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Algorithmic-facilitated Coordination – Note by Michal Gal

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Algorithmic-facilitated Coordination

Note by Michal S. Gal*

1. Introduction

1. The use of algorithms in digital markets brings about many benefits. They offer consumers the ability to compare online offers in a more efficient and sophisticated manner, thereby enabling consumers to enjoy lower-priced products, or products that better fit their preferences.[1] They enable suppliers to more quickly and efficiently analyze large amounts of data which is updated in real time on market conditions, thereby allowing suppliers to better and more quickly respond to consumer demand, to better allocate production and marketing resources, and to save on human capital. To do so, algorithms perform a myriad of tasks including sorting through data, organizing it, and making decisions based on the data collected with regard to multiple issues.

2. These advantages, researchers claim, are currently threatened by algorithmic-facilitated coordination.[2] As the argument goes, algorithms make coordination among suppliers - both implicit or tacit- much easier and quicker than ever before. Coordination can be sustained at lower levels of concentration; and firms can more quickly and easily detect and punish deviations from the coordinated equilibrium, thereby reducing incentives for shirking. As our assumptions about which market conditions must exist for firms to coordinate are altered, the number of red flags that are raised rises. Ezrachi and Stucke suggest in their seminal work on virtual competition that this effect is so strong that is the end of competition as we know it.[3]

3. Should, indeed, algorithms facilitate tacit coordination in markets not otherwise prone to it, we need to explore which tools – either market-based or regulatory – can be used, if at all, in order to reduce the negative welfare effects of algorithmic coordination among competitors.[4] If some of the assumptions that stand at the basis of the current rule

* Professor and Director of the Forum for Law and Markets, University of Haifa Faculty of Law; President, International Association of Competition Law Scholars (“ASCOLA”). Many thanks to Nicolas Petit and Bill Kovacic on excellent discussions.

[1] Michal S. Gal and Niva Elkin-Koren, “Algorithmic Consumers,” 30(2) *Harvard Journal of Law and Technology* (2017). See also the British Competition and Markets Authority, *Market Study on Digital Comparison Tools* (draft, May 2017).

[2] Ariel Ezrachi and Maurice Stucke, *Virtual Competition* (Harvard University Press, 2016); Salil K. Mehra, “Antitrust and the Robo-Seller Competition in the Time of Algorithms,” 100 *Minn. L. Rev.* 1323 (2016); Bruno Salcedo, “Algorithms and Tacit Collusion” (2015) available at brunosalcedo.com/docs/collusion.pdf (“when firms compete via algorithms that are fixed run the short run but can be revised over time, collusion is not only possible but is *inevitable*.” His results hold under specific assumptions regarding market conditions such as demand shocks that are more frequent than algorithm revisions). For a different view see Steve Tadelis and Kai-Uwe Kuhn (forthcoming paper).

[3] *Id*.

[4] Partly based on a Michal S. Gal, “Algorithmic-Facilitated Coordination: Market and Legal Solutions“ Competition Policy International (May 2017).

under which tacit collusion is not considered an "agreement in restraint of trade" do not hold anymore, such as the assumption that collusion can generally only be reached in highly concentrated markets, it is time to determine whether our laws are fit to deal with the digitized world; whether we are looking under the lamp while most of the occurrence in the real world is happening outside its scope of light. To further use this metaphor in the remedial stage- can we widen the scope of our existing laws by simply using a stronger light bulb in the same lamp, or do we need to create a new source of light altogether?

4. Accordingly, this paper focuses on three issues that arise from this technological challenge. First, it explores the effects of algorithms on the ability of suppliers to coordinate their conduct. Second, it briefly explores the promises as well as the limits of market solutions to welfare-reducing algorithmic coordination. The third part explores the ability of existing legal and regulatory tools to deal effectively with algorithmic-facilitated coordination. Such tools can be complementary or provide at least some viable alternative for the possible failure of market-based solutions to deal with algorithmic-facilitated coordination. The analysis explores three interconnected questions that stand at the basis of designing a welfare-enhancing policy towards the use of coordination-facilitating algorithms: Do algorithms that facilitate coordination fulfil the requirement of "an agreement", and if so- under which conditions?; what exactly do we wish to prohibit and can we spell it out clearly for market participants?; and is there justification for widening the regulatory net beyond its current prohibitions, in light of the changing nature of the marketplace.

2. Algorithms as Facilitators of Coordination

5. The starting point for the analysis if whether, and if so to which extent, algorithms facilitate coordination. To answer this, we first need to understand the conditions that must exist for coordination to take place. Then we need to explore and how algorithms affect them, if at all. These two questions are the basis of this part of the paper. We build on the existing literature and apply it to algorithms.

2.1. The Economics of Coordination

6. In certain circumstances, firms in a market may have incentives to coordinate their conduct instead of competing among themselves. Competitor coordination can significantly increase their profits and reduce consumers' welfare accordingly. While early research tended to view coordination as an industry structure problem, Nobel Laureate economist George Stigler suggested a novel way of thinking about coordination and identified three cumulative conditions that must exist for such coordination to take place, which still serve as a basis for much of the economic literature on coordination.[5] These conditions must hold whether coordination is a result of an explicit agreement:

1. *Reaching an understanding* on trade conditions (price, quantity, quality, etc.) which are profitable to all parties to the understanding. This involves resolution of any disagreement between firms as to the "correct" trade terms, and communication of the ultimate decision to all parties. Otherwise, market participants will not be able to create a stable status-quo that is perceived to be

[5] George J. Stigler, "Theory of Oligopoly," 72 *Journal of Political Economy* 44 (1964).

beneficial to each and every one of them relative to a situation in which they do not coordinate, and competition will ensue;

2. *Detection of deviations* from the supra-competitive equilibrium of other firms. The slower and less completely deviations are detected, the weaker the coordination, as firms have stronger incentives to cheat. Also, if market conditions are not conducive to exposing deviations, firms would have to incur substantial costs to detect deviations, which reduce the overall attractiveness of coordination in the first place;
3. Creating a *credible threat of retaliation* against deviators, in order to discourage such deviations ion the first place.

7. Economic theory further recognizes a fourth condition which must exist for coordination to take place: *High entry barriers* in the market in which the competitors operate, as otherwise new competitors might easily enter and sweep away the high profits, thereby reducing incentives to set supra-competitive prices in the first place.

8. The economic literature identifies additional market conditions that help facilitate coordination. Facilitating factors can be grouped into five broad categories: market structure variables (such as market concentration, entry barriers), the nature of the product (such as product and cost homogeneity, multiplicity of product variables), the nature of sales (such as lumpiness and secrecy), the nature of demand (such as demand fluctuations, difficulties of estimating demand for new products), and the "personality" of the firms operating in the market (such as their tendency to act as mavericks).[6] The relevant factors may vary within a market over time and some of them, such as entrepreneurial attitudes towards the engagement in illegal activity, are intrinsically variable. None of the factors are deterministic in their ability to facilitate coordination. Rather, they all reflect general tendencies subject to random deviations. In reality, a combination of market conditions will determine the likelihood of coordination. Some major examples of factors when can help facilitate coordination are noted below.[7]

9. A major structural condition which is said to facilitate the three first conditions for coordination is a small number of competitors, i.e. a concentrated market structure. This condition eases all three of Stigler's conditions. Most importantly, reaching an understanding to limit competition is easier and less costly if the number of firms is small. Detection of chiseling is also easier, given that there is a lower number of firms that should be checked for deviating conduct. Furthermore, as suggested in the background paper by the OECD, "[a] large number of firms not only makes it harder to identify a "focal point" for co-ordination, but it also reduces the incentives for collusion as each player would receive a smaller share of the supra-competitive gains that an explicit or tacit collusive arrangement would be able to extract."[8]

10. Indeed, the number of firms is so important, that it is largely assumed that tacit collusion can only be reached in oligopoly markets (hence its alternative name,

[6] Michal S. Gal, *Competition Policy in Small Market Economies* (Harvard University Press, 2003), chapter 5.

[7] See, e.g. Marc Ivaldi, Bruno Jullien, Patrick Rey, Paul Seabright & Jean Tirole, *The Economics of Tacit Collusion*, FINAL REPORT FOR DG COMPETITION, EC (2003) http://ec.europa.eu/competition/mergers/studies_reports/the_economics_of_tacit_collusion_en.pdf; Sigrid Stroux, US and EC Oligopoly Control (2004); Patrick Rey, "Collective Dominance and the Telecommunication Industry," in The Economics of Antitrust and Regulation in Telecommunication Markets (Pierre A. Buigues and Patrick Rey eds., 2004), 91, 91–102.

[8] OECD Secretariat, *Background Paper on Algorithms and Collusion* (2017), p. 18.

"oligopolistic coordination"). Oligopoly means few sellers. The main economic characteristic of oligopolistic markets is that each firm's decisions have a noticeable impact on the market and on its rivals. Though each firm may independently decide its strategic moves, any rational decision must take into account the anticipated reaction of its rival firms to its decisions. As Shapiro states, "the hallmark of oligopoly is the presence of strategic interactions among rival firms."[9] An oligopolist's decisions may thus be interdependent though arrived at independently. Such mutual interdependence may forestall rivalrous conduct.

11. Transparency of transactions also makes it easier to coordinate, since market offers are easier to coordinate, deviations are easier to detect, and the height of sanctions if easier to observe. Transparency of one's decisional parameters and the inputs used in the decision process makes it easier for others to understand what drives their rival's actions, thereby making it easier to reach an equilibrium and limit the instances in which a mistaken categorization of one's rival's action would lead to a price war.

12. Demand patterns also significantly affect the ability to coordinate. Demand fluctuations make it more difficult to set a stable jointly profitable price. They also make detection of deviations much harder and increase the chance of a price war.[10] Consider the following example: a supplier observes that demand for his product is reduced. He cannot effectively differentiate between natural changes in consumer demand which have affected all the suppliers in the market (or even mainly his product if products are heterogenous) and the cheating of a rival supplier who now enjoys a larger market share. Both possibilities may, nonetheless, lead him to lower his prices. This in turn, might trigger a price war in the market. It might take time until a coordination is once again achieved, if at all.

2.2. Algorithms as Coordination Facilitators

13. Can algorithms affect the market equilibrium? To answer this question, we need to explore how algorithms may affect the conditions for coordination explored above. If the abilities of algorithms do not help overcome those factors that currently limit coordination, then the answer is negative. If, on the other hand, they can overcome some of the coordination-limiting factors, then the answer is positive. An important note is in order: the ability of algorithms to facilitate collusion should be compared to how firms would have fared under the exact same conditions, without the use of algorithms. This implies that if, for example, digital markets make it more difficult to coordinate, given the increased uncertainty regarding consumers' demand in a world of many more choices, then the benchmark for comparison should be coordination in such a world but without algorithms.

14. Economic models, and especially game-theoretic models are of limited assistance in answering this question. This is because they are mainly focused on which equilibrium will be created under *given* market conditions, but do not focus on how firms *reach* such equilibria, and in particular what kind of communication is needed, if at all.

15. Current studies regarding the qualities of algorithms argue that algorithms operating in the data economy can make meeting the conditions for coordinated conduct

[9] Carl Shapiro, "Theories of Oligopoly Behavior," in *Handbook of Industrial Organization,* R. Schmalensee and R. Willig eds., Vol. I (Amsterdam: Elselvier Science Publishers, 1989), 329.

[10] For price wars triggered by misinterpretation of signals see, e.g., Green and Porter.

much easier and quicker than ever before.[11] Below we explore such studies. For the analysis below it is assumed that the fourth condition for coordination- that high entry barriers exist- is fulfilled. In markets where this is not true, firms will easily enter are reduce the supra-competitive price which resulted from coordination. Does the use of algorithms increase entry barriers? Not necessarily. In some circumstances, however, in which the algorithm's special qualities or the unique dataset on which the algorithm operates cannot be copied or easily reconstructed[12] (such as Google's database), the algorithm can create a significant comparative advantage that erects an entry barrier.

16. If, indeed, entry barriers are high, reaching a supra-competitive equilibrium by using algorithms can be easier for several reasons. The availability of real-time information on other competitors' digital offers, as well as more accurate information on consumers' preferences, facilitated by technological advances in data collection and data analytics as well as by increased connectivity capabilities in cyberspace, make it easier to calculate the jointly profitable level. The availability of real-time data also makes it easier to detect and adjust to market changes (such as an increase in the price of a major input of production), thereby shortening the reaction time to changes in market conditions and creating a new status-quo. Indeed, algorithms may employ automatic repeat actions which can very quickly reach a new status-quo. Of no less importance, algorithms can more quickly and accurately calculate the jointly profitable level among many competitors, thereby potentially overcoming the condition that the market be oligopolistic. Also, the algorithm makes an economic, rational decision, devoid of ego, unless the coder of the algorithm decides otherwise.

17. Detection of deviations from the status-quo is also made easier and quicker in a world in which data on competing offers is available online and algorithms can monitor prices in real-time.[13] As noted in the excellent OECD background paper, the increase in market transparency is not only a result of more data being available, but also of the ability of algorithms to make predictions and to reduce strategic uncertainty: algorithms may distinguish better than humans between intentional deviations from collusion and natural reactions to changes in market conditions or even mistakes, which may prevent unnecessary retaliations.[14] Furthermore, as Ezrachi and Stucke suggest, firms may have incentives to share their data and offers online, allowing all players to have access to the same information set.[15]

18. Creating a credible threat of retaliation against deviators is also facilitated by algorithms, as they can be coded to react immediately to such deviations. Consumers may

[11] See sources in footnote 3 above. Note, however, that as our understanding on how exactly algorithms interact develops, the insights from such studies will need to be incorporated into our understanding of how algorithms can be used to facilitate coordination and possibly change some of the assumptions currently made in the literature.

[12] See, e.g. Dan Rubinfeld and Michal S. Gal, "Access Barriers to Big Data", Iowa L. Rev. (2016).

[13] Of course, detection can be more difficult if demand fluctuates and aggregate demand is not observable. See Edward J. Green and Robert H. Porter, "Noncooperative Collusion under Imperfect Price Information" 52(1) *Econometrica* 87 (1984). The digital economy might even increase demand uncertainty in some industries. Observe, however, that the argument here is that given these conditions, algorithms can make it easier to coordinate than without them.

[14] OECD Background Paper, *supra*, p. 20.

[15] Ezrachi and Stucke, *supra*.

thus not even be aware of ephemeral price differences between competitors. Competitors, acknowledging this fact, have lower incentives to deviate in the first place.[16] Also, algorithms can better calculate the risk of being caught and the correct height of sanction to ensure nobody deviates. As elaborated below, sharing the cost data that is necessary to ensure that the calculation is correct might be a competition law offense, but this does not take away from the claim that algorithms can be used to facilitate (legal or illegal) coordination. Furthermore, they may create a higher risk of policing deviations, especially if changing the algorithm's decision tree is not simple (e.g. if it has to go back to the coder). This may make the status-quo more stable.

19. Furthermore, an algorithm is a pre-set decision mechanism, which some have likened to a recipe for making a decision. Where its decision-process is transparent, its rivals can better predict its decisions, including its reactions to their own decisions and to changes in market conditions, thereby making it easier to calculate the jointly profitable price, to detect deviations, and calculate how to best sanction the deviator. It also sends a strong and clear signal to other market participants about which parameters should affect the way he sets his terms of trade (e.g., whether he will follow a rivals' price or set a price and lower it is rivals do not follow). Several other types of transparency further strengthen this observation: (1) Transparency with regard to changes in the algorithmic decision-process. Such transparency limits instances of cheap talk and induces commitment; (2) Transparency with regard to the input (the data) used to reach the decision. Such information is important, because it is the combination of both- the algorithm and the data- which determines the final outcome. Interestingly, the algorithm or the database need not be directly made available. Rather, as Salcedo argues, the analytical qualities of other algorithms can be utilized to determine the decision-process of another algorithm, provided it has sufficient data about the decisions made by the algorithm under changing market conditions.[17] Observe, however, that it is much more difficult to reach such transparency where decisions are taken by neural networks. In such systems there is no explainable causality between input (data) and output (the decision make). Nonetheless, if the specific process of net neutrality on which the algorithm is based is transparent and can be copied, then some transparency can nonetheless be reached.

20. Therefore, algorithms increase the risk of tacit collusion without the need for explicit communication or interaction. This is not to say that algorithms can facilitate coordination in all industries. Where entry barriers are low, or where one or more of Stigler's conditions cannot be effectively met, coordination will not take place. This may be the case, for example, in markets in which demand fluctuations are significant and cannot be relatively easily differentiated from deviations from the equilibrium. Yet in markets in which entry barriers are high and algorithms can ease meeting the conditions for coordination, the instances and the stability of supra-competitive trade terms may increase.

21. Another observation is also in order: The use of algorithms does not imply that the coordinated equilibrium will be based on the perfectly calculated jointly profitable price. For that to happen, firms need to obtain information regarding the real production costs and production capacities of their rivals. This does not imply, however, that without such information firms cannot reach an equilibrium that raises prices to consumers. Some

[16] For studies of the effects of increased transparency on prices see, e.g., Ezrachi and Stucke, OECD paper (2017).

[17] Salcedo, *supra* note 3.

of this information can be indirectly observed or calculated, even if not perfectly; in a repeated game until an equilibrium is reached firms can signal such factors to each other; the equilibrium might be based on a benchmark that was used before or is a good enough approximation of the maximal price. Put differently, given that explicit communication of such information is often illegal, firms may settle for an imperfect price which is based on what they consider to be legal communication, but still increases their profits. This implies that an argument that algorithms cannot reach the perfect equilibrium does not lead to the conclusion that coordination is not facilitated.

22. Another conclusion from the above is that more transparency in online offers, while also potentially benefitting consumers, also sustains and strengthens coordination. Indeed, applications for finding cheap gasoline in one's area in fact drove prices to be higher, since each competitor could see in real time when others were changing their price and act accordingly.[18] Less trivially, transparency of competitors' algorithmic models and sources of data also strengthen coordination. This is because it clarifies how one will respond to another's actions.

23. A further conclusion is that due to these more efficient ways of fulfilling Stigler's three conditions, coordination might be reached even if the market is comprised of many small suppliers, all using algorithms coded to monitor and police deviations.[19] Indeed, the negligible costs of communicating and processing information make coordination and integration cost-effective in a way that was not available before, enabling large-scale coordination.

24. At the same time, as the OECD background paper suggests, algorithms may make collusion more difficult. This may be the case where algorithms create a comparative advantage to some firms over others (such as in the case of search algorithms). The diversity among firms may reduce incentives to coordinate. Observe, however, that often this implies that such firms may enjoy unilateral market power. What is more unique to algorithms is the fact that they can more accurately calculate the maximal price that each consumer can be charged,[20] thereby increasing pricing complexity. The next section explores the effects of this characteristic on a coordinated equilibrium.

2.3. How do "Digital Shadows" affect Coordination?

25. So far we assumed that competitors set similar, although supra-competitive, trade terms to consumers. But in the digital world another factor comes into play: increased information about each consumer's elasticity of demand. As more data is gathered about each consumer's preferences, it is claimed, a personalized "digital profile" can be created by algorithms, which calculates and updates each consumer's elasticity of demand in real-time. This digital shadow, the argument goes, can then be used by suppliers to increase their profits even further, if they can price-differentiate between the offers they make to different consumers. This, in turn, implies that setting one price for all consumers may be

[18] OECD Background Paper, *supra*.

[19] For a similar conclusion see the OECD Background Paper, p. 19.

[20] This ability may be limited, inter alia, by limited data on consumers' elasticity resulting from consumers' strategic response to the accumulation of personal data by holding back or hiding information or, more commonly, from limited data sources.

welfare-reducing for suppliers and that more factors enter into the coordinated equilibrium, thereby making coordination more complicated.[21]

26. For the purposes of the analysis below let us assume that the above is true, even if not to a perfect extent, given the unclarity of price signals sent by the consumer, unknown demand for new products, the effects of changing market conditions on demand, etc. How is coordination affected by this feature of digital markets? First and foremost it increases the incentives to engage in coordination. This is because without coordination it will be more difficult to reach a jointly profitable price, as multi-factored decisions may create great variations in price offers that may affect suppliers' stability.

27. At the same time, increased information about consumer's real-time preferences also make it more difficult to coordinate trade terms. The ability to coordinate depends, inter alia, on the type of coordination reached between algorithms and on the information each firm has about consumer preferences. Should firms not share such information, they may have a tendency to reach a market-division agreement (e.g., I sell to businesses and you sell to individuals), in which each does not enter the market segment of the other, and each can exploit information regarding consumer preferences in its designated market, and even engage in perfect price discrimination (what some call like to call in the more obscure name "personalized pricing").[22] Another possibility is that all firms possess such information, whether because each consumer's individual preferences are easily calculated by each of them alone, or because they all refer to a common database and use similar data analytical tools. If so, they can coordinate with regard to the price charged from each and every consumer, rather than in the market as a whole. While such coordination would be almost impossible for humans, under some market conditions it can be facilitated by algorithms. Whether the use of common data is legal is a separate question, to be addressed below. The difficulties involved in coordination may create a trade-off between competition with price discrimination and collusion with less price discrimination.

28. A related issue involves the use of digital shadows in order to differentiate products. Indeed, algorithms may allow firms to differentiate the products or services they offer in order to better meet the preferences of each consumer. This, in turn, may lead to product heterogeneity, which makes collusion harder to sustain. The same observations made above apply here as well. Furthermore, observe that while a focal point on which to base the coordinated equilibrium might be more difficult to find in any market in which products are heterogeneous, algorithms may ease this difficulty by engaging in a swift multiple factored analysis.

2.4. Algorithms Increase Harm to Welfare

29. The effects of algorithms as coordination-facilitators increases the harms of coordinated conduct among potential competitors. Indeed, in the data-driven economy, these harms are more significant than ever before.

[21] See also Nicolas Petit, "Antitrust and Artificial Intelligence: A Research Agenda," *JECLAP* (2017).

[22] In a simple (but likely illlegal) scenario, the algorithm is set so as to quote high prices to consumers belonging to groups that are to be served by another firm.

30. To understand the size of this threat, take as a baseline the current harm created by cartels.[23] By assisting competitors to overcome what was assumed to be the inherent limitations of coordination, algorithms strengthen both the ability to reach as well as the duration of coordinated conduct. Accordingly, the potential for harm is much larger. Should this technological change not be recognized and dealt with, its effects on our marketplace and on our social fabric might well be significant.

31. Let me offer a final observation, which pertains to macro-incentives: if, due to the use of algorithms, more markets can maintain a coordinated equilibrium, and if personalized price-discrimination can still be exercised under such an equilibrium, the incentives of consumers to work and earn more may be reduced. This may happen if two conditions are met: (1) the price of basic necessities does not change significantly; (2) the price of luxury goods is increased significantly, to (almost) the maximum price that each and every consumer is willing to pay for the product. The first condition is necessary, because if the price of basic goods (such as electricity, milk, etc.) rises, so does the need to work more in order to afford them. If their price stays relatively constant, they do not change willingness to work. The second condition ensures that the maximal price is charged for such products. This is because a larger portion of consumers' profits will be taken away by suppliers, basing their prices on the maximum price that can be charged from each individual based on his level of elasticity of demand. Consumers' acknowledging this fact, may therefore find it more welfare-enhancing to work less and earn less, given that they do not enjoy the fruits of their increased investments. Furthermore, a version of the tragedy of the commons may arise, since each supplier seeks to maximize the profits for his product, while not taking into account the negative externalities its conduct creates when multiple suppliers engage in similar conduct. This, in turn, might completely change the dynamics in the market. To my mind, this poses a significant concern, which should not be overlooked by regulators.[24]

32. So how do we ensure that consumers enjoy the benefits of the data-driven digital economy? The next two parts briefly explore two potential solutions to limit the negative effects of algorithmic-facilitated coordination: market-based ones, and competition law ones.

3. Market-based solutions: Algorithmic COnsumers

33. Can the market devise its own solutions to algorithmic coordination? The answer is a partial yes. As shown by Gal and Elkin-Koren, the use of algorithms by consumers can counteract at least some of the effects of algorithmic-facilitated coordination by suppliers.[25] Put differently, (consumer) algorithms can sometimes beat (supplier) algorithms.

34. Algorithmic consumers ("digital butlers") are algorithms that are employed by consumers, both private and business ones, which make and execute decisions for the consumer by directly communicating with other systems through the Internet. The algorithm automatically identifies a need, searches for an optimal purchase, and executes

[23] See, e.g. John M. Connor and Robert H. Lande, "Cartels as Rational Business Strategy: Crime Pays," 34 *Cardozo Law Review* 427 (2012).

[24] This threat also arises when many markets are characterized by unilateral market power.

[25] Gal and Elkin-Koren, *supra*.

the transaction on behalf of the consumer. Such algorithms offer many benefits to consumers as they can significantly reduce search and transaction costs, and help consumers overcome biases and enable more rational and sophisticated choices.[26] Most of the analysis below assumes that algorithmic consumers are coded to best serve the consumer. This assumption is relaxed later on.

35. Algorithmic consumers are no science fiction, as they already are part of our markets.[27] In some industries, such as stock trading, algorithms automatically translate their results into buying decisions. Consumers can already purchase a washing machine from the W9000 series developed by Samsung and IBM, which uses IBM's ADEPT (Autonomous Decentralized Peer-to-Peer Telemetry) technology to make autonomous orders and payments to restock detergent, for example, and then update the owner via a smartphone.[28] This technology, revealed in 2015, exemplifies what is known as the Internet of Things ("IoT"), whereby connected devices automatically handle myriad day-to-day tasks.[29] The algorithm can also be coded to search for the best offer for detergent at any given time. Another example involves the British application Flipper, which monitors prices of competitors in the energy market and automatically switches suppliers when it is profitable.[30]With the advent of these technological changes, it is envisaged that algorithmic consumers will become the rule rather than the exception for an exponentially increasing number of transactions — realizing a vision of a world where "humans do less thinking when it comes to the small decisions that make up daily life."[31]

36. Algorithmic consumers can potentially counteract at least some of the negative welfare effects of algorithmic-facilitated coordination. How can they do so? Below I explore several ways, all of which are based on the idea that instead of sitting back and indirectly affecting suppliers' decisions through demand preferences; consumers can actively change market conditions through introducing another active player into the market game.

37. First, algorithmic consumers can create **buyer power**. Such power can be created if an algorithmic consumer has a sufficiently large number of users, or if it coordinates its conduct with other algorithmic consumers. This, in turn, may allow consumers to counteract suppliers' buyer power. Indeed, the algorithm can be coded not to buy a certain good if price is above a certain level. The aggregation of buyers can also make transactions less frequent and small, thereby increasing incentives of suppliers to deviate

[26] *Ibid*.

[27] *Id*.

[28]Stan Higgins, IBM Reveals Proof of Concept for Blockchain-Powered Internet of Things, CoinDesk (Jan. 17, 2015, 7:12 PM), http://www.coindesk.com/ibm-reveals-proof-concept-blockchain-powered-internet-things**;** IBM Inst. for Bus. Value, IBM, ADEPT: An IoT Practitioner Perspective 13 (Draft Copy for Advance Review, Jan. 7, 2015), http://www.scribd.com/doc/252917347/IBM-ADEPT-Practictioner-Perspective-Pre-Publication-Draft-7-Jan-2015.

[29] See OECD, The Internet of Things: Seizing the Benefits and Addressing the Challenges 9 (May 24, 2016).

[30] https://flipper.community/

[31] Danny Yadron, Google Assistant Takes on Amazon and Apple to Be the Ultimate Digital Butler, The Guardian (May 18, 2016, 2:17 PM), https://www.theguardian.com/technology/2016/may/18/google-home-assistant-amazon-echo-apple-siri**.**

from the coordinated equilibrium.[32] Furthermore, should the group of buyers represented by the algorithm be sufficiently large, it can negotiate and enter into a transaction with a supplier "off the digital grid," thereby creating stronger incentives for suppliers to deviate from the jointly profitable price. Note that such negotiations need not necessarily involve human intervention.

38. Furthermore, algorithmic consumers can be coded to **include decisional parameters designed to eliminate or at least reduce some market failures** in the long run. Algorithms are sufficiently flexible to include considerations such as long-run effects on market structures that might harm consumers. For example, an algorithm might be able to recognize coordination among suppliers, and refrain from doing business with those suppliers until prices are lowered. Alternatively, it might always buy some portion of its goods from at least one new source, to strengthen incentives for new suppliers to enter the market. Of course, including such decisional parameters requires more sophisticated modeling and analysis of market conditions and their effect on welfare, but given advances in economics and in data science, they are becoming easier. It also requires incentives for collective action, since refraining from doing business is personally costly to a customer, while disrupting a cartel is a public good (it benefits all customers). Such incentives can be created when many consumers are aggregated by one algorithmic consumer.

39. Finally, Algorithmic buying groups may **reduce the ability of suppliers to price discriminate** among consumers. By aggregating the choices of different consumers into one virtual buyer, they obscure the personal demand curves of the consumers (what might be called anonymization-through-aggregation). Indeed, if consumers are aggregated into sufficiently large consumer groups, suppliers lose the ability to collect information on consumers' individual preferences with regard to products bought through the group, and to discriminate among them based on each consumer's elasticity of demand.[33] The loss of this ability, in turn, could increase consumers' welfare, if suppliers are forced to set a lower price for all. However, in some situations it might also affect welfare negatively, by limiting the ability of some flexible-demand consumers to enjoy lower prices,[34] or by limiting consumers' exposure to personalized offers.

40. Algorithmic consumers can therefore improve market dynamics and limit the harmful effects of algorithmic-facilitated coordination, without need of legal intervention. Rather, their regulating power resides in the proactive reaction of consumers to the change in market conditions.

[32] An interesting question, which is beyond the scope of this article, is what are the effects of such buyer power on buyers who do not use the algorithm. Another question which arises is whether the buying group infringes competition law. See Gal and Elkin-Koren, *supra*. The ability to create buyer power and to obscure the details of the specific buyers can also affect market structure by creating a comparative advantage to algorithms which serve a large number of heterogeneous buyers.

[33] See, e.g. Samuel B. Hwang & Sungho Kim, "Dynamic Pricing Algorithm for E-Commerce," in Advances in Systems, Computing Sciences and Software Engineering 149 (Tarek Sobh & Khaled Elleithy eds., 2006). For a discussion of the welfare effects of price discrimination, see, e.g. R. Preston McAfee, "Price Discrimination," in Issues in Competition Law and Policy 465, 480–83 (ABA Section of Antitrust Law 2008).

[34] If a consumer is aware of his higher price elasticity for a certain product, he might choose to but this product directly from the supplier thereby potentially enjoying a lower price. This, however, might lead to a natural selection: a situation where only low-elasticity consumers will buy through the algorithm, indirectly signaling to suppliers they can set a higher price for those left in the buying group.

41. This market-based solution is not, however, without limitations. Three main potential limitations, in which competition authorities may have an important role to play, can be identified. First, the use of algorithmic consumers might infringe competition laws, if they are found to engage in anti-competitive agreements or to abuse their market power. While it is undoubtedly important to limit anti-competitive conduct by algorithmic consumers, it is equally important to clarify the rules that will be applied to the use of buyer power to counteract supplier power.[35] In particular, it is important to clarify whether the laws applied to buyer power differ, if it all, from those applied to supplier power. It is often the case that economists and competition authorities treat supplier and buyer power similarly. To my mind, an important distinction exists: while increased supplier profits might lead to increased research and development, this is not true of buyer power. Questions regarding the regulation of buyer power are not new. Yet algorithmic consumers may make buying groups more relevant and powerful than ever. Therefore, issues regarding the effect of buyer power on welfare becomes more relevant.[36]

42. Second, algorithmic consumers might incur entry barriers in reaching potential consumers, if platforms through which consumers are exposed to applications are dominated by firms with other sets of incentives.[37]

43. The third concern is that the market for algorithmic consumers will be dominated by digital butlers who are not benign, but rather serve their suppliers' purposes (such as Amazon's Alexa). Indeed, the major digital platforms are already racing to develop the best digital shopping assistant.[38] As observed by Ezrachi and Stucke, their incentives to do so are straightforward: "digital assistants" are likely to become consumers' gateway into the digitized world, especially if users are likely to use an all-inclusive digital butler.[39] Furthermore, algorithmic consumers can obscure each individual consumer's preferences by aggregating all of them, thereby limiting the incentives of platforms whose value depends on such data to grant access to such applications. The more important the access through the intermediary or to the unique data held by it, the more likely that the handful of mega platforms dominating digital markets will attempt to control that access. Such access is important because voice-activated digital butlers create a unique gateway, which does not show the options to the consumer (such as the "ten blue links"), thereby

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[35.] Buyer power refers to the ability of buyers to influence the terms of trade with their suppliers. Joint buying algorithms may generate significant market power for consumers if a significant percentage of buyers makes their purchases through them. See OECD, DAF/COMP(2008)38, Monopsony and Buyer Power 9 (Dec. 17, 2009). Buyer groups are established in order to take advantage of economies of scale and scope. Peter C. Carstensen, "Buyer Cartels Versus Buying Groups: Legal Distinctions, Competitive Realities, and Antitrust Policy," 1 Wm. & Mary Bus. L. Rev. 1, 13–14 (2010).

[36] Antitrust law is mostly tolerant towards buying groups even when they hold a significant share of the input market. Gal and Elkin-Koren, supra.

[37] See Stucke and Grunes, supra.

[38] See Mark Prigg, Apple Unleashes Its AI: 'Super Siri' Will Battle Amazon, Facebook and Google in Smart Assistant Wars, Daily Mail (June 13, 2016), http://www.dailymail.co.uk/sciencetech/article-3639325/Apple-unveil-SuperSiri-Amazon-Google-smart-assistant-wars.html [http://perma.cc/8K3Z-6HF5]. This concern was also recognized by Ezrachi and Stucke, supra.

[39] Ariel Ezrachi & Maurice E. Stucke, Is Your Digital Assistant Devious? (Oxford Legal Studies Research Paper No. 52/2016; Univ. of Tenn. Legal Studies Research Paper No. 304 Aug. 23, 2016), available at https://papers.ssrn.com/sol3/papers2.cfm?abstract_id=2828117 [https://perma.cc/2VWT-VLJW].

generally operating as a single-homing device, which may have some black-box qualities. This, in turn, might further fortify the mega platform's market power and increase entry barriers into the markets for both mega platforms and algorithmic consumers.[40]

44. An important question is in place: if low entry barriers exist for developing an application of an algorithmic consumer, how could such platforms come to dominate that market? One of the strategies used by some platforms to lure consumers to their applications is to create multi-task algorithms, which combine many functions, including services such as organizing the user's calendar, issuing reminders of scheduled meetings, advising the user to take an umbrella when rain is forecast, and calling contacts at the user's request.[41] Algorithms like Siri and Google Assistant already perform many of these tasks free of charge, and in the near future it is envisaged that they will perform many more, including purchasing decisions (extending an example given by Google: "Find my daughter a Spanish tutor").[42] Accordingly, firms like Google and Apple have evolved from mainly being intermediaries in two-sided markets between advertisers and consumers to operating as multi-tasking agents that combine a multitude of services, including algorithmic consumers. Consumers might still use such algorithmic consumers, possibly due to imperfect information about applications with better results or, more likely, due to a combination of factors noted below.

45. As we noted elsewhere,[43] this technological tying of services may give those intermediaries inherent advantages that create entry barriers into the market for algorithmic consumers. First, because of their current dominant position over existing platforms, their digital butlers become the default option. This, in turn, creates a large base of users and raises switching costs. Second, their ability to combine many tasks, including some already provided for free (like displaying maps), creates an advantage relative to uni-task algorithms. This advantage will be strengthened by the ability of these digital butlers to serve as a one-stop shop for making interconnected decisions. Third, the range of their services allows these intermediaries to accumulate more data on each user. This enables them to create better user profiles, which in turn enables them to act as better algorithmic consumers.[44] Fourth, and relatedly, the fact that such intermediaries currently serve as major gateways to the digital world enables them to accumulate more data. To the extent that data about other users (as opposed to data about each particular user) is important for the functioning of an algorithmic consumer, this might further increase entry barriers.[45] Therefore, the roles of algorithmic butlers and algorithmic consumers reinforce each other and raise entry barriers for other firms in the market for algorithmic consumers. If so, users might be inclined to have these platforms also make purchasing decisions for them.[46] Much depends, however, on the perceived interests of such bundled

[40] Ezrachi & Stucke, Virtual Competition, supra, at 191–92.

[41] See Danny Yadron, Google Assistant Takes on Amazon and Apple to Be the Ultimate Digital Butler, The Guardian (May 18, 2016), https://www.theguardian.com/technology/2016/may/18/google-home-assistant-amazon-echo-apple-siri [https://perma.cc/VVE3-Z3NR].

[42] See id.; Google Developers, Google I/O Keynote — 2016, YouTube at 24:50 (May 18, 2016), https://www.youtube.com/watch?v=862r3XS2YB0 [https://perma.cc/WD5N-QBJC].

[43] Gal and Elkin-Koren, supra.

[44] See Ezrachi & Stucke, Virtual Competition, supra at 195.

[45] Id.

[46] Id. at 194.

algorithmic butlers in the eyes of consumers. Should they be perceived as furthering mainly the interests of their suppliers and not those of consumers, consumers might prefer to use algorithmic consumers written solely for their benefit.[47] Furthermore, competition among the large platforms can potentially reduce the risk of them providing algorithmic consumers that do not serve the consumer to the fullest extent possible.

46. An interesting question is how this market structure will affect the supply of goods. Data on consumers' actual and predicted preferences could generate a significant competitive edge for any suppliers that collaborate with the large platforms, because those suppliers will be better able to predict and cater to consumer demand. Consequently, control over unique consumer data may enable platforms supplying algorithmic consumers to leverage their power so as to partially control the supply of goods.[48] This would actually result in significant power over both demand and supply. Another troubling possibility is that a large platform could come to control both consumer algorithms and some suppliers. The risk is that the platform might use algorithmic consumers to shape demand to match their own supply. More subtle effects might also arise. For instance, even when the platform does not control suppliers, it might change consumers' choices if doing so gives it an advantage in other aspects of its operations.[49]

47. It is noteworthy that other market solutions may also play a role in limiting the ability of suppliers to abuse their algorithmic-facilitated coordination. Tools to obscure the actions of consumers online, such as the use of search algorithms which do not store consumers' searches (an example being the search engine DuckDuckGo), limit the ability to engage in first-degree price discrimination. Interestingly, not many people have chosen as of yet to use such data-obscuring devices. Furthermore, the effects of such solutions on welfare is not one-dimensional, since increased data regarding consumer preferences may also lead to some positive effects such as better targeted innovation and marketing.[50]

4. Legal Solutions: Is Competition Law Working for Us?

48. "Smart coordination" by suppliers requires "smart regulation" that sets rules which limit the harms of increased coordination whilst ensuring that the digital economy's welfare-enhancing effects are not lost. The question is whether competition law is fit to the task. Indeed, current legal tools were designed to deal with human facilitation of parallel conduct. New ways to coordinate, as well as the potential scale and scope of the resulting coordinated conduct, were not envisioned at the time when competition law prohibitions were fashioned. Rather, competition law currently relies on the exploitation of human limitations in order to increase competition in the market. For example, it prevents market players from engaging in explicit agreements and from using

[47] One way to indicate such incentives is to base the algorithmic provider's revenues on a percentage of the cost savings generated.

[48] See. e.g., Rubinfeld and Gal, supra. While some entry barriers have been reduced (such as storage costs which have been reduced as a result of cloud computing), others might still remain high, such as when high entry barriers exist for collecting unique data.

[49] For example, the algorithm could experiment with how users react to choices which do not precisely fit their preferences, but which might increase the mega platform's revenues. See, by way of analogy, the Facebook experiment on how changes in users' news feeds affected their emotions.

[50] Cite.

the legal system in order to enforce their agreements, making it harder to reach and enforce an agreement. But in the algorithmic world in which coordination, detection and punishment are made easier, reaching an explicit agreement or its enforcing it through the court system are of less importance. The challenge is, therefore, to determine to which extent we can rely on our existing competition laws in order to prevent new ways of engaging in anti-competitive conduct. The answer to this question will also serve as a basis for exploring whether new regulatory tools are needed in the digital economy.

49. The analysis below focuses mainly on the application of the prohibition of agreements in restraint of trade to algorithms that facilitate coordination. The application of alternative regulatory tools, such as shared monopoly, is briefly analyzed below. Accordingly, the analysis strives to explore and provide preliminary answers to three interconnected questions that stand at the basis of designing a welfare-enhancing policy towards the use of coordination-facilitating algorithms:

1. Do algorithms that facilitate coordination fulfill the requirement of “an agreement”, and if so- under which conditions?;
2. Even if the answer to the first question is positive, what exactly do we wish to prohibit and can we spell it out clearly for market participants?;
3. Given the answers to the two questions above, is there justification for widening the regulatory net beyond its current prohibitions, in light of the changing nature of the marketplace.

50. As elaborated below, contrary to what some scholars suggest, I argue that the answer to the first question can be positive in quite a few cases. The real challenge lies in the second question, which focuses on whether and under which conditions such facilitating devices should be treated as “restraints of trade.” Our ability to set rules that not only fit the logic of our competition laws but can also be justified based on decision-theory considerations,[51] ensuring that the costs of enforcement do not outweigh its benefits, determines the answer to the third question. Observe, however, that since many of the issues addressed below are new, I do not strive to suggest definitive answers. Rather, my goal is to open up the discussion by shedding light on the myriad of new issues that need to be addressed by competition authorities.

4.1. Coordination-Facilitating Algorithms as “Agreements”?

51. For liability to arise from coordinated conduct, an “agreement” must be found to exist.[52] Some types of coordination among algorithms easily satisfy this condition. A simple scenario involves the use of an algorithm(s) to implement, monitor, police or strengthen an explicit agreement among suppliers. In such a situation, a clear agreement exists between the users of the algorithms and the algorithms simply serve as the tools for its execution.[53] The case brought in 2015 by the U.S. DOJ against Topkins for coordinating with other sellers the prices of posters sold online, illustrates such agreements. Topkins and its co-conspirators designed and shared dynamic pricing

[51] *See, e.g.,* Frederick Beckner III and Steven C. Salop, “Decision Theory and Antitrust Rules”, 67 *Antitrust L. J.* 41 (1999).

[52] We use a broad term, to include alternative wordings used by some jurisdictions such as arrangements, etc.

[53] For four main scenarios, see Ezrachi and Stucke, *supra*.

algorithms, which were programmed to act in conformity with their agreement.[54] Observe that the algorithms played a secondary role, based on an existing agreement between the sellers.

52. This simple case already raises an important question: Is the concept of explicit agreement relevant when decisions in the marketplace are made by algorithms? If so, what conditions should exist for an explicit agreement- reached by and among algorithms- to be found? Answering these questions requires us to define, inter alia, what should be considered as offer, consent and intent in the virtual world. We might need to create a new taxonomy, which is relevant to the algorithmic world and which parallels the one in which humans make the decisions. These questions, which are not unique to competition law, are now beginning to be addressed in multiple legal fields. [55] Given the difficulties involved, and the preliminary stage of the discussion, the discussion below focuses on the facilitation of implicit agreements by algorithms. It should be stressed, nonetheless, that even if the meeting of minds takes place among machines, it is intentionally set in place by humans.

53. This leads to the following issue: Which rules apply when tacit collusion is created or maintained by algorithms, without an explicit agreement among the algorithms or their users? This can be the case, for example, when each algorithm bases its trade terms on its predictions of the best responses of other parties in the market. No prior agreement among suppliers, or among algorithms, is necessary.

54. Tacit collusion is not considered to constitute an agreement by competition law.[56] The question therefore is whether tacit collusion which was facilitated by algorithms may constitute an agreement, and if so under which conditions. Tacit collusion that results from algorithms that simply mimic human choice, taking the exact same actions and making the exact same decisions as humans engaged in lawful tacit collusion, should not constitute an "agreement."[57] Any other rule would unjustifiably differentiate between algorithms and human choice, even when they lead to the exact same outcomes. The following example illustrates this point: Assume a market in which long-standing tacit collusion exists. Firms operating in the market adopt an algorithm, which is based on the benchmark for pricing that they have been using for years. Does the fact that they are now using algorithms to achieve the exact same result change the legal status of their conduct? In the simple case, if each and every supplier unilaterally decided to adopt such an algorithm, and the algorithm does not significantly change the ability to reach and maintain the existing jointly profitable equilibrium, then it should not be regarded differently from the original method for decision-making, which was deemed to be legal.

[54] Press Release, U.S. Dep't of Justice, Office of Pub. Affairs, Former E-Commerce Executive Charged with Price Fixing in the Antitrust Division's First Online Marketplace Prosecution (Apr. 6, 2015), https://www.justice.gov/opa/pr/former-e-commerce-executive-charged-price-fixing-antitrust-divisions-first-online-marketplace [https://perma.cc/QMT6-ZQMN]. It was alleged that the sellers "adopted specific pricing algorithms for the sale of certain posters with the goal of coordinating changes to their respective prices and wrote computer code that instructed algorithm-based software to set prices in conformity with this agreement." Id.

[55] See, e.g., Gal, "Algorithmic Challenges to Autonomous Choice" (2017), available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2971456, and sources cited therein.

[56] See, e.g., Nicolas Petit, "The Oligopoly Problem in EU Competition Law," in I. Liannos and D. Geradin eds., Research Handbook in European Competition Law (Edward Elgar, 2013).

[57] See also Ezrachi and Stucke, supra.

55. A tougher question arises when the algorithm engages in the exact same conduct and makes similar decisions as humans, just in a more efficient manner. Take, for example, the task of calculating the jointly profitable price under changing market conditions. Algorithms can more easily detect price deviations from the coordinated equilibrium, thereby easing the meeting of Stigler's second and third conditions. Should the higher level of efficiency and accuracy in performing this coordination-strengthening act change their legality? To my mind, the answer is not as straightforward as some scholars suggest. On the one hand, the *pattern* of conduct is similar to what would otherwise be considered lawful. On the other hand, the *effect* of the conduct may differ significantly. Once this effect is recognized by market players, not only the ability but also their incentives to engage in tacit collusion are strengthened. Moreover, the algorithm- by its nature- can serve as a credible and clear declaration to one's rivals about how firms are going react to market conditions, thereby changing the dynamics of the interaction from making decisions on what one assumes to be its rivals' reaction cures to what its rivals declare they would do. Furthermore, the fact that an active step is taken- the use of an algorithm- adds another r*emedial option*.

56. A most relevant concept in this regard is that of **facilitating practices**. As Gal and Elkin-Koren suggest elsewhere, at least some types of algorithms -or rather algorithmic functions- that facilitate coordinated conduct in the market, can be regarded as "plus factors." Alternatively they can be regarded as "facilitating practices."[58] The latter are positive, avoidable actions, engaged in by market players, which allow firms to easier and more effectively achieve coordination, by overcoming the impediments to coordination, thereby making it easier to meet Stigler's conditions for coordination.[59] In doing so, they increase oligopolists' incentives to cooperate and reduce their incentives to compete despite their divergent interests.[60] Facilitating practices can therefore create, maintain or strengthen coordinated conduct.

57. Many facilitating practices exist, with varying degrees of success in promoting coordinated conduct. Salop identifies two distinct types: information exchange and incentive management.[61] Information exchange devices facilitate coordination by

[58] Gal, CPI, supra. For a similar suggestion see OECD Background Paper, supra, p. 41. For facilitating practices see, e.g., Steven C. Salop, "Practices that (Credibly) Facilitate Oligopoly Coordination" in Joseph Stiglitz and Frank Mathewson (eds), New Developments in the Analysis of Market Structure (MIT Press, 1986) 271; M. D. Blechman, "Conscious Parallelism. Signaling and Facilitating Devices: The Problem of Tacit Collusion Under the Antitrust Laws," 24 N.Y.L. Sch. L. Rev. 881, 881–906 (1979); Holt, C.A. & D.T. Scheffman, "Facilitating Practices: The Effects of Advance Notice and Best-Price Policies," 18 Rand J. Econ. 187, 187–97 (1987); T. Kauper, "Oligopoly: Facilitating Practices and Plus Factors", in B. Hawk (ed.), Fordham Competition Law Institute, 2007, 751; William H. Page, "Facilitating Practices and Concerted Action under Section 1 of the Sherman Act" ?. For an excellent analysis of plus factors see William E. Kovacic, Robert C. Marshall, Leslie M. Marx, and Halbert L.White, Jr., "Plus Factors and Agreement in Antitrust Law" 110(3) Michigan Law Review, 393 (2011).

[59] For the law in the US. see, e.g., P Areeda and H Hovenkamp, Antitrust Law: An Analysis of Antitrust Principles and Their Application (Aspen Law & Business, 2003) ¶1435c-¶1435i; Louis Kaplow, Competition Policy and Price Fixing (Princeton, 2013) 276-285; George Hay, "Facilitating Practices" in Issues in Competition Law and Policy (ABA Book Publishing, 2008) Vol II, ch 50; Iain Ayres, "How Cartels Punish: A Structural Theory of Self-Enforcing Collusion" (1987) 87 Columbia LR 295; R Rees, "Tacit Collusion" (1993) 9 Oxford Review of Economic Policy 27.

[60] Salop, supra.

[61] Ibid.

reducing the uncertainty about rivals' actions and intentions. For example, by sharing information on actual sales and actual costs, a reduction in prices can better be identified with defection in the relevant cases. Incentive management devices alter the structure of firms' pay-off matrixes. By restructuring payoffs, the incentives of a firm to offer price discounts may be directly affected. Incentive management devices may take numerous forms. To illustrate, meeting competition clauses, under which a firm announces that its price is the minimum of some price and the lowest price posted by another firm, may be used as facilitating devices.[62] Such clauses automatically incorporate the aggressive responses to price cutting -the immediate matching of prices- that are needed to support coordination. Consumers are used to police the arrangement, because the chance of receiving price discounts creates incentives for them to ensure performance and bear the costs of monitoring the other suppliers' conduct. These clauses may not be in the consumers' interest if their collective acceptance stabilizes the suppliers' joint profit outcome and makes discounting less desirable or price increases less risky.[63]

58. When firms expressly agree to adopt a facilitating practice, for example they all agree to post their prices in advance, that agreement may, by itself, constitute an agreement in restraint of trade.[64] Furthermore, in some jurisdictions the parallel adoption of facilitating practices with no offsetting beneficial effects to consumers also amounts to an "agreement".[65] The logic behind the rule regulating such parallel adoption can be explained as follows: Facilitating practices are avoidable actions. They change market conditions in a way that makes it easier to coordinate conduct. In the absence of procompetitive benefits from the adoption of the facilitating practice, firms would not have engaged in such conduct unless they expected others to engage in the coordinated conduct that was facilitated by the practice. Accordingly, the facilitating practice is part of an indirect communication device used between firms to signal to each other their intent to engage in coordinated conduct.

59. This rule leads to two observations that are relevant to the discussion below. First, an agreement is inferred *regardless of how it was reached*. It does not matter whether one firm adopted the facilitating practice and others followed suit, whether several phases of the market game took place until the facilitating practice was adopted, or whether each firm reached a decision on its own that adopting the facilitating practice was the best course to be taken in the market, with the result of parallel adoption of the facilitating conduct. Second, an implicit agreement, *achieved solely through unilateral yet interdependent actions,* can also be captured under the law. No direct or prior or direct communication between the firms is necessary. Rather, intent to adhere to the jointly profitable equilibrium is inferred through the parallel engagement in avoidable actions that help facilitate the coordinated outcome. Indeed, reaching such an agreement can be likened to a dance: one firm takes a step forward, its partner tried to follow in the same direction, until their steps are synchronized.

60. Let us now apply this rule to algorithms. Some algorithms, or parts thereof, may constitute facilitating practices, therefore fulfilling the condition of "agreement." In accordance with the rule regulating parallel adoption of facilitating practices, algorithms

[62] *Id*.

[63] *Id*.

[64] *Id*.

[65] Page, *supra*.

constitute an "agreement" when (1) the algorithms used by the market players include in their decision trees elements that limit other firms' incentives to compete beyond those that exist naturally, thereby facilitating, maintaining or strengthening coordination among potential competitors; (2) market players employ such algorithms in parallel; and (3) the algorithm does not serve any procompetitive purpose.[66]

61. We suggest that the justification for the last two conditions be reexamined.[67] With regard to the second condition, it is disputable whether the adoption of facilitating practices must be parallel. Put differently, if the adoption of a facilitating practice by only one (or some) firms is sufficient to ease meeting Stigler's conditions, can this also constitute an agreement? In our view, the answer is positive under some circumstances. Assume, for example, that the algorithms do not adopt a similar decision-tree, but the combination of their decisions facilitates coordination. This may be the case when one firm adopts an algorithm which sets price at the jointly profitable level, and the others set a price based on that algorithm's price, recognizing that it was based on the jointly profitable level (follower-leader scenario). Requiring, in such a situation, parallel adoption of the algorithm by all firms, would make it easy to circumvent the requirement of "agreement."[68] Furthermore, if the justification for the requirement for parallel adoption is that each firm engage in avoidable acts, then there is no need that such acts be similar.

62. The third condition, which requires that the adoption of the algorithm not serve any procompetitive purpose, should also be re-examined. Indeed, even Turner, on whose view the law which exempts tacit collusion from being regarded as an agreement is commonly believed to be based, argued that facilitating practices can fulfill the condition of an agreement. His reasoning was that the remedial problem that arises with regard to tacit collusion is mitigated since the facilitating practice can be prohibited.[69] In accordance with this view, the adoption of an algorithm which facilitates coordination, followed by accommodating conduct by other firms in the market, can be sufficient to imply the existence of an implicit agreement. Observe that this does not imply that such agreements are illegal. Rather, the legality of the agreement should be explored in a separate phase of the inquiry, which focuses on its offsetting procompetitive effects, explored in more depth in the next sub-chapter.

63. Let us now turn to the first condition, which requires that the algorithm facilitate coordination. Several points are worth emphasizing in this regard. First, the decision to include coordination-facilitating elements in the algorithm is a conscious and avoidable decision by the algorithm's coder; the decision to employ that specific algorithm is a conscious and avoidable decision by the algorithm's user. Second, algorithms should not be treated differently than any other facilitating device used by players in the marketplace and therefore should be prohibited if they fulfill the legal requirements. Third, not all algorithms facilitate coordination. Some may perform functions that do not change the

[66] An interesting question, which is beyond the scope of this paper, is whether the \user must know that the algorithm has the tendency to facilitate coordination.

[67] This critique is relevant not only to algorithms, but rather to all facilitating practices.

[68] A more complicated question arises when the others do not use algorithms.

[69] Donald F. Turner, "The Definition of Agreement Under the Sherman Act: Conscious Parallelism and Refusals to Deal," 75 Harv. L. Rev. 655, 675-6 (1962). See also Richard A. Posner, Antitrust Law: An Economic Perspective 98–99 (University of Chicago Press, 2001).

incentives of firms to coordinate. Fourth, the algorithm is often combined with other practices which facilitate coordination. For example, a firm might design its website to continually display the price calculated by the algorithm.

64. Fifth, in determining the coordination-facilitating effects of an algorithm, it is important to separate the facilitating effects that result from the unique conditions of the digital world regardless of algorithms- mainly increased connectivity and transparency, and advancements in data science that allow for the collection and analysis of vast amounts of data in real time, from the effects of the use of the algorithm itself in such a world. The former should be taken as a given.

65. Finally, it is useful to differentiate between algorithms that facilitate an agreement among their users and other market players, and those that might facilitate coordination among other market players. The algorithms used in the online posters case noted above illustrate the first case, while price comparison algorithms (sometimes termed DCTs: Digital Comparison Tools) fall into the second category. Their analysis should not be confused, as they should be differentiated in both their economic functions and their legal implications. While the former may be considered part of an agreement, the latter usually cannot.

66. In today's digital world, information-exchange facilitating practices may sometimes be less necessary. Real-time and swift data collection and analysis make information exchanges redundant if information about relevant factors- such as price offers- can be achieved through independent means. Still, some forms of information exchanges, such as those pertaining to the kind of dataset used by the algorithm, competitors' output and cost data, or the decision parameters included in the algorithm, may facilitate coordination.[70] Furthermore, other facilitating practices may be even more potent in our digital world than ever before. Take, for example, meeting competition clauses, such as the ones used by Booking.com, in which the online retailer promises consumers he will meet any lower price found on the internet. If such a retaliation strategy is included in an algorithm, and reaction is immediate, other competitors will have no incentives to lower price in the first place, given that their lower price will be immediately matched.

67. Some prominent scholars suggest using the "front door" to capture tacit collusion: in accordance with their view, the term "agreement" is sufficiently wide to include such conduct. This argument was famously raised by Richard Posner,[71] who argued that tacit collusion involves offer and acceptance through conduct, and therefore literally and materially fulfills the conditions for an agreement. This view, dormant for many years, was recently strongly endorsed by Louis Kaplow. Analyzing both economic models as well as U.S. case law, Kaplow showed that the line between explicit and tacit collusion is blurred, and therefore the definition of "agreement" is sufficiently wide to include both.[72]

68. Both pathways enable us to capture at least some coordination-facilitating algorithms under the term "agreement." Indeed, we suggest that the real issue lies in the next question, explored in the next sub-section.

[70] Note that sometimes reverse-engineering or backtracking logic can be used to determine these factors without information exchange.

[71] Posner, *supra*.

[72] Louis Kaplow, *Competition Policy and Price Fixing* (Princeton University Press, 2013). There is also a series of articles, by Professor Kaplow, making a similar point.

4.2. Which Conduct should we prohibit?

69. The real problem with pathways which treat certain algorithms as agreements, is two-fold. First, algorithms perform many functions in the digital environment and bring about many benefits. Accordingly, if we cast the net too widely, we risk chilling welfare-enhancing conduct, including innovation. This requires us to ensure that our laws are based on an understanding of the role of algorithms in the marketplace, including their comparative advantages over human decision-making. In our view, this does not imply that we should adopt a “hands off” approach to algorithms, but rather that we should tread carefully and start with the easy cases in which harm to competition and welfare is more evident. Some suggestions with regard to such cases are elaborated below. Furthermore, a rule which prevents the inference of illegal agreement in cases in which each firms’ actions are in its individual self- interest, regardless of whether the others acted in the same way, serves to ensure that the use of at least some efficiency-enhancing algorithms will not be prohibited.

70. The second problem is the content of the prohibition: what exactly do we wish to prohibit and can we spell it out clearly for market participants? To use the rule of thumb that the late Phillip Areeda suggested: can we clarify, in less than twenty words, what kind of conduct the firm is prohibited from engaging in?[73]

71. Kaplow addresses this problem, in the context of tacit collusion, by arguing that if the remedy is sufficiently strong (such as criminal sanctions), then market players will have sufficiently strong motivations not to engage in the prohibited conduct.[74] In our view, Kaplow answers the question of how to create incentives for compliance, rather than how to clarify what conduct is prohibited.

72. While we tackle this issue in depth elsewhere,[75] let me offer some general observations. First, application of competition law to algorithms should take into account and balance the level of coordination they create among potential competitors and their offsetting pro-competitive effects. It should not be required that the algorithm has no potential procompetitive effects, but rather a balance is needed. Otherwise, we may not capture any algorithms under our laws. This is because, as Mehra suggests, “it is doubtful whether the employment of an [algorithm] 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.”[76] Accordingly, algorithms should be subject to the following rule of reason analysis:

[73] Thanks to Bill Kovacic for suggesting the use of this test in this context.

[74] Kaplow, *supra*.

[75] Gal and Petit, *Algorithms as Facilitating Devices*, work in progress.

[76] Mehra, *supra*.

Figure 1. Determining whether an algorithm is an illegal facilitating practice

Did a market player choose to employ an algorithm to determine its market decisions (price, quality, quality, etc.)? no → no issue

↓ yes

Does the algorithm facilitate or strengthen in a non-negligible way the ability to reach or maintain a jointly profitable status-quo in the market? no → legal

↓ yes

Is the use of the algorithm justified by neutral or pro-competitive considerations? no → illegal

↓ yes

Do these considerations outweigh the algorithm's coordination-facilitating effects? Are the latter needed in order to enjoy the former? yes → legal

↓ no

illegal facilitating practice

73. Second, algorithms should not always be treated as a whole. Indeed, the facilitating device may not be all of the algorithm, but rather a part thereof. It is often the case that the algorithm performs many functions, such as determining which data should be gathered, gathering the data, analyzing it, determining which trade terms to set based on the data, etc. Many of these functions can be welfare-enhancing, by reducing costs or increasing the quality of production or marketing functions. The part of the algorithm which performs these actions, should not be considered to be an agreement in restraint of trade. At the same time, some functions may be used to facilitate coordination. It is thus essential to separate the different functions and determine whether the benefits of the former are dependent on the harms of the latter. Otherwise we might throw away the baby with the bath water. This suggestion also serves as a partial answer to those who are concerned that regulating algorithms would harm the benefits they bring about.

74. This leads to the third observation: when applying competition laws, we should be wary of the alternatives. In some situations, prohibiting the use of a coordination-facilitating algorithm might lead instead to the strengthening of unilateral market power of some market players. When this is the case, such effects should be taken into account.

75. Fourth, because of the early state of our understanding, I suggest that the rules regulating algorithms should be developed in widening circles, dependent on the level of understanding at the time of enforcement of their potential effects on the market and on the potential chilling effects of an over-broad prohibition. Accordingly, as a first step, competition authorities should strive to identify the relatively easy cases in which the requirements for facilitating devices can more easily be applied and a relatively clear rule can be created.

76. Below we provide five cases which we suggest can raise red flags and therefore are good candidates for a relatively narrow circle of cases which create a prima facie justification for further examining their legality, if they facilitate supra-competitive parallel pricing. All may facilitate coordinated conduct, are potentially avoidable by the

algorithm's designers, and are, on their face, less likely to be necessary in order to achieve pro-competitive results. They may thus amount to "coordination by design"[77]:

1. Suppliers consciously use **similar algorithms**, even though there are better algorithms they could otherwise use. The algorithm need not be exactly similar, but its operative part - which calculates the trade conditions - should generate relatively similar outcomes. This may not only ease reaching a jointly profitable level, but also clearly signify the cost of cheating to all involved.

   Yet the similarity of the algorithm, by itself, is insufficient to lead to a coordinated outcome. This can be illustrated by a simple example: assume that the algorithm calculates the price to be charged based on one's production costs. If production costs differ among suppliers, the algorithm will not lead to a jointly profitable price. To create jointly profitable equilibrium, the algorithm must be based on a decision-mechanism which takes into account market-wide factors, including the reaction curves of other firms to price changes.

2. The second example relates to the conscious use of **similar data** regarding consumer preferences or other relevant market conditions in the algorithms. Data is an essential input in the decision-making process- it may largely determine the outcome. Using similar data is especially important when prices are based on each consumer's digital shadow. Note that the data source need not be similar, so long as the information gleaned from it may be relatively analogous. Of course, to be prohibited, the data source must not be the only one or the best one available.

   Relatedly, red flags may be raised when firms make it **easier for their rivals to observe data** which is important for reaching and sustaining coordination, such as data regarding rivals' quantities and costs, the data which is used as an input in their algorithm, or the responses to changes in market conditions which were coded into the algorithms.

3. A more complex case arises when a learning algorithm is given **similar case studies** by its operators, from which to learn. Learning algorithms change their decision-tree based on learning from past experience. If fed similar cases, the algorithms may learn similar things and change their decisions accordingly. Once again, the case studies must not be the only ones or the best ones available.
4. Suppliers use algorithms which track and automatically adjust their prices based on a **similar benchmark**. This benchmark can be external (e.g., double the price of a certain input used by all at bought by them at similar prices), or internal (the price set by one of the suppliers in the market, thereby creating a hub-and-spoke coordination).[78]
5. Suppliers **reveal the content of their algorithms** and/or of their databases. Such an action is generally not needed by consumers. Rather, is serves as a "written script" to action by algorithms, that can signal to other market players how the firm is likely to react to market conditions

77. In our view, algorithms which fall under each of these categories in markets, in which supra-competitive parallel pricing is observed, should raise red flags and trigger a deeper investigation into the justifications for using that specific algorithm for

[77] A paraphrase on "privacy by design" which is an approach to systems engineering which takes privacy into account throughout the whole engineering process

[78] OECD Background Paper, *supra*, p. 27.

determining trade terms in the market. One point is worth emphasizing: the justification cannot pertain to the act of coordination itself, but rather to the use of the specific algorithms to achieve the procompetitive goal, unless the algorithm is part of a justifiable joint venture.

78. Observe that to apply such rules in practice, competition authorities need to strengthen their technological expertise, by either creating an internal “algorithmic regulator” or by employing outside talent to detect algorithmic conduct that facilitates coordination without offsetting justifications in markets in which supra-competitive parallel pricing is observed. In accordance with the suggestions made above, authorities need to devise “reasonableness tests” that are based on understanding how algorithms work in the digital environment, while exploring the quality of the data and its analysis which serve as inputs into the algorithm, the model used to make the decision, the way the decision is communicated in the market, and the anticipated reaction to this decision by other market players. Some people treat algorithms as “black boxes”, but in fact several features of algorithms might make such regulatory tasks easier. First, the algorithm’s decision-tree reveals the considerations taken into account in reaching its decision. Second, the algorithm can be tested by running it on specific data, thereby indirectly understanding its decisional parameters.[79] Third, as explained by Avigdor Gal, algorithms can be used by regulators to police and understand the operation of other algorithms.[80]

79. A final question is whether algorithms based on machine learning should be exempt from the prohibition. Such algorithms are designed to achieve a given target, such as its user’s profit maximization. Yet instead of being specifically coded to react in a certain way, the algorithm independently determines the means to reach that target, through self-learning and feedback collected from the market. Should the algorithm adopt a strategy that leads to tacit collusion, coordination will not be the fruit of explicit human design but rather the outcome of evolution, self-learning and independent machine execution. To my mind, such algorithms should not be treated differently than those which were specifically coded to react in a certain way. The algorithm should be viewed as the long arm of the supplier, who should not be allowed to hide behind the algorithm. At the very least, so long as the algorithm’s designer can code it not to act in a certain manner, placing safeguards that limit the scope of its reactions to market conditions, then the fact that the designer did not do so should be taken into consideration in the analysis.[81] Here, again, computer scientists, economics and legal scholars have a joint role to play, in setting clear boundaries on how designers should limit algorithms in a way which does not harm the efficiencies they create. This can be likened to other limitations placed on autonomous algorithmic decision-making: a self-driving car should not be allowed to make any decision it deems good, just because its algorithm is autonomous.

[79] See also Ezrachi and Stucke, Background Paper, supra.

[80] Avigdor Gal, “It’s a Feature, not a Bug: On Learning Algorithms and what They Teach Us”, paper prepared for the OECD meeting on Algorithms and Collusion (2017).

[81] EU Commissioner Vestager argued for a similar view: “What businesses can and must do is to ensure antitrust compliance by design. That means pricing algorithms need to be built in a way that doesn’t allow them to collude.”

4.3. Alternative Regulatory Tools: Widening the Net

80. The above analysis focused solely on the regulation of coordination-facilitating algorithms through the prohibition of agreements in restraint of trade. Where relevant, other tools may also indirectly apply, such as shared monopoly and merger regulation.[82] In applying these tools, it is important to determine which regulatory tool best promotes welfare.

81. Setting an efficient set of rules also requires us to efficiently set the rules regarding the level of transparency and explainability that is legally required from coders of algorithms. Some considerations to be taken into account include the fact that transparency enables consumers and regulators to detect coordination as well as other types of anti-competitive conduct such as discrimination. At the same time, transparency can help facilitate coordination by exposing the considerations that one's rivals take into account, including the weight given to different parameters. Furthermore, the benefits of transparency and explainability fall short when the algorithm employs machine learning based on neural networks, that is, it teaches itself the best way to behave in the market even if the coder did not model such conduct.

82. A final challenge arises from the fact that competition law is part of a wider landscape of values and regulatory tools, all designed to jointly increase welfare. This situation requires regulators to ensure that while talking into account competition-related considerations, other factors which affect welfare such as privacy, right to identity, the protection of business secrets in order to ensure incentives to innovate, and cyber security, should not be disregarded. The opposite is also true: competition authorities should take an active role in ensuring that other regulators are aware of, and give sufficient weight in their decisions, to actions that might facilitate coordination through algorithms. To illustrate, mandating the sharing of data might increase the ability to engage in collusive conduct, if all algorithms make their decisions based on similar data.

5. Conclusion

83. The brave new world in which algorithms make many decisions challenges some of our most basic assumptions about how markets operate. Indeed, as shown, algorithms make coordination easier and quicker than ever, thereby reducing incentives to compete. This, in turn, increases the importance of market or legal reactions to reduce potential welfare-reducing effects, while ensuring that the consumer can enjoy the benefits that the digital world offers. This paper attempted to briefly explore some of the basic challenges to competition which are created by algorithms used by suppliers, as well as some potential market-based and legal counter-measures.

84. We are already playing catch-up with technological developments in the use of algorithms, and will likely continue to do so. But even if we learn on the run, efficiently-structured regulation can potentially positively affect welfare if we learn to understand how algorithms affect our marketplace. Given the welfare stakes involved, our only real options is to brace ourselves for the road ahead and make sure we are as prepared as possible.

[82] See, e.g., OECD Background Paper, *supra*.