advent of the robo-seller shifts the balance between these arguments in the direction of Posner's half-century-old argument. Contemporary discussions of antitrust policy are dominated by the application of the error-cost framework associated with Frank Easterbrook's landmark article *The Limits of Antitrust*.[90] Under this rubric, upon which the Supreme Court seemed to draw in *Bell Atlantic Corp. v. Twombly*,[91] the choice of optimal antitrust rules must balance their benefits against the error and administrative costs that they spawn.[92] Automated pricing powered by algorithmic processing and mass data collection should reduce the costs to firms to the interdependent pricing that concerned Posner, and that continues to worry Kaplow.

B. STANDARD OLIGOPOLY MODELS AND THE ROBO-SELLER

The reasons that the robo-seller makes interdependent pricing more feasible can be demonstrated by considering a very simple Cournot model oligopoly in which two firms produce the same good (no product differentiation) and simultaneously and independently select the quantity that they produce. These assumptions are crucial, though they do make the model a solid fit for industries with a lag between investment and production, such as pharmaceuticals, information technology hardware, and agriculture. One might question the choice of a model in which sellers set quantities, when robo-sellers, though increasingly being integrated into the supply chain, are for now primarily used for price changes.[93] The simple answer is that it is the best model for assessing oligopolistic behavior; as leading economist Xavier Vives has written, "[a]fter one hundred and fifty years the Cournot model remains the benchmark of price

Antitrust Enforcement in Private Equity: Target, Bidder, and Club Sizes Should Matter, 31 YALE J. ON REG. 25, 36–37 (2013) (asking whether parallel conduct in the shadow of possible tit-for-tat retaliation is excluded from antitrust liability by *Twombly*).

90. Frank Easterbrook, *The Limits of Antitrust*, 63 TEX. L. REV. 1 (1984).

91. 550 U.S. 544, 558–60 (2007) (discussing the impact of discovery costs and the fear of large erroneous judgments that even low plausibility claims spawn).

92. *See* Mark Anderson & Max Huffman, Iqbal*,* Twombly*, and the Expected Cost of False Positive Error*, 20 CORNELL J.L. AND PUB. POL'Y 1, 22–23 (2010); Judd E. Stone & Joshua D. Wright, *Antitrust Formalism Is Dead! Long Live Antitrust Formalism! Some Implications of* American Needle v. NFL, 2009–10 CATO SUP. CT. REV. 369, 382 (2010).

93. *See supra* Part I.B.

formation under oligopoly."[94] The contrasting Bertrand model implies that if firms select prices, then only two firms are required to achieve a perfectly competitive price level; but the Bertrand model's theoretical result proves dubious empirically.[95] As a result, the Cournot model is a better choice for modeling real-world oligopolies.

Working through the model, suppose q_1 denotes the quantity firm 1 chooses and q_2 denotes firm 2's choice, and that the demand for the product is given by an inverse relationship between quantity and price (as is normal) given by the function $p = 1 - q_1 - q_2$. To simplify, assume the cost of production to be zero. As a result, firm 1's payoff is its revenue (the price times the quantity chosen) minus cost, or

$(1 - q_1 - q_2)q_1$

and firm 2's payoff will be

$(1 - q_1 - q_2)q_2$.

Since firm 1's payoff function is a parabola with the open part facing down, its optimal strategy can be found by taking the partial derivative of its payoff function with respect to q_1 and setting it equal to zero (thereby finding a maximum point), yielding

$1 - 2q_1 - q_2 = 0$.

Solving for q_1, we get $q_1 = 0.5 - q_2/2$, and since firm 2's payoff function is identical, firm 2's best response is $q_2 = 0.5 - q_1/2$. As a result of this symmetry, $q_1 = q_2$, which yields the result that each firm will produce the Nash equilibrium quantity of 1/3,[96] which implies positive profits of 1/9.[97] As has been ob-

94. Xavier Vives, *Cournot and the Oligopoly Problem*, 33 EUR. ECON. REV. 503, 511 (1989).

95. *See* ANDREW LEDVINA & RONNIE SIRCAR, DYNAMIC BERTRAND AND COURNOT COMPETITION: ASYMPTOTIC AND COMPUTATIONAL ANALYSIS OF PRODUCT DIFFERENTIATION 1 (2012), https://www.princeton.edu/~sircar/Public/ARTICLES/dynBvsCprodDiff.pdf ("[T]he original Bertrand model results in perfect competition in all cases besides monopoly, which is unrealistic in most settings, leading one to conclude that the correct set-up leads to the wrong result.").

96. $q_1 = 0.5 - q_2/2$

$q_2 = 0.5 - q_1/2$

substituting for q_2 in the first equation: $q_1 = 0.5 - ((0.5 - q_1/2) / 2)$

$2q_1 = 1 - 1/2 + q_1/2$

$4q_1 = 2 - 1 + q_1$

$3q_1 = 1$

$q_1 = 1/3$

and substituting 1/3 for q_1 back into the second equation in the list, $q_2 = 1/3$.

97. Substituting 1/3 for q_1 and q_2 in the first equation—the payoff function

served for over a century, this means that each firm will price at a supracompetitive level rather than competing away all profit to cost (zero in this example) as in a perfectly competitive market, even though they are not explicitly colluding, but merely calculating their best response given the duopoly and the market realities they face.

This result—that the Nash equilibrium is higher than the competitive level—also obtains for industries with more than two players, though the margin above the competitive level decreases as the number of firms increases.[98] The point is not that a Cournot model is the best or only depiction of oligopoly. Rather, the general implication is that even if the firms are unable to explicitly communicate or agree, to maximize revenue they will each independently choose a quantity to produce which will result in a price that exceeds marginal cost—and is thus higher than the socially-optimal competitive price—though it also falls short of the monopoly price.[99] Such a result is also possible given certain assumptions in a Bertrand model, in which the firms directly choose price rather than quantity.[100] Moreover, as Herbert Hovenkamp has pointed out:

> One reason antitrust needs to take game theoretic solutions such as Cournot's more seriously is that the resulting arrangements can be more stable than cartel solutions. Under collusion each firm has marginal revenues that greatly exceed marginal costs. This makes cheat-

for each firm—yields *(1 – 1/3 – 1/3)(1/3) = 1/9*.

98. Indeed, this is the central implication of the Cournot Limit Theorem, under which equilibrium pricing continues to be higher than perfect competition, but lower than in a monopoly, though prices approach the perfectly competitive level as the number of firms increases. *See* JEAN TIROLE, THE THEORY OF INDUSTRIAL ORGANIZATION 224–28 (1988) (discussing the Cournot model and limit behavior); *see also* ROY GARDNER, GAMES FOR BUSINESS AND ECONOMICS 127 (2d ed. 2003) ("[W]hen the number of firms grows large[,] . . . quantity competition approaches as a limit perfect competition, a result known as the Cournot limit theorem.").

99. *See* HOVENKAMP, *supra* note 77, at 159 ("[E]conomists have argued that firms in concentrated markets can increase their prices above the competitive level without expressly communicating . . . [and] the resulting social loss [from oligopoly] (as compared to competitive behavior by firms with the same costs) seems to be quite substantial."); James W. Friedman, *A Non-cooperative Equilibrium for Supergames*, 38 REV. ECON. STUD. 1, 11 (1971); *see also* Kaplow, *supra* note 30, at 783–84 ("[F]irms in an oligopoly setting may indeed be able to sustain coordinated supracompetitive prices . . . regardless of whether each firm's expectation about the other's reaction arises from their mutual appreciation of their situation or is a consequence of direct discussions of the matter.").

100. *See* Kaplow, *supra* note 30, at 784 (detailing a similar repeated game version of a Bertrand model that results in "coordinated supracompetitive prices" despite the absence of legally enforceable agreements).

> ing [on one's cartel partners by reverting to a competitive market price despite an agreement to fix prices] highly profitable. By contrast, in the Cournot equilibrium each firm is maximizing its profits, and no one has an incentive to deviate. For this reason Cournot-style oligopolies may be a much more substantial competitive problem in concentrated markets than are classic cartels.[101]

Hovenkamp made this point almost a decade ago, well before the deployment of robo-sellers.

To the extent that mass data collection and automated, algorithmic pricing convey a better understanding of market conditions to oligopolists, the risk of social harm due to Cournot-style oligopolies will rise. Robo-sellers should be more effective than humans at sussing out the right choice of quantity or price in the absence of explicit agreement or communications. As a result, instances in which humans would be cognitively incapable of assessing their competitors' responses become at the margin much more feasible. All things being equal, the probability that market players can successfully adopt Cournot-style interdependent pricing should rise.

C. THE ROBO-SELLER AND PRICE-FIXING AMONG OLIGOPOLISTS

> The speed of response depends upon the time required to detect a given choice by the other player. The shorter this time is, the more stable cooperation can be. A rapid detection means that the next move in the interaction comes quickly, thereby increasing the shadow of the future.
>
> –Robert Axelrod, *The Evolution of Cooperation*[102]

In his classic study of the repeated Prisoner's Dilemma, Robert Axelrod invited experts to participate in a stylized computer competition in which their dueling software programs played a repeated Prisoner's Dilemma. We are at the dawn of the deployment of the robo-seller, in which computers will participate in real-world market competition. One possible outcome: collusion and cartels, which are widely understood to be a solution to a real-world repeated Prisoner's Dilemma. Axelrod's experiment is on the verge of becoming our real world.

To wit, while robo-sellers exacerbate the problem of oligopoly by potentially giving individual firms the incentive to raise prices even in the absence of coordination, they also make it

101. HOVENKAMP, *supra* note 77, at 161.

102. ROBERT AXELROD, THE EVOLUTION OF COOPERATION 7 (1984), http://www-ee.stanford.edu/~hellman/Breakthrough/book/pdfs/axelrod.pdf (adapted version of Axelrod's landmark work).

more likely that actual, and more durable, cartels will form. That is to say, robo-sellers are likely to play the repeated Prisoner's Dilemma better than humans. Coming back to the Cournot duopoly model in the prior section, consider again the Nash equilibrium of $q_1 = q_2 = 1/3$, which yields a payoff of 1/9 for each firm. While this is better for the firms than a socially-optimal, perfectly competitive market, in which price would equal marginal cost, it is worse for them than if they could share the monopoly level of output and each produced 1/4,[103] which would give them each revenue of 1/8 (which is greater than 1/9).[104] This outcome would require each firm to cooperate or coordinate to lower its output (because 1/4 is less than 1/3).

If the two firms interact every day, potentially infinitely, we can consider the implications of an infinitely repeated version of the Cournot duopoly, in which each stage is as described in the static model previously.[105] A possibility that emerges significantly in the literature is that each firm will adopt a grim-trigger strategy (also referred to as "Nash reversion," since the parties return to the original Nash equilibrium).[106] Each firm will select an output of 1/4, until and unless the other firm defects and selects 3/8[107] (which will increase its revenue), in which case the "victim" firm will forever select 1/3, causing the other firm to also thereafter forever select 1/3—thus reverting to the noncooperative equilibrium described in Part II.B. Economists have observed that one of the most effective methods of deterring cartel cheaters is for other cartel members to credibly threaten to lower their own price to the competitive level if

103. Consider a single firm model in which revenue is $(1 - q)\, q$. Setting the partial derivative to zero yields $1 - 2q = 0$, or $q = 1/2$. Splitting this monopoly level between two firms q_1 and q_2 equally means each produces $1/4$.

104. *If* $q_1 = q_2 = 1/4$, then, per the payoff formulae in the prior section:

Firm 1's payoff is $(1 - q_1 - q_2)\, q_1 = (1/2)(1/4) = 1/8$

and

Firm 2's payoff is $(1 - q_1 - q_2)\, q_2 = (1/2)(1/4) = 1/8$.

105. *See, e.g.*, JAMES N. WEBB, GAME THEORY: DECISIONS, INTERACTION AND EVOLUTION 107–08 (2007); William E. Kovacic et al., *Plus Factors and Agreement in Antitrust Law*, 110 MICH. L. REV. 393, 411 (2011) ("[F]irms in an oligopoly are players in a repeated game.").

106. *See* AXELROD, *supra* note 102 (discussing Robert Axelrod's experiment detailed in *The Evolution of Cooperation*).

107. If firm 1 is the defector, and firm 2 does not defect, firm 1's payoff function will be $(1 - (1/4) - q_1)q_1$, since firm 2 is selecting 1/4. Setting the partial derivative with respect to q_1 to zero yields $1 - 1/4 - 2q_1 = 0$, or $2q_1 = 3/4$, which yields $q_1 = 3/8$, the output that maximizes the defector's revenue.

cheating is detected;[108] the data collection made powerful by robo-sellers should make detection cheaper and more accurate.

As a result, cooperation will generate a firm the payoff of

$(1/8) (1 + d + d^2 + d^3 + . . .) = 1 / (8 (1 – d)).$

Selecting 3/8 means that the firm will get 9/64 $(> 1/8 = 8/64)$ in the first period,[109] but that it will get a discounted (by a per-period discount rate d) 1/9 in all subsequent periods, which sums to a defection payoff stream of

$9/64 + d / (9 (1 – d)).$

As a result, collusion can only be sustained if the payoff stream from not defecting outweighs that of defecting, or

$1 / (8 (1 – d)) > 9/64 + d / (9 (1 – d)),$

which is true when d ≥ 9/17. Essentially, the question to each individual cartel participant is whether its discount rate is high enough that the gains from defecting in the first period outweigh the future discounted costs from losing cartel pricing in each subsequent period. As a result, collusion is possible as a kind of self-enforced anticompetitive contract, when firms do not discount too much. If they discount future payments enough, then they prefer the current period payoff of defecting relative to the lost future payoffs.

Three key aspects of the robo-seller exacerbate antitrust's current "oligopoly dilemma." First, the effects relating to the discount rate should make interdependent supracompetitive pricing more stable. Second, greater accuracy in detection of price changes will have similar effects. Finally—and perhaps most importantly—minimization of the human factor removes an element of irrationality and agency cost that will likely reduce the chance that a cartel is undermined by mistake or an individual employee's priority of her own needs over that of the firm.

First, the robo-seller's effects relating to the discount rate should make cartel formation more likely and increase the stability of cartels once formed. Mass data collection and pro-

108. *See* Martin J. Osborne & Carolyn Pitchik, *Cartels, Profits and Excess Capacity*, 28 INT'L ECON. REV. 413, 413–14 (1987) (noting the power of such a threat); Garth Saloner, *Excess Capacity as a Policing Device*, 18 ECON. LETTERS 83, 83 (1985) (noting that the threat must be credible). *See generally* AXELROD, *supra* note 102 (discussing how an experimental tournament of dueling computer programs playing the Prisoner's Dilemma yielded a similar version of a "tit-for-tat" strategy as the winner).

109. The payoff period in the first period will be $(1 – 1/4 – q_1)q_1$ since the other firm is selecting 1/4, and plugging in 3/8 for q_1 yields profit of 9/64.

cessing should make a co-conspirator's price cut more quickly detectable.[110] The result will be to shorten the time period between defection and detection. As a result, given a particular discount rate, there will be a shorter time lag before the second period in which the parties revert to the lower-profit (but still supracompetitive) Nash equilibrium of the noncooperative Cournot duopoly.[111] All things being equal, the first period gain from defecting will be relatively less valuable, and so the cartel will be more stable.

Second, errors should diminish in the face of mass data collection, algorithmic processing, and automated decisionmaking. Increased accuracy in understanding what is happening to pricing in the market should lower the possibility that a price war would break out due to noisy price information.[112] For example, better data collection and analysis should reduce the odds that a seller confuses a period of unusually low demand with cheating by its cartel partner.[113] In essence, a robo-seller could come to function much in the way that resale price maintenance can provide certainty to an upstream cartel that agreed-upon prices

110. *See* Stephanie Clifford, *Retail Frenzy: Prices on the Web Change Hourly,* N.Y. TIMES, Nov. 30, 2012, http://www.nytimes.com/2012/12/01/business/online-retailers-rush-to-adjust-prices-in-real-time.html (reporting that "[i]n the old days, merchants sent employees into competitors' stores to check on pricing, and days later 'sale' signs reflected new markdowns" but "[n]ow, sophisticated computer programs accomplish the same goal online within hours, and even minutes").

111. *See* Ian Ayres, *How Cartels Punish: A Structural Theory of Self-Enforcing Collusion,* 87 COLUM. L. REV. 295, 300–01 (1987) (noting that "[i]f breaches [of a price-fixing agreement] could be detected instantaneously, the profits from breach would be driven to zero"—and the cartel would be more stable—"because firms could punish [the breacher] immediately" by lowering their prices in retaliation).

112. *See* AREEDA & HOVENKAMP, *supra* note 76, ¶ 1430c ("[U]ncertainty about rivals' behavior may force each oligopolist to act more like a perfect competitor . . . [and] [s]uch uncertainty [grows] . . . as public knowledge [about prices] fails or lags."); *see also* Jonathan Bendor, *When in Doubt . . . Cooperation in a Noisy Prisoner's Dilemma*, 35 J. CONFLICT RESOL. 691, 712–14 (1991) (concluding that "noise" can lead to the collapse of a tit-for-tat strategy into repetitive retaliation if one party mistakenly observes a defection when the other party intended to cooperate); Ronald J. Gilson et al., *Contracting for Innovation: Vertical Disintegration and Interfirm Collaboration*, 109 COLUM. L. REV. 431, 479 (2009) (observing that reliance "on informal enforcement can break down because relational enforcement requires that each party be able to observe and properly characterize the other's behavior").

113. *See, e.g.*, Kaplow, *supra* note 30, at 788 (describing the scenario in which a firm mistakes a period of unusually low demand for cheating by its cartel partner).

are being followed,[114] or that certain pricing systems, such as basing point or uniform delivered pricing, can simplify the task of monitoring prices.[115] The dissemination of price and output information through industry practice or agreement has long been a concern for antitrust due to its tendency to facilitate price fixing;[116] mass data collection and automated pricing possesses the potential to similarly turbocharge cartel coordination. In the corporate context more generally, Margaret Blair and Lynn Stout, as well as Carol Rose, have observed how a tit-for-tat strategy involving clear threats, including implicit ones, can perform a role akin to that of trust in informal enforcement.[117]

Finally, implementation of algorithmic pricing and automated decisionmaking will reduce the possibility that agency slack will lead to choices by employees that undercut a cartel. Think, for example, about discounting again, this time by sales and marketing staffs. Experimental economics literature makes clear that humans do not maintain constant discount rates over a series of time periods; rather, they tend to heavily favor immediate payoffs, with a very large discount rate to the next period, but a smaller discount rate for subsequent periods.[118] Salespeople and marketers may tend to use such *hyper-*

114. *See, e.g.*, Benjamin Klein, *Assessing Resale Price Maintenance After* Leegin, *in* RESEARCH HANDBOOK ON THE ECONOMICS OF ANTITRUST LAW 191 (Einer Elhauge ed., 2012) (discussing resale price maintenance after the Supreme Court's *Leegin Creative Leather Products, Inc. v. PSKS, Inc.* decision, and noting that it can help stabilize a cartel by "restrain[ing] the ability of retailers to reduce prices" and "by making it easier to detect manufacturers who cheat on a cartel by reducing wholesale price").

115. *See* AREEDA & HOVENKAMP, *supra* note 76, ¶ 1435f (describing how these pricing methods can facilitate practices that promote coordination among competitors).

116. *See, e.g.*, United States v. Container Corp. of America, 393 U.S. 333, 338 (1969) (holding that the exchange of price information between suppliers of corrugated containers violated Section 1 of the Sherman Act); Am. Column & Lumber Co. v. United States, 257 U.S. 377, 411–12 (1921) (holding that the "Open Competition Plan," under which competitors in the hardwood manufacturing industry exchanged sales information, violated the Anti-Trust Act of 1890).

117. *See* Margaret M. Blair & Lynn A. Stout, *Trust, Trustworthiness, and the Behavioral Foundation of Corporate Law*, 149 U. PA. L. REV. 1735, 1747–48 (2001) (noting that the threat of retaliation by one's peers may lead one to "behave trustworthily"); Carol Rose, *Trust in the Mirror of Betrayal*, 75 B.U. L. REV. 531, 539–40 (discussing how employing a tit-for-tat strategy can engender confidence in one's peers).

118. *See generally* Shane Frederick et al., *Time Discounting and Time Preference: A Critical View*, 40 J. ECON. LITERATURE 351 (2002) (reviewing at-

bolic discounting; this may be rational to them, since they may be short-termers—in contrast, the firm itself is potentially immortal. To the extent that this phenomenon leads them to offer price cuts (that management would not) that undermine a cartel, replacing their decisionmaking with robo-sellers' should reduce that risk to cartel stability. Additionally, to the extent that sales people might offer a lower price than the cartel price due to intrafirm competition between them for promotions, salary increases, or similar rewards, replacing them with robo-sellers also displaces a source of agency slack that undermines cartel stability.

* * *

The rise of the robo-seller exacerbates antitrust law's longstanding weakness at addressing social harm from oligopoly. Black-letter law's blind spot when it comes to independent price coordination—that is, without overt acts such as communication or the adoption of facilitating practices—may become a cloaking device behind which algorithmic price coordination can readily hide. Additionally, the challenges that face explicit collusion by oligopolists may become easier to surmount with mass data collection and algorithmic assistance.

III. ANTITRUST LAW'S ROBO-SELLER DILEMMA: MONOPOLISTS AND MORE OVERT PRICE-FIXING

> I invited experts in game theory to submit programs for a computer Prisoner's Dilemma tournament—much like a computer chess tournament. Each of these strategies was paired off with each of the others to see which would do best overall in repeated interactions. Amazingly enough, the winner was the simplest of all candidates submitted. This was a strategy of simple reciprocity which cooperates on the first move and then does whatever the other player did on the previous move. Using an American colloquial phrase, this strategy was named Tit for Tat.[119]
>
> –Robert Axelrod,
> *The Evolution of Cooperation*

In contrast, antitrust law does not have a gap in dealing with monopolists' anticompetitive acts or with price fixing by

tempts to estimate discount rates and analyzing the preference for immediate utility over delayed utility); Richard Thaler, *Some Empirical Evidence on Dynamic Inconsistency*, 8 ECON. LETTERS 201 (1981) (estimating individual discount rates from survey data and finding that, for gains, such rates vary inversely with the size of the reward and the length of the waiting time).

119. AXELROD, *supra* note 102, at 2.

firms that requires explicit coordination via communication or facilitating practices in order for firms to come to some kind of anticompetitive "agreement." In these cases, usually analyzed as a Prisoner's Dilemma in which the Nash equilibrium is to "cheat" on the cartel and undercut each other, price fixers need an "agreement" to avoid the inferior (for them, not consumers) outcome of competitive pricing.

Of course, because competitive pricing instead of collusion is socially beneficial, antitrust enforcement currently strives to disrupt the development of reciprocity and trust that can "solve" the Prisoner's Dilemma that cartel participants face. The emergence of the robo-seller will require a conceptual shift in some of antitrust law's bedrock doctrines. Antitrust law evolved over the past century-plus based on an embedded assumption of personhood among the actors it seeks to regulate. However, the robo-seller presents a new antitrust actor whose strengths relative to humans may make it more resistant to existing antitrust methods of deterring anticompetitive harm.

Antitrust law's approach to three central issues presumes a human actor. First, in deciding whether Section 2 of the Sherman Act has been violated, existing standards seek to gauge a monopolist or attempted monopolist's intent.[120] Second, to try to deter competitors from forming an explicit cartel agreement in violation of Section 1, antitrust enforcement agencies adopt policies designed to sow distrust and fear. Finally, where the existence of a cartel agreement is in question, courts draw heavily on common law contract notions such as whether there has been a "meeting of the minds" or "mutual assent"[121] Concepts of intent, fear, and "meeting of the minds" presuppose quintessentially human mental states; they may prove less useful in dealing with computer software and hardware. Each of these three issues is vitally important, since they deal with monopolies and cartels, the prime foci of antitrust law. Unfortunately, the approaches that current antitrust law

120. This is done either directly, *see, e.g.*, Alon Y. Kapen, *Duty To Cooperate Under Section 2 of the Sherman Act:* Aspen Skiing*'s Slippery Slope*, 72 CORNELL L. REV. 1047 (1987) (discussing courts' application of monopolists' intent); or indirectly, *see, e.g.*, Herbert Hovenkamp, *Exclusion and the Sherman Act*, 72 U. CHI. L. REV. 147, 149–50 (2005) (examining defendants' willingness to sacrifice short-term profits for expected monopolization and the recoupment test for predatory pricing).

121. *See* HOVENKAMP, *supra* note 77, at 159 ("In determining whether such an agreement exists, courts have relied heavily on common law contract formulations, such as 'meeting of the minds' or 'mutual assent.'").

takes to monopolies and cartels are a poor fit for regulating the robo-seller.

A. THE MONOPOLIST'S INTENT

Courts applying antitrust law focus on evidence of intent in deciding whether Section 2 of the Sherman Act has been violated. They do not punish bad intent for its own sake.[122] Rather, they use intent as a guide to characterizing observed conduct.[123] In cases involving monopolization through exclusionary conduct, as well as attempted monopolization, courts have adopted tests that seek to gauge the monopolist or attempted monopolist's intent.

In dealing with exclusionary conduct, the Supreme Court in leading cases has adopted approaches that focus on intent. Two of the most-commented upon antitrust decisions, *Aspen* and *Trinko*—strikingly different though their opinions may be in their outlook[124]—both look to the alleged violator's intent. In *Aspen*, the Court concluded that, for monopolization through exclusionary conduct, evidence of intent is "relevant to the question [of] whether the challenged conduct is fairly characterized as . . . anticompetitive."[125] As a result, the Court held that a monopolist's refusal to deal may violate Section 2 if the monopolist does not have a legitimate competitive reason for its conduct.[126]

Subsequently, the Court readdressed the issue of intent's role in understanding exclusionary conduct in *Trinko,* a case that contains strong dicta limiting *Aspen*.[127] In *Trinko*, the Court endorsed a less plaintiff-friendly test than the one in *As-*

122. *See id.* at 280.

123. *Id.* at 280 (observing that "[m]any kinds of conduct, such as the refusal to deal with a competitor . . . [are] extremely difficult for courts to characterize" and "evidence of intent can aid courts in the characterization problem").

124. *Compare* Aspen Skiing Co. v. Aspen Highlands Skiing Corp., 472 U.S. 585, 600–01 (1985) (finding an exception to the rule that even a monopolist has no duty to deal with a competitor) *with* Verizon Commc'ns Inc. v. Trinko, 540 U.S. 398, 409 (2004) (describing *Aspen* as "at or near the outer boundary of § 2 [monopolization] liability").

125. *Aspen*, 472 U.S. at 602.

126. *Id.* at 604–05, 610 (upholding jury instruction stating that defendant monopolist's refusal to deal with plaintiff "does not violate Section 2 if valid business reasons exist for that refusal" and concluding jury was justified in concluding that defendant did not have valid business reasons).

127. *Trinko*, 540 U.S. at 409 (describing *Aspen* as "at or near the outer boundary of § 2 liability").

pen, one that requires evidence that the defendant monopolist had sacrificed short-term profits by its conduct. The *Trinko* court took such "profit sacrifice" to "reveal[] a distinctly anticompetitive bent."[128] While commentators disagree about the merits of the diverging approaches to intent in *Aspen* and *Trinko*,[129] both tests clearly aim at the monopolist's intent (or "bent").

Courts also focus on intent in dealing with allegations of an attempt to monopolize in violation of Section 2. Justice Holmes imported a specific intent requirement from the common law's approach to attempted crimes into Section 2 attempted monopolization over a century ago.[130] Courts continue to apply a three-part test requiring a "specific intent to monopolize" as an element of the offense.[131]

Courts' use of intent under Section 2 may well prove to become more difficult in the era of the robo-seller. Decisions to exclude, for example by refusing to sell to a particular market participant, will not necessarily be accompanied by a record of e-mail or suspicious paperwork from which courts may infer intent.[132] Courts' reliance on particular changes of policy or price from which to infer intent will be hard to square with a new model of algorithmic selling, in which such changes may occur thousands of times per hour. Questions of profit sacrifice may become very difficult to answer when multiple different algo-

128. *Id.* at 409.

129. *Compare* Marina Lao, Aspen Skiing *and* Trinko*: Antitrust Intent and "Sacrifice,"* 73 ANTITRUST L.J. 171 (2005) (arguing against broader application of profit-sacrifice test), *with* A. Douglas Melamed, *Exclusionary Conduct Under the Antitrust Laws: Balancing, Sacrifice, and Refusals to Deal*, 20 BERKELEY TECH. L.J. 1247 (2005) (advocating for a version of the profit-sacrifice test).

130. Swift & Co. v. United States, 196 U.S. 375, 396 (1905).

131. Spectrum Sports, Inc. v. McQuillan, 506 U.S. 447, 454–55 (1993); H.J., Inc. v. Int'l Tel. & Tel. Corp., 867 F.2d 1531, 1540–42 (8th Cir. 1989); Int'l Distribution Ctrs. v. Walsh Trucking Co., 812 F.2d 786, 790 (2d Cir. 1987); William Inglis & Sons Baking Co. v. ITT Cont'l Baking Co., 668 F.2d 1014, 1027 (9th Cir. 1981).

132. *See* Geoffrey A. Manne & E. Marcellus Williamson, *Hot Docs vs. Cold Economics: The Use and Misuse of Business Documents in Antitrust Enforcement and Adjudication*, 47 ARIZ. L. REV. 609, 646–47 (2005) (describing, and decrying, courts' reliance on documents showing intent in order to interpret potentially anticompetitive conduct); Maurice E. Stucke, *Is Intent Relevant?*, 8 J. L. ECON. & POL'Y 801, 803 (2012) (defending reliance on such evidence to infer intent and guide interpretation of conduct); *see also* HOVENKAMP, *supra* note 77, at 283 (discussing the types of evidence jurors rely upon in analyzing intent).

rithms' interactions are so complex that determining the "best" price available may not be realistically possible even with the fastest computers.[133] Even where the notes of software writers are available, they may not provide courts with evidence as easy to digest as that of traditional sales and marketing staff. As a result, the current approach to intent under Section 2 may be hard to continue as algorithmic pricing and trading progress.

This would not necessarily be an unwelcome development for many antitrust experts.[134] While Herbert Hovenkamp observes that, as a positive matter, "[i]ntent has often been antitrust's ghost in the machine,"[135] he nonetheless is normatively quite negative about intent, describing "[f]ormulations requiring 'purpose' or 'intent' [as] generally unnecessary and sometimes harmful."[136] Even in those contexts where the Court has suggested other approaches to Section 2, it crafts such approaches as a proxy or filter to replace a direct inquiry into intent.[137] Similarly, Judge Posner has opined that intent should not be relevant in the context of Section 1 price fixing;[138] the late Phillip Areeda questioned the usefulness of intent in the context of Section 2 monopolization.[139] However, in practice,

133. *See* Sara Robinson, *Computer Scientists Find Unexpected Depths in Airfare Search Problem*, 35 SOC'Y FOR INDUS. & APPLIED MATHEMATICS NEWS, July–Aug. 2002, at 2–3; Keith Devlin, *The Crazy Math of Airline Ticket Pricing*, MATHEMATICS ASS'N OF AM.: DEVLIN'S ANGLE (Sept. 2002), https://www.maa.org/external_archive/devlin/devlin_09_02.html (suggesting that algorithms' interactions are so complex that determining the actual single best airfare currently available would take longer than a lifetime using the fastest computers available).

134. *See, e.g.*, FRANKLIN M. FISHER, JOHN J. MCGOWAN, & JOEN E. GREENWOOD, FOLDED, SPINDLED AND MUTILATED: ECONOMIC ANALYSIS AND *U.S. V. IBM* 272 (1983); *see also* Steven C. Salop & R. Craig Romaine, *Preserving Monopoly: Economic Analysis, Legal Standards, and Microsoft*, 7 GEO. MASON L. REV. 617, 652 (1999) (suggesting the place for an anti-competitive effects test).

135. *See* HOVENKAMP, *supra* note 77, at 282.

136. AREEDA & HOVENKAMP, *supra* note 76, ¶ 651c.

137. *See* Leslie, *supra* note 29, at 1710–12 (observing that the recoupment element applied by the Court in *Brooke Group* in the context of a predatory price discrimination claim has been praised by its advocates as "a convenient filter to avoid all inquiries into intent in predatory pricing cases," and noting that some jurisdictions continue to treat predatory intent as an element in such cases).

138. *See* Gen. Leaseways, Inc. v. Nat'l Truck Leasing Ass'n, 744 F.2d 588, 595–96 (7th Cir. 1984).

139. Phillip Areeda, *Essential Facilities: An Epithet in Need of Limiting Principles*, 58 ANTITRUST L.J. 841(1989) ("The defendant's intention is seldom

purging antitrust of what is claimed to be a subjective and underdetermined inquiry continues to be theorists' unrealized dream.[140] As a descriptive matter, investigations into human intent continue to play a significant role in antitrust analysis. The existing intent inquiry will fit the robo-seller only with major alterations, if at all.

B. DISTRUST AND FEAR AMONG EXPLICITLY COLLUDING COMPETITORS

The antitrust enforcement agencies' policies against Section 1 explicit price fixing by competitors focuses on sowing distrust among cartel members and putting fear of criminal punishment into them and their employees. Each of these methods is likely to prove less effective in a world of robo-sellers.

Cartel behavior has long been modeled as a repeated Prisoner's Dilemma.[141] Cartel members face a problem: because their agreement to fix a price is legally unenforceable, there is a risk that their counterparts will defect from the agreement, lower their prices, and increase profits at the expense of their cartel partners. If they all do so, their collective welfare will be worse than if they had remained faithful to their (illegal) agreement.

As a result, cartel members must find a way to make their commitments credible to each other.[142] As Christopher Leslie has explained, a key method is to build trust among one another.[143] Indeed, experimental economists have found that face-to-face communication of promises in cartel simulation games,

illuminating, because every firm that denies its facilities to rivals does so to limit competition with itself and increase its profits. Any instruction on intention must ask whether the defendant had an intention to exclude by *improper* means. To get ahead in the marketplace is not itself the kind of intention that contaminates conduct.").

140. HOVENKAMP, *supra* note 77, at 283 (noting that business decisions are "the product of many minds" and the "discovery search through corporate documents for evidence of specific intent is a turkey shoot").

141. *See* Friedman, *supra* note 99, at 1; *see also* Ariel Rubinstein, *Equilibrium in Supergames with the Overtaking Criterion*, 21 J. ECON. THEORY 1, 1–2 (1979).

142. *See* Ian Ayres, *How Cartels Punish: A Structural Theory of Self-enforcing Collusion*, 87 COLUM. L. REV. 295, 296–97 (1987) (explaining the role of punishment in future periods in making current period commitments credible).

143. Christopher Leslie, *Trust, Distrust, and Antitrust*, 82 TEX. L. REV. 515, 528–31 (2004).

even where such promises are unenforceable, helps human players build the trust they need to cooperate in maintaining a cartel.[144] The Department of Justice's Antitrust Division's leniency program for cartel members who defect and cooperate in the prosecution of their counterparts sows distrust.[145] By rewarding the first to confess, the leniency program alters the payoff in the repeated Prisoner's Dilemma so that cooperation becomes even more difficult; the cartel members need to be concerned not only that their counterparts might be planning to defect and cut prices, but also that any instability caused by unforeseen market impacts on the cartel will trigger a race to confess.[146]

By contrast, any collusion by a robo-seller will not in the near future involve the building of emotional trust through face-to-face secret meetings. Instead, cartel stability will likely be generated by more rapid detection of cheating and more probable retaliation.[147] Credibility will likely be generated through mutual expectation that swift retaliation will occur.[148]

Whether as a result of cooperation under the leniency program or, more generally, fear of existing criminal enforcement similarly will likely prove to be pretty weak tea in regulating robo-sellers. The Supreme Court has ruled that the Department of Justice's Antitrust Division must prove criminal intent to obtain an antitrust conviction.[149] Consequently, the Division files criminal actions only for clearly intentional violations of antitrust law, usually for explicit price fixing or bid rigging; overall, by the DOJ, the FTC, and private plaintiffs, far more

144. *See* MIGUEL A. FONSECA & HANS-THEO NORMANN, DÜSSELDORF INST. FOR COMPETITION ECON., EXPLICIT VS. TACIT COLLUSION: THE IMPACT OF COMMUNICATION IN OLIGOPOLY EXPERIMENTS 26 (Aug. 2012), http://www.dice.hhu.de/fileadmin/redaktion/Fakultaeten/Wirtschaftswissenschaftliche_Fakultaet/DICE/Discussion_Paper/065_Fonseca_Normann.pdf (last visited Mar. 15, 2016).

145. *See* Leslie, *supra* note 143, at 640.

146. *Id.*

147. *See* Ayres, *supra* note 142, at 300–01 (discussing how this would happen with human actors).

148. *See, e.g.*, Phil Evans, Presentation Before EU Directorate Generale for Health and Consumers: Dynamic Pricing Déjà vu All over Again—or Brave New World 8, http://judoeconomics.files.wordpress.com/2013/02/dynamic-pricing-pe.pptx (last visited Mar. 15, 2016) (noting the ability of algorithm-driven price data collection to reduce the incentives for firms to cut prices to consumers due to more rapid detection by competitors who are thus more likely to match price cuts).

149. *See* United States v. U.S. Gypsum Co., 438 U.S. 422, 443 (1978).

civil antitrust cases are brought than criminal ones.[150] As discussed in Part I, imputing intent to a data-collecting, algorithm-driven software process is difficult in the civil context; it should be even harder to find a requisite level of intent for a criminal conviction.

Moreover, even if the intent problem were surmountable, the rationale for criminal antitrust enforcement cannot be squared with a world of corporate robo-sellers. The Antitrust Division believes that incarceration is the most powerful deterrent for price fixing, since it imposes costs on employees for which the employer cannot easily reimburse them;[151] money is believed to be incommensurable with the various nonmonetary costs, including social stigma, to an individual of serving a sentence in federal prison. Accordingly, the Division has had a standard policy of refusing to agree to a "no jail" sentence for a criminal defendant, though it will plea bargain concerning the possibility of serving a sentence in a minimum security federal prison camp.[152] In the absence of a willingness to make the difficult leap of inferring criminal intent from a robo-seller's ac-

150. Only the DOJ can bring criminal antitrust actions, and it brings more criminal actions than civil ones. U.S. DEP'T OF JUSTICE ANTITRUST DIV., WORKLOAD STATISTICS, FY 2005–2014, http://www.justice.gov/atr/file/788426/download (identifying 8 civil cases filed by the DOJ and 45 criminal cases filed that year). The FTC only brings civil cases, and a search for the same time period showed that it brought 242 competition cases. *See* FTC Cases and Proceedings, FTC, http://www.ftc.gov/enforcement/cases-proceedings/advanced-search (select "Competition" under Mission and announcement dates from Jan. 1, 2005 to Dec. 31, 2014) (last visited Mar. 15, 2016). Additionally, private plaintiffs, who can only bring civil antitrust cases, file suit far more often than the federal antitrust agencies combined. Paul E. Godek, *Does the Tail Wag the Dog? Sixty Years of Government and Private Antitrust in U.S. Courts,* ANTITRUST SOURCE, Dec. 2009, http://www.americanbar.org/content/dam/aba/publishing/antitrust_source/Dec09_Godek12_17f.authcheckdam.pdf (showing roughly 1000 private civil antitrust actions filed annually in the federal courts in recent years). The disparity between criminal and civil case numbers might decrease where the focus is limited to Section 1 price-fixing, though such an analysis would be very difficult since cases often involve multiple claims of anticompetitive conduct of varying strength.

151. *See* R. Hewitt Pate, Assistant Att'y Gen., Antitrust Div., U.S. Dep't of Justice, Speech Before the 2004 ICN Cartels Workshop: International Anti-Cartel Enforcement 12–14 (Nov. 21, 2004) (transcript available at http://www.justice.gov/atr/file/517921/download); *see also* U.S. SENTENCING GUIDELINES MANUAL, § 2R1.1 cmt. background (U.S. SENTENCING COMM'N 2004) (stating that "the most effective method to deter individuals from committing this crime [of price fixing] is through imposing short prison sentences coupled with large fines").

152. *See* ABA SECTION OF ANTITRUST LAW, CRIMINAL ANTITRUST LITIGATION HANDBOOK 90–93 (2d ed. 2006).

tions and imputing that intent to its human deployers,[153] obviously neither reputation-harming stigma nor fear of prison are likely to alter a robo-seller's behavior.

C. SECTION 1 "AGREEMENT" AND A MEETING OF MINDS

In Section 1 price-fixing cases, debates over how to define the requirement of "agreement" in the text of the Sherman Act have drawn heavily on common law notions of contract formation.[154] As a result, courts seek to find a "meeting of the minds" via an offer—sometimes referred to as an invitation to collude—and an acceptance.[155] A robo-seller that relies on massive data collection, machine learning, and algorithmic pricing will not have the ability to communicate directly with other robo-sellers in the manner that humans do. That is, robo-sellers will not be able to conclude a meeting of the minds in an archetypal smoke-filled room.[156] As a result, theories of agreement that require explicit, direct communication—apart from mere observance of market data and interdependent adjustment of prices in response—will fit the robo-seller poorly.[157]

Because parties to Section 1 price-fixing agreements have strong incentives to be quite secretive about them, courts have fashioned approaches that allow for the inference of an agreement in the absence of direct evidence. A classic statement is found in *American Tobacco Co. v. United States*:

> No formal agreement is necessary to constitute an unlawful conspiracy. Often crimes are a matter of inference deduced from the acts of the person accused . . . . The essential combination or conspiracy in

153. *See infra* Part IV considering this argument.

154. *See generally* HOVENKAMP, *supra* note 77, § 4.2 (discussing various ways to find a price fixing agreement).

155. *See* Interstate Circuit, Inc. v. United States, 306 U.S. 208, 227 (1939) (holding that "[a]cceptance by competitors . . . of an invitation to participate in a plan, the necessary consequence of which, if carried out, is restraint of interstate commerce, is sufficient to establish an unlawful conspiracy under the Sherman Act"); Toys "R" Us, Inc. v. FTC, 221 F.3d 928, 936 (7th Cir. 2000) ("[Toy] manufacturers were in effect being asked by [Toys "R" Us] to reduce their output . . . [and] [i]t accomplished this goal by inducing [them] to collude, rather than compete."); *see also* Bell Atlantic Corp. v. Twombly, 550 U.S. 544, 556 (2007) (dismissing for failure to state a claim with "enough factual matter (taken as true) to suggest that an agreement was made").

156. *See* Transcript of Record, *supra* note 7, at 4889 (testimony of Elbert H. Gary).

157. *See, e.g.*, Page, *supra* note 30, at 178 (critiquing Kaplow and advocating an interpretation of "agreement" in section 1 that requires direct communication between competitors).

violation of the Sherman Act may be found in a course of dealing or other circumstances as well as in any exchange of words.[158]

To shape the process by which factfinders may make such inferences, courts have pointed to "plus factors" that make mere parallel conduct more suspicious, and to "facilitating practices" whose adoption renders parties susceptible to liability for an anticompetitive agreement. However, neither conventional plus factors nor the approach to facilitating practices is likely to be very helpful with robo-sellers.

Traditionally, "plus factors" have included evidence of clandestine meetings and secret exchanges of information.[159] The delegation of competitive intelligence and pricing activities previously done by marketing and sales people to robo-sellers will likely render such plus factors irrelevant. Automated agents crunching massive data collections cannot "meet" nor will they necessarily exchange information—indeed, their ability to gather and process huge amounts of data obviates the need to do so. Price-fixing human salespeople need to meet in secret to conspire in significant part because they cannot actually observe each other's prices comprehensively. As the ability to observe or deduce each other's price information grows via automation, there is less need to conspire in clandestine meetings; if you can independently, rapidly, and reliably verify, the need to meet to build trust is reduced.

Antitrust courts also have focused on the adoption by competitors of facilitating practices to infer an anticompetitive agreement.[160] Typically, such practices make collusion more likely by changing competitors' incentives; to the extent that their payoffs are properly modeled as an iterative Prisoner's Dilemma,[161] facilitating practices change the payoffs they face. Such practices include information exchanges among competitors and supply contracts provisions such as an most-favored-

158. Am. Tobacco Co. v. United States, 328 U.S. 781, 809–10 (1946).

159. *See, e.g.*, United States v. Andreas, 216 F.3d 645, 650 (7th Cir. 2000) (pointing to aliases, front organizations, and the use of prostitutes to clandestinely gather information from competitors as examples of particularly egregious behavior demonstrating "an inexplicable lack of business ethics and an atmosphere of general lawlessness"); C-O-Two Fire Equipment Co. v. United States, 197 F.2d 489, 497 (9th Cir. 1952) (citing price hike during a time of surplus). *See generally*, Kovacic et al., *supra* note 105, at 405–07.

160. *See, e.g.*, Texaco Inc. v. Dagher, 547 U.S. 1, 5–6 (2006) (holding a joint venture that set prices as not *per se* illegal); *In re* Sulfuric Acid Antitrust Litig., 743 F. Supp. 2d 827, 872–73 (N.D. Ill. 2010) (discussing actions that facilitated an anticompetitive effect).

161. *See infra* Part II.B.

nation clause (MFN) that enables a buyer to receive a discount that sellers provide to another buyer or a meeting competition clause (MCC) that requires a buyer to notify sellers and give them a chance to meet another seller's lower price offer; these contract provisions have drawn significant recent scrutiny from competition enforcers.[162] Massive data collection and analysis make information exchanges less necessary by providing the same sort of certainty about competitors' pricing without the need for contractual agreement. MFNs and MCCs foster quicker detection of prices lower than those agreed upon by price fixers; under current policy, the ability to monitor and process large amounts of pricing data should provide firms the price-coordination benefits of these clauses without their cost in attracting the attention of antitrust enforcers.

* * *

New technology and its incorporation into twenty-first-century business models have created a mismatch between the emerging robo-seller and the paradigms centered on human traits that drive more than a century of antitrust legal doctrine. The robo-seller's lack of identifiable intent, fear, or a subjective mind that can "meet" pose significant challenges to black-letter antitrust law. The question, as the next section discusses, is how antitrust enforcers can adapt to this challenge.

IV. ROBO-SELLERS: BOON OR BANE?

In *The Circle,* a 2013 techno-dystopian novel by bestselling author Dave Eggers, massive data collection and processing allows an innovative and ambitious corporation to exercise harmful influence on markets and consumer behavior.[163] Attempts to use antitrust law to combat its effects fail.[164] The negative impacts spin beyond markets to politics and beyond.[165]

162. *See* Steven C. Salop & Fiona Scott Morton, *Developing an Administrable MFN Policy*, 27 ANTITRUST, Spring 2013, at 15–17 (discussing MFN clauses' effects on competition); Steven C. Salop, *Practices That (Credibly) Facilitate Oligopoly Coordination*, in NEW DEVELOPMENTS IN MARKET STRUCTURE (J. Stiglitz ed. 1986), 279–83 (discussing how MCC clauses facilitate tacit collusion and deter entry, helping entrench oligopolies); Fiona Scott-Morton, Deputy Assistant Attorney General for Economic Analysis, U.S. Department of Justice, "Contracts that Reference Rivals" Speech at Georgetown University (April 5, 2012), http://www.justice.gov/atr/speech/contracts-reference-rivals, 3 (discussing generally contract clauses that reference a firm's rivals' pricing or other actions, such as MFNs and MCCs).

163. DAVE EGGERS, THE CIRCLE 173 (2013).

164. *Id.* at 174, 206, 259–60.

165. *Id.* at 489–91.

In a similar vein, our inner Luddite might ask whether, looked at purely from the increased possibility of supracompetitive pricing, robo-sellers might seem like candidates for prohibition. However, as this Part will discuss, they do carry the promise of significant benefits that might offset the risk they pose of decreased social welfare. Complicating matters, however, is robo-sellers' own complexity; existing competition enforcers may struggle to handle this technology. Robo-sellers are unlikely to be good candidates for per se prohibition. Instead, a rule of reason approach would seem more appropriate. However, the application of the rule of reason to robo-sellers will likely be difficult, and prone to error. Alternatively, imputing robo-sellers' actions to the humans that program or deploy them might work in some cases, but would likely lead to highly unpredictable results given existing antitrust tests. Additionally, the possibility of attributing agency to robo-sellers and handling them directly might hold promise, though the deontological reasoning generally used to justify recognition of robotic agency would be initially difficult to square with antitrust's existing instrumental justifications. Finally, an evolving process of norm creation by the FTC, in tandem with its program of privacy-related enforcement, may be the best, if yet imperfect, current choice.

A. THE EFFICIENCY OF ROBO-SELLERS

The deployment of mass-data collection, algorithmic pricing, and automated decisionmaking makes sense for several business reasons not directly related to the possibility of anticompetitive harm. Employing robo-sellers promises a reduction of headcount in departments such as sales, accounting, and marketing. Robo-sellers can labor twenty-four hours, seven days a week without breaks—and can do so at a very high work rate. As the trade press describes them:

> In the old days, actual humans were dedicated to the task of following the competition. They scanned newspapers, advertising, investment reports, and journals, gleaning information wherever they could find it, never sure if there was high-value information that they had missed. Now that the process to gather competitive intelligence has been loaded into software, comprehensive data collection occurs in real-time, and is presented on an easy-to-use dashboard. You can now dedicate 100% of your time to analyzing the data, rather than collecting it.[166]

166. Kalie Moore, *Harness the Power of Human Intelligence: Where Data and Strategy Meet*, RIVALFOX BLOG (Feb. 21, 2014), https://rivalfox.com/blog/

Understandably, this description may contain a degree of puffery. Realistically, however, in synergy with roles that are not automated, mass data collection and algorithmic processing promises to assist managers in making more, faster, and better decisions. Where the decisionmaking is also automated, robo-sellers promise still more cost savings.[167]

As a result, prohibition of robo-sellers appears unwise; something akin to a *per se* rule against them would be a poor fit. Fortunately, antitrust has longstanding alternatives to blanket prohibition, chief among them the rule of reason.[168] As an approach, it is far from perfect,[169] and involves quite a bit of uncertainty for antitrust defendants.[170] Nonetheless, courts have more than a century of experience in ascertaining "whether [a] restraint . . . promotes competition."[171] If the answer is "yes," in practice, courts ask whether the restraint could be achieved with a less restrictive means; if the answer is "no" then the restraint is redeemed.[172]

At first glance, the rule of reason might seem useful in dealing with potential harmful effects of robo-selling. As discussed in the prior sections, automated pricing via algorithmic processing of collected mass data may tend to lead pricing above the competitive level, either via tacit collusion or more robust cartel formation. However, the significant labor cost savings and better competitive intelligence that robo-selling promises may partially or completely offset the potential for competitive harm. In more technical terms, the possibility that producers who adopt robo-selling may see their marginal cost

harness-the-power-of-human-intelligence-where-data-and-strategy-meet.

167. Dana Mattioli, *Holiday Price War Rages in Real Time*, WALL ST. J., Nov. 24–25, 2012, at A1 ("[T]he rise of e-commerce, along with an explosion in data and the power of technology for analyzing it, has made it possible for retailers of all stripes to monitor their rivals' pricing strategies and react in seconds, sometimes with computer algorithms making the decisions."); *see also* Moore, *supra* note 166.

168. *See* Chi. Bd. of Trade v. United States, 246 U.S. 231, 239 (1918).

169. *See* Maurice E. Stucke, *Does the Rule of Reason Violate the Rule of Law*, 42 U.C. DAVIS L. REV. 1375, 1377–87 (2009) (analyzing deficiencies of the rule of reason against "rule-of-law ideals").

170. *See Chi. Bd. of Trade*, 246 U.S. at 239 (introducing the rule of reason); DANIEL A. CRANE, ANTITRUST 52 (2014) (observing that "[a]t its core, the rule of reason asks whether, on balance, the restraint is good or bad for competition" and "[a]t its worst, the rule of reason feels like a completely amorphous and unstructured inquiry into all the motivations behind the restraint and its alternative and economic effects"); *see also* Stucke, *supra* note 169, at 1377–78.

171. *Chi. Bd. of Trade*, 246 U.S. at 238.

172. AREEDA & HOVENKAMP, *supra* note 76, ¶ 1505.

drop may outweigh the incremental risk of deadweight loss due to increased supracompetitive pricing. Consider, for example, the discussion of Uber in the introduction of this Article. The Uber platform lowers transaction costs between drivers and riders, making possible mutually beneficial exchanges that enhance social welfare. At the same time, the platform coordinates pricing between competing drivers, raising at least the theoretical risk of price manipulation that harms consumers. The rule of reason traditionally aims to try to gauge such countervailing positive and negative effects on competition.

Despite more than a century of experience, rule of reason case law is not a perfect fit for the robo-seller. Firms are already employing automated pricing via algorithmic data processing—but they appear to be doing so individually, not as part of an explicit or tacit agreement with competitors.[173] However, though the rule of reason originated in a Section 2 monopolization case,[174] courts have not specified how rule of reason in monopolization cases should apply so as to balance the anti- and procompetitive effects of a single firm's conduct.[175] Instead, the standard approach to single firm conduct asks first whether that conduct is "exclusionary" or "predatory";[176] conduct should be condemned only if it can only be profitable by injuring competition and lacks any other legitimate business justification.[177] It is doubtful whether the employment of a robo-seller could ever be deemed lacking a legitimate business justification, given the tremendous cost savings possible from sales and marketing staff reductions, plus the improved speed and accuracy of competitive intelligence gathering.[178]

In fact, most recent Supreme Court discussion of the rule of reason occurs in cases dealing with agreements among com-

173. *See infra* Section II.

174. Standard Oil Co. v. United States, 221 U.S. 1 (1911).

175. *See* HOVENKAMP, *supra* note 77, at 277 § 6.4 (noting that "[t]he meaning and scope of the rule in monopolization cases are nevertheless ambiguous").

176. *See, e.g.*, United States v. Microsoft Corp., 253 F.3d 34, 58 (D.C. Cir. 2001); *see also* David McGowan, *Between Logic and Experience: Error Costs and* United States v. Microsoft Corp., 20 BERKELEY TECH. L.J. 1185, 1217 (2005) (describing Microsoft as applying the standard categorical approach in Section 2 cases).

177. *See* Verizon Commc'ns Inc. v. Trinko, 540 U.S. 398, 409 (2004) (observing that defendant's conduct in *Aspen* involved forgoing a normally profitable course of business); Aspen Skiing Co. v. Aspen Highlands Skiing Corp., 472 U.S. 585, 610–11 (1985) (applying profit-sacrifice test).

178. Moore, *supra* note 166.

petitors—that is to say Section 1 violations.[179] In cases involving concerted action, antitrust courts have long taken a relatively wide view of circumstances surrounding a restraint to decide whether its precompetitive benefits outweigh its anticompetitive harm.[180] While early statements of the scope of the inquiry were perhaps overbroad,[181] the rule of reason in Section 1 cases now tends to focus on the likely anticompetitive effects of a restraint adopted by competitors, whether they have the market power to make a difference, possible offsetting procompetitive justifications, and finally, whether there are less restrictive alternatives.[182] For a couple of reasons, the robo-seller's mixed implications for competition will make the rule of reason complex to apply, thus tending to create uncertainty. First, similarly to the Section 2 context, the adoption of robo-seller technology would seem to come with a built-in procompetitive justification: reduced cost and more accurate competitive intelligence. Thus, virtually all applications of the rule of reason to robo-selling will involve a difficult problem of balancing pro- and anticompetitive effects. Second, unless adopted as part of an agreement among competitors—including via a standard-setting or trade association—Section 1 as currently interpreted would not consider the use of robo-seller technology to be the adoption of a restraint by competitors.

Thus, while the rule of reason aims specifically at considering balancing the anticompetitive and procompetitive effects of a restraint, it is not well suited to dealing with the potential harms of the growth of automated pricing by algorithmic processing of mass-collected data. In the Section 2, single-firm context, the built-in legitimate business justification will tend to

179. *See* HOVENKAMP, *supra* note 77, at 274.

180. *See* Broadcast Music Inc. v. Columbia Broad. Sys., Inc., 441 U.S. 1, 23 (1979) (observing that the restraint at issue was not illegal "where the agreement on price is necessary to market the product at all" and that the benefit therefore outweighs the harm); Continental T.V., Inc. v. GTE Sylvania Inc., 433 U.S. 36, 54–56 (1977) (balancing a restraint's harm to competition among intra-network dealers against the benefit to competition among inter-network dealers).

181. *See* Chi. Bd. of Trade v. United States, 246 U.S. 231, 239–41 (1918) (adopting a rule of reasonableness to the application of the Sherman Act); *see also* HOVENKAMP, *supra* note 77, at 725 § 5.6b (describing Justice Brandeis' statement of the rule of reason in *Chi. Bd. of Trade* as "one of the most damaging in the annals of antitrust").

182. *See* California Dental Ass'n v. Fed. Trade Comm'n, 526 U.S. 756, 781 (1999) (Breyer, J., dissenting) (limiting the contemporary judicial approach to the rule of reason).

exculpate even harmful robo-selling; Section 1 may be inappropriate since multi-firm conduct is not necessarily required to adopt anticompetitive incidences of robo-selling.

B. AN AGENCY LAW SOLUTION?

In dealing with a robo-seller that takes anticompetitive actions there are three choices in attributing responsibility: to the robo-seller itself, to the humans who deploy it, or to no one.[183] The choice really comes down to the first two options, as choosing the third option—no liability—would essentially provide immunity to anticompetitive conduct and results achieved through automation. Such a choice of inaction does not accord with competition law based on efficiency and the error-cost framework; the decision to do nothing would clash starkly with the current logic and assumptions on which contemporary antitrust law has been tailored and justified.

The choice between attributing responsibility to the robo-seller, the humans deploying it, or both, is not an easy one. Consider the choice of the robo-seller. First, to attribute anticompetitive acts and impact to robo-sellers does not accord well with existing concepts of agency. The Restatement (Third) of Agency—already a decade old—states that

> [a]t present, computer programs are instrumentalities of the persons who use them. If a program malfunctions, even in ways unanticipated by its designer or user, the legal consequences for the person who uses it are no different than the consequences stemming from the malfunction of any other type of instrumentality. That a program may malfunction does not create capacity to act as a principal or an agent.[184]

Not too long ago, the view that computers must be seen as mere tools may have seemed uncontestable.[185] And indeed, a move away from this proposition would probably require changes to multiple statutes governing electronic contracting.[186]

183. See CHOPRA & WHITE, *supra* note 32, at 175 for a similar set of choices.

184. RESTATEMENT (THIRD) OF AGENCY § 1.04 cmt. E, illus. 3 (AM. LAW INST. 2006) (concluding that "a computer program is not capable of acting as a principal or an agent as defined by the common law").

185. *See, e.g.*, Joseph Sommer, *Against CyberLaw*, 15 BERKELEY TECH. L.J. 1145, 1177–78 (2000) (stating that "[a] programmed machine is not a juridical person and therefore cannot be an agent" and that it "cannot appear to be a principal, thereby triggering the law of undisclosed principals: it is clearly a machine").

186. For the point that a computer is incapable of being an agent, the term "electronic agent" appears in some statutes as a defined term. The Uniform

At any rate, the law's current stance that computer programs are simply tools of their operators creates tension with antitrust law. Such a view implies that the acts done by robo-sellers can be directly attributed to their human operators. But as noted in Section III.A, as a matter of current practice, antitrust law uses intent or proxies for it to interpret allegedly anticompetitive conduct. Thus antitrust's current approach requires a more in-depth investigation into intent than an agency law approach that would automatically pin a robo-sellers conduct on its employer as one might in the case of a mere "tool;" by contrast, no one asks whether a there is a disjunction between the effect of a baseball bat used in an attack and the intent of its wielder.

Electronic Transactions Act, § 2(6) 7A U.L.A. (1999) (UETA) defines "electronic agent" as "a computer program or an electronic or other automated means used independently to initiate an action or respond to electronic records or performances in whole or in part, without review or action by an individual." With one addition, "electronic agent" is defined identically in the federal Electronic Signatures in Global and National Commerce Act, 15 U.S.C. § 7001 (2000). The federal definition concludes with the words "at the time of the action or response." 15 U.S.C. § 7006(3) (2000). Both statutes also treat "person" as a defined term and do not include electronic agents in a list of persons. The comment to Section 2 of the UETA is informative, stating that the definition of electronic agent establishes that it is "a machine. As the term 'electronic agent' has come to be recognized it is limited to a tool function." The comment further explains that an electronic agent is the tool of the person who uses it and,

> [a]s a general rule, the employer of a tool is responsible for the results obtained by the use of that tool since the tool has no independent volition of its own. However, an electronic agent, by definition, is capable within the parameters of its programming, of initiating, responding or interacting with other parties or their electronic agents once it has been activated by a party, without further attention of that party. Section 7, the fundamental premise of the UETA, provides that the legal significance of a record, signature, or contract is not affected by the medium in which it was created. Section 9(a) attributes an electronic record or signature to a person if it was the act of the person.

It further provides that "[t]he act of the person may be shown in any manner, including a showing of the efficacy of any security procedure applied to determine the person to which the electronic record or electronic signature was attributable." Under subsection 9(b), the effect of an electronic record or signature attributed to a person "is determined from the context and surrounding circumstances at the time of its creation, execution, or adoption, including the parties' agreement, if any, and otherwise as provided by law." Comment 5 to Section 9 states that the section applies to determine the effect of a "click-through" transaction. A click-through, if executed with intention to sign, constitutes an electronic signature. While the UETA acknowledges that a person's actions include those taken by human agents, Section 9 "does not alter existing rules of law regarding attribution." UNIF. ELEC. TRANSACTIONS ACT, § 9 cmt. 1 7A U.L.A. (1999). On conceptions of legal personality more generally, see Ngaire Naffine, *Who Are Law's Persons? From Cheshire Cats to Responsible Subjects*, 66 MOD. L. REV. 346 (2003).

Moreover, as robo-sellers' sophistication increases, their ability to act and price autonomously may make the current agency law' approach untenable. In particular, some argue that greater ability to act autonomously counsels for greater recognition of software agents as actors in their own right. For example, in their book *A Legal Theory for Autonomous Artificial Agents,* Samir Chopra and Lawrence F. White have made a strong argument that increasingly autonomous agents such as robo-sellers deserve recognition as actors beyond mere tools. Unlike U.S. antitrust law—which is relentlessly teleological, particularly given its focus on consumer welfare—much of Chopra and White's argument stems from deontological reasoning.[187] Their proposal may be right for antitrust, even if their conclusion is not driven by consumer welfare or another instrumentalist goal; importing their distinction between autonomous artificial agents, including robo-sellers, and those who employ them, would be a good step for competition law.

Antitrust law would do well to start formulating a more nuanced approach towards autonomous agents. The challenges may soon increase. For example, "agreement technologies," a class of software agents, increasingly are able to manage supply chains and contract with either on behalf of the firms that employ them.[188] These nascent technologies may eventually surpass robo-sellers by going beyond price and output setting to negotiating, crafting, and executing contractual commitments that may enable them cause anticompetitive harm. While it is too early to know how these technologies will play out, it is worth appreciating that robo-sellers may well represent a technological beginning rather than a conclusion.

C. REGULATORS VS. ROBO-SELLERS

The deployment of robo-sellers requires several large investments: capital, to be sure, but also time and mindshare—robo-sellers involve the interweaving of mass data gathering, interconnectivity, algorithmic processing, machine learning, and automated decisionmaking. Accordingly, a useful understanding of robo-sellers' implications for competition will require regulators to grapple with different complex ideas. As a result, it might be important to ask the following question: Can

187. *See* CHOPRA & WHITE, *supra* note 32, at 172–73.

188. *See* Toni Penya-Alba et al., *An Environment to Build and Track Agent-Based Business Collaborations*, *in* AGREEMENT TECHNOLOGIES 611–24 (Sascha Ossowski ed., Law Governance & Tech. Ser. Vol. 8, 2013) (ebook).

regulators correctly answer the competition questions that robo-selling poses? This is particularly important given the existing gap for Nash equilibrium oligopolistic pricing; this important problem, which will likely grow worse, is not even currently illegal, though it does factor into merger review policy, in which regulators try to block mergers that will produce industries susceptible to such coordination. And can regulators do so accurately enough to make their involvement worthwhile?

As discussed, antitrust *law* as it currently stands will face significant challenges in dealing with robo-sellers. Despite that, there are at least a couple of reasons to think antitrust *institutions* may nonetheless succeed in addressing these new regulatory challenges. First, the FTC already is pursuing regulatory programs involving privacy, data collection, and price discrimination.[189] This current regulatory push builds on the agency's past experience in dealing with the collection of consumer data and its use by sellers.[190] There is likely a substantial overlap between the knowledge needed to handle inquiries in these areas and that needed to address the potential anticompetitive impact of robo-sellers. Second, the FTC has substantial capacity to interact with industry, consumer groups, and other stakeholders to shape legislation and to generate norms to govern the proper deployment of automated pricing powered by mass data collection and algorithmic processing.[191]

189. *See* FED. TRADE COMM'N, DATA BROKERS: A CALL FOR TRANSPARENCY AND ACCOUNTABILITY, (May 2014), https://www.ftc.gov/system/files/documents/reports/data-brokers-call-transparency-accountability-report-federal-trade-commission-may-2014/140527databrokerreport.pdf [hereinafter DATA BROKERS] (summarizing information about data brokers and consumer privacy learned from investigative orders and calling for Congress to legislate and for data broker industry to adopt several best practices)*; see also* Press Release, Fed. Trade Comm'n, FTC Recommends Congress Require the Data Broker Industry To Be More Transparent and Give Consumers Greater Control Over Their Personal Information (May 27, 2014), http://www.ftc.gov/news-events/press-releases/2014/05/ftc-recommends-congress-require-data-broker-industry-be-more.

190. For example, the FTC has enforced the Fair Credit Reporting Act since its enactment in 1970. DATA BROKERS, *supra* note 189, at i. Additionally, the FTC has already taken aim at consumer privacy concerns in the era of big data more generally. *See* FED. TRADE COMM'N, PROTECTING CONSUMER PRIVACY IN AN ERA OF RAPID CHANGE: RECOMMENDATIONS FOR BUSINESS AND POLICYMAKERS, (Mar. 2012), https://www.ftc.gov/sites/default/files/documents/reports/federal-trade-commission-report-protecting-consumer-privacy-era-rapid-change-recommendations/120326privacyreport.pdf.

191. Indeed, even prior to its May 2014 comprehensive report, the agency had already advised Congress about the impact on consumers of the data broker industry. *See Prepared Statement of the Fed Trade Comm'n on What In-*

The FTC's recent experience with the mass collection of consumer data is important, because regulation of robo-sellers by standard competition policy approaches may be quite difficult. As discussed in prior sections, conventional antitrust approaches that hinge on intent or on proxies chosen to avoid an intent inquiry will likely not work well when robo-sellers replace human sales and marketing staff and their paperwork.

A second important problem concerns pricing and measurement. Current antitrust analysis depends crucially on asking whether a seller's conduct raises prices to consumers above a competitive level; this is a key question that competition enforcers and their economic advisers ask as they proceed with an investigation. Typically this is done by comparing the market price given the conduct at issue with a hypothetical (or pre-conduct) competitive market price.

However, it is not clear that the individualized and moment-to-moment prices made possible by algorithmic pricing will be easily amenable to comparing an overall price with a baseline competitive price. To take a related example in an industry experienced with such pricing, the algorithms used by the airlines in the twenty-first century change prices based on supply and demand. They do so with such speed, with such complex rules, and with so many interactions between them, that mathematicians have observed that, in fact, finding the cheapest airfare between two locations is actually unsolvable as a practical manner, since "it could take the fastest computer longer than the lifetime of the universe to find the solution."[192] As a result, trying to do the standard price comparison may be very difficult;[193] this type of measurement problem may grow to encompass other industries.

formation Do Data Brokers Have on Consumers, and How Do They Use It Before the S. Comm. on Commerce, Sci. & Transp., 113th Cong. (Dec. 18, 2013), https://www.ftc.gov/sites/default/files/documents/public_statements/prepared-statement-federal-trade-commission-entitled-what-information-do-data-brokers-have-consumers/131218databrokerstestimony.pdf.

192. Devlin, *supra* note 133; *see also* Robinson, *supra* note 133.

193. Notably, in the context of the US Airways/American Airlines merger, the Justice Department's complaint attempted a unilateral effects analysis, comparing selected moment-in-time pricing in selected city pairs where the two airlines competed with those in which they did not. Whether this method would have been persuasive to a court remains unknown, as the DOJ greenlighted the merger subject to certain multi-year commitments by the merged airline. *See* U.S. Dep't of Justice, Competitive Impact Statement, United States v. US Airways Grp., NO. 1:13-CV-01236(CKK) (D.D.C. Nov. 12, 2013), (explaining that settlement is in the public interest under the Tunney Act and

As a result, the better route to avoiding competitive harm may be to undertake proactive shaping of industry behavior through dialogue with stakeholders, targeted regulation, and/or norm generation. The FTC is comparatively well-placed to do this job. On a general level, the FTC's Bureau of Consumer Protection has for more than a decade dealt with consumer privacy issues online.[194] In a string of cases, the FTC has brought enforcement actions against companies that handled consumer information in ways that breached prior representations made initially when gathering that data—for example, by subsequently selling consumer data after having assured consumers that it would not be shared externally.[195] Other FTC consumer data cases involve promising, yet failing to deliver, state-of-the-art consumer data protection.[196]

detailing the Department's asserted remedies for competition concerns).

194. *See* Kenneth A. Bamberger & Deirdre K. Mulligan, *Privacy on the Books and on the Ground*, 63 STAN. L. REV. 247, 251–52 (2011) (describing and critiquing FTC's activity as an online privacy regulator).

195. *E.g.*, News Release, Fed. Trade Comm'n, FTC Announces Settlement with Bankrupt Website Toysmart.com, Regarding Alleged Privacy Violations, FTC.GOV (July 21, 2000), https://www.ftc.gov/news-events/press-releases/2000/07/ftc-announces-settlement-bankrupt-website-toysmartcom-regarding (announcing settlement of charges against Toysmart after it violated its policy of not sharing customer information with third parties); News Release, Fed. Trade Comm'n, Online Pharmacies Settle FTC Charges (July 12, 2000), https://www.ftc.gov/news-events/press-releases/2000/07/online-pharmacies-settle-ftc-charges (announcing a settlement involving misuse of online pharmacy customer data for purposes other than physician consultation, in violation of company policy); News Release, Fed. Trade Comm'n, Internet Site Agrees to Settle FTC Charges of Deceptively Collecting Personal Information in Agency's First Internet Privacy Case (Aug. 13, 1998), https://www.ftc.gov/news-events/press-releases/1998/08/internet-site-agrees-settle-ftc-charges-deceptively-collecting (settling charges that a website with a two million member virtual community was mispresenting the purpose for which it gathered consumer data online).

196. *E.g.*, News Release, Fed. Trade Comm'n, Guess Settles FTC Security Charges: Third FTC Case Targets False Claims about Information Security (June 18, 2003), https://www.ftc.gov/news-events/press-releases/2003/06/guess-settles-ftc-security-charges-third-ftc-case-targets-false (settling case alleging that clothing company website claimed personal information including credit card data was encrypted though it was not and was left vulnerable to hackers); News Release, Fed. Trade Comm'n, Microsoft Settles FTC Charges Alleging False Security and Privacy Promises (Aug. 8, 2002), https://www.ftc.gov/news-events/press-releases/2002/08/microsoft-settles-ftc-charges-alleging-false-security-privacy (setting charges that Microsoft falsely claimed that it used appropriate security measures to protect consumer data entrusted to its "Passport" service, which would remember consumer sign-in and other information across different websites).

The FTC's experience with consumer privacy and with data brokers, as well its engagement in dialogue with Congress, consumers, and industry on related issues, makes it a comparatively strong choice for dealing with robo-sellers. Because robo-sellers require massive collection of sales data, their operation implicates actions and issues that overlap with data collection by online retailers and data brokers. Data brokers themselves already parse that data algorithmically to divvy up markets into narrower segments for sellers to target, with shorthand names such as "green consumer" or, perhaps involving ethnic or racial targeting, "Urban Scramble."[197] The FTC as a regulator is already addressing the possibility that such practices may lead to potentially harmful forms of price discrimination,[198] and Congress is already considering legislation in the form of a "Data Broker Accountability and Transparency Act"[199] that would further empower the FTC to deal with these issues.

Steps beyond new regulation may be required. The FTC is already engaged in dialogue with leading data brokers such as Acxiom, Corelogic, and Datalogix that deal in data involving hundreds of millions of customers, combining both online and offline information.[200] Discussions of best practices may help address feared harm from robo-sellers before it actually occurs. In addition, the FTC may need to develop new, independent competencies. For example, the private sector already uses "al-

197. DATA BROKERS, *supra* note 189, at iv–v, 20, 47 (raising the issue of market segmentation and labelling possibly being a form of racial profiling).

198. *See* JOSEPH TUROW, THE DAILY YOU 196 (2011) (describing use of consumer data for price discrimination purposes); Jeff Gelles, *Time to Rein in the Data-Broker Industry*, PHILA. INQUIRER (Jun. 2, 2014), http://articles.philly.com/2014-06-02/business/50248175_1_data-brokers-data-broker-industry-rapleaf (warning of possibility of data-driven price discrimination).

199. STAFF OF S., 113TH CONG., WORKING DRAFT OF BILL ON THE DATA BROKER ACCOUNTABILITY AND TRANSPARENCY ACT (Feb. 12, 2014), http://www.commerce.senate.gov/public/_cache/files/13d141a3-76b8-4191-810b-ebbfd5125759/764C58973E7D889E72B470ECEDA988D9.data-broker-accountability-and-transparency-act.pdf; Meena Harris, *Data Broker Accountability and Transparency Act Introduced By Senate Democrats*, INSIDEPRIVACY (Feb. 20, 2014), http://www.insideprivacy.com/united-states/congress/data-broker-accountability-and-transparency-act-introduced-by-senate-democrats.

200. The FTC recently created an Office of Technology, Research and Investigation, whose aim is at least in part to investigate the effects of algorithms on markets. The Department of Justice also recently prosecuted its first criminal case involving the use of algorithmic software to fix prices. *See* Jill Priluck, *When Bots Collude*, NEW YORKER (Apr. 21, 2015), http://www.newyorker.com/business/currency/when-bots-collude.

gorithmic enforcement" to press its rights in high-tech fields.[201] The FTC may need to employ such techniques in order to detect the anticompetitive use of robo-selling.

Proactive regulation by the FTC will likely not be a panacea. Nonetheless, it is important to avoid making the perfect the enemy of the good in an area undergoing such rapid and uncertain change. Significant resource asymmetries between business and government may drive doubt about the utility of regulation. Competition for profit incentivizes business to invest and innovate in its use of technology proactively; government regulators, not similarly impelled by market forces, tend to adapt in a more reactive manner, subject to political constraints.[202] Nonetheless, cooperatively generating norms and best practices for firms employing robo-sellers may be a good start that also benefits from synergies with the FTC's preexisting regulatory initiatives.

* * *

As this Section has discussed, key systemic issues will complicate how current antitrust law handles the robo-seller. In sum, two key issues dominate. First, it is possible to underestimate the benefits of the robo-seller. Even if, as this Article has discussed, tacit collusion becomes more likely with robo-sellers, they may nonetheless be so efficient that their benefits outweigh their harms. In more formal terms, using algorithms, software, and big data to do key business functions such as market intelligence, information gathering, strategic management, and sales may reduce marginal cost even while they make tacit collusion and pricing to consumers above marginal cost more likely; the problem becomes a question of weighing the expected value of positive and negative effects.[203] Second, a question that is difficult to answer under current knowledge is whether robo-sellers can be successfully regulated. Robo-sellers' poor fit with existing antitrust doctrines, the complexity of the algorithms involved and their interaction makes this potential-

201. *See* Ben Depoorter, *Intellectual Property Infringements & 3D Printing: Decentralized Piracy*, 65 HASTINGS L.J. 1483, 1498 (2014) (describing "algorithmic enforcement" of IP rights).

202. *See* DANIEL INNERARITY, THE DEMOCRACY OF KNOWLEDGE 176 (2013) ("The government would only pay attention to innovation in a reactive manner, adapting legislation to new technological circumstances . . . .").

203. There are conflicting viewpoints on how to treat such a circumstance. Some commentators view any welfare transfer from consumers to producers as in conflict with antitrust law's original intent and continuing goal, regardless of any offsetting overall social welfare benefits. *See* Lande, *supra* note 31.

ly a daunting regulatory challenge. Nonetheless, there appears to be potential synergies between the FTC's exiting regulatory program for consumer privacy and a potential initiative to address robo-sellers.

CONCLUSION: FROM CRISIS TO OPPORTUNITY TO SOLUTION?

After almost 125 years of the Sherman Act, the nature of concerted action and the definition of price fixing remain contested. This is unfortunate, since how concerted action is defined is a critical question for courts to decide when oligopoly behavior crosses the line into price fixing—and deserves the treble damages and criminal penalties that such cartel behavior entails. The advent of autonomous pricing via algorithmic processing of mass sales data can turn this doctrinal antitrust crisis into an opportunity for reexamination.

In fact, antitrust is not the only area that will require adaptation. Consider an analogy to the autonomous cars developed by Google and several major automakers. As mentioned, there exists a current debate over whether the algorithms in these vehicles should choose to save a single occupant even if that requires killing several others; this is a variant on the famous "trolley problem"[204] in moral philosophy.[205] At issue is whether algorithms should be designed to do things that are individually rational yet socially harmful. While that is a difficult question to answer, because it implicates ethics, policy, and law, it should be handled not merely behind closed doors by coders working for private firms, but through more open interplay between various stakeholders, including firms, consumers, and regulators. Similar logic should apply to robo-sellers to avoid results that, while profitable for individual firms, are harmful to consumer welfare overall.

As discussed, the problems with applying current antitrust enforcement techniques to the new challenge of robo-sellers suggest that a new regulatory dialogue is required. Fortunately, the FTC's existing regulatory program provides a platform on which to locate that dialogue. If fruitful, that dialogue may

204. *See* Limer, *supra* note 41.

205. *See* Philippa Foot, *The Problem of Abortion and the Doctrine of the Double Effect*, OXFORD REV., no. 5, 1967, at 3–4.

serve to help shore up an existing fault line in antitrust doctrine and theory.