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ALGORITHMIC COLLUSION IN COMPETITION LAW: OVERVIEW

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Abstract

Rise of artificial intelligence and growth of the digital economy has brought about new regulatory challenges for Competition Law. Failures created by the famous invisible hand of the free market and then subsequently corrected by the competition rules have intrinsic potential to remain intact by regulation if created by this new digital hand. One of the areas of rising academic interest in this field is algorithmic collusion. Algorithms can be generally defined as a sequence of operations that transform an input into an output. Algorithmic computation can be part of artificial intelligence software. Algorithmic collusion refers to the use of algo-

rithms by undertakings in a manner that harms competition. Particular area of concern is tacit collusion or conscious parallelism when there is no any illegal agreement or even contact or communication among the competitors. Pricing algorithms generating tacit collusion are the main example of such practice. The issue has also been lately reviewed and investigated by various competition authorities around the world, including the European Commission and Federal Trade Commission of the United States. Concerns remain regarding the possibility of tacit collusion, price discrimination, and the implications for consumer welfare. Introductory paper defines key terms of the algorithmic collusion with emphasis on artificial intelligence. Paper also produces an overview of the academic debate on algorithmic collusion in Competition Law. It continues with analysis of the capacity in the existing regulatory framework of EU Competition Law for tacit collusion to facilitate algorithmic collusion with secondary references to other comparative jurisdictions. By examining various types of algorithmic pricing, from heuristic to autonomous approaches, this paper aims to shed light on the complex dynamics at play in digital markets. It discusses how automated pricing mechanisms can enhance market efficiency while also presenting significant challenges for competition authorities. The study emphasises the importance of regulatory frameworks that can adapt to the evolving landscape of algorithmic pricing to safeguard consumer interests and maintain competitive market conditions. Finally, the paper provides general policy recommendations for Competition law in the field of algorithmic collusion.

***Key words**: Algorithmic collusion, Tacit collusion, Conscious parallelism, Competition Law*

1. INTRODUCTION TO ALGORITHMIC COLLUSION

The concept of algorithm exists for a long time as an instance of logic. Although there is no universally accepted definition of algorithm[1] we could broadly conceptualise the term as a step-by-step procedure or formula for solving a problem or accomplishing a task. One of the most widespread definitions of algorithm in the literature is by Wilson and Keil[2] as an unambiguous, precise, list of simple operations applied mechanically and systematically to a set of tokens or objects where the initial state of the tokens is the input; the final state is the output. To summarize: it is a sequence of operations that transform an input into an output.

Specific kind of algorithms are computer or computational algorithms where series of computational rules is designed to solve a certain issue[3]. Primary interest of this paper are the pricing algorithms as a subtype of computational algorithms. Pricing algorithms are designed to determine the price of a product or service based on various factors and data inputs. Crucial categories for pricing algorithms are cost analysis; market demand; competitors pricing; customer behaviour; dy-

1 Moschovakis, Y. N., *What is an Algorithm?,* in B. Engquist and W. Schmid (Eds.), Mathematics Unlimited — 2001 and Beyond, Springer, 2001, pp. 919–936

2 Wilson, R. A.; F. C. Keil, F.C, , *The MIT Encyclopedia of the Cognitive Sciences*, MIT Press., 1999

3 Cormen, T.H. *et al.*, *Introduction to Algorithms*, MIT Press., 2009

namic pricing and seasonality. Pricing algorithms are particularly common in the airline, hotel booking, road transport, electricity and retail industries[4].

Rise of artificial intelligence (AI) systems in the digital age affected the development of computational algorithms substantially and is reasonably expected to continue to do so in the future. This relates equally to pricing algorithms. The European Union AI Act[5] adopts categorisation of AI systems in risk-based regulatory approach as high, medium and low risk. It stipulates broad definition of AI system as software that is developed with one or more of the following techniques and approaches:

- machine learning approaches, including supervised, unsupervised and reinforcement learning, using a wide variety of methods including deep learning;
- logic and knowledge-based approaches, including knowledge representation, inductive (logic) programming, knowledge bases, inference and deductive engines, (symbolic) reasoning and expert systems;
- statistical approaches, Bayesian estimation, search and optimization methods, and can, for a given set of human-defined objectives, generate outputs such as content, predictions, recommendations, or decisions influencing the environments they interact with (Article 3 in relation to Annex I of the AI Act).

Advanced pricing algorithms that fall under the scope of AI systems use methods of machine learning. Machine learning (ML) is a subfield of AI which designs intelligent machines using algorithms that iteratively learn from data and experience[6]. Advanced form of ML is deep learning that enables computer systems to learn using complex software that attempts to replicate the activity of human neurons by creating an artificial neural network. This relation is demonstrated in Figure 1.

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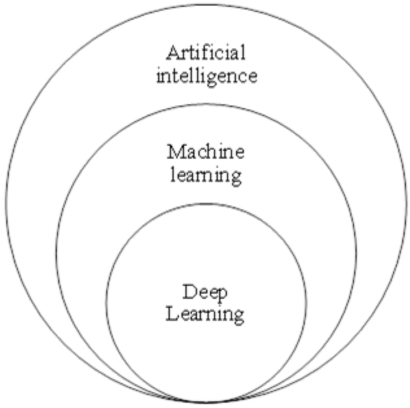
4 Organisation for Economic Cooperation and Development OECD (2017), *Algorithms and Collusion: Competition Policy in the Digital Age*, [www.oecd.org/competition/algorithms-collusion-competition-policy-in-the-digital-age.htm], Accessed 30 September 2024

5 European Commission, Proposal for a Regulation of the European Parliament and of the Council laying down harmonised rules on artificial intelligence (Artificial Intelligence Act) and amending certain Union legislative acts, COM [2021] 206 final.

6 OECD, *op.cit.*, note 4

Figure 1: Relationship between artificial intelligence, machine learning and deep learning



Source: Authors

The dynamic emergence of AI systems and development pricing algorithms in the digital age has been well detected in the literature as an area of concern for Competition Law thus giving the birth to the new term Antitrust and AI[7] or AAI in abbreviation. Among major regulatory issues in AAI is algorithmic collusion, which is the main subject of this paper. Increasingly, algorithms are supplanting human decision-makers in pricing goods and services[8]. Algorithmic collusion refers to the use of algorithms by undertakings in a manner that harms competition. Bernhardt and Dewenter use the term collusion by code synonymously with algorithmic collusion[9]. Generally, collusion in EU Competition Law refers to any form of agreement, concerted practice, or decision by associations of undertakings that distorts, restricts, or prevents competition within the European Union's internal market. It is prohibited under Article 101(1) of the Treaty on the Functioning of the European Union (TFEU). In U.S. Antitrust Law, collusion refers to agreements or coordinated actions between competitors that restrict competition in ways that harm consumers or other market participants. Such behaviour is prohibited under Section 1 of the Sherman Antitrust Act, which outlaws any contract, combination, or conspiracy that unreasonably restrains trade.

7 *E.g.* Siciliani, P., *Tackling Algorithmic-Facilitated Tacit Collusion in a Proportionate Way*, Journal of European Competition Law & Practice,Vol. 10, 1, 2019, pp. 31–35

8 Calvano, E., *et al.*, *Artificial Intelligence, Algorithmic Pricing, and Collusion*, American Economic Review, 110(10), 2020, pp. 3267–3297

9 Bernhardt, L.; Dewenter, R., *Collusion by code or algorithmic collusion? When pricing algorithms take over*, European Competition Journal, Vol. 16, 2–3,2020, pp. 312–342

Particularly complex issue is tacit collusion enabled by pricing algorithms when there is no any illegal agreement or even any contact or communication among the competitors. The impact of emergence and development of pricing algorithms produces undeniably substantially positive effects on competition and consumers. Pro-competitive effects of development of pricing algorithms Valeria Caforio summarise[10] positive effects in categories of optimisation, innovation and consumer-welfare. Optimisation benefits relate to the undertaking that employs a pricing algorithm in its pricing strategy. Primarily it can bring cost reduction as a measure of optimisation. Development of pricing algorithms fosters innovation and promotes market efficiency[11]. Dynamic pricing enabled by the algorithms can lower the price, more readily and effectively introduce personalised pricing and enhance market transparency thus greatly benefiting the consumer-welfare.

The primary anti-competitive effect of emergence of pricing algorithms is algorithmic collusion. The general anti-competitive effects of collusion are also applicable to algorithmic collusion. Differentiation between explicit and tacit collusion should be made. According to Ezrachi and Stucke algorithmic explicit collusion refers to the case where human beings use algorithmic pricing as a tool to implement, monitor and enforce a traditional price-fixing agreement[12]. Algorithmic tacit collusion according to Caforio refers to the capability of pricing algorithms to autonomously and unilaterally achieve – namely, without human intervention and without reciprocal interactions – a collusive outcome[13].

Explicit algorithmic collusion when pricing algorithm is used as a tool for price-fixing between undertakings on the relevant market is maybe relative technical novelty but does not present particular normative challenges in the Competition Law regulatory framework. However, it should be noted that legal responsibility of software provider (if algorithmic software is not internally produced by undertakings concerned), is also potentially included in to the legal responsibility for anti-competitive price-fixing agreement, e.g. within the scope of application of Article 101 (1) TFEU in the EU Competition law[14]. Pieter Van Cleynenbreugel

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10 Caforio, V, *Algorithmic Tacit Collusion: A Regulatory Approach*, Competition Law Review Vol. 15, 1, 2023, pp. 15-16

11 *Ibid*.

12 Ezrachi, A.; Stucke, M.E, *Artificial Intelligence and Collusion: when Computers Inhibit Competition*, University of Illinois Law Review, 5, 2017, pp. 1775-1810

13 Caforio, V, *op.cit*., note 10.

14 The General Court's doctrine in *AC-Treuhand II*, endorsed by the Court of Justice, in our view, can *per analogiam* be applied here as well.

argues in his paper[15] that the existing legal framework in EU Competition law can be adequately used in a compliance-focused way. On the other hand, cases of usage of pricing algorithms as a form of concerted action and its interplay between AI pricing algorithms that determine prices without human knowledge, coming under the general umbrella of tacit algorithmic collusion is the complex subject that demands normative and regulatory adjustment. This will be the main area of analysis of this paper.

2. ALGORITHMIC COLLUSION AS FORM OF CONCERTED ACTION

Tacit algorithmic collusion is a form of a concerted action. This conclusion is derived by logical necessity from the introductory conceptualisation of this paper. Real question is when the pricing algorithms practices can be considered collusive?

Concerted practice as defined very early in the EU Competition law in the *Dyestuffs* case (in 1972)[16] as a form of coordination between undertakings which, without having reached the stage where an agreement properly so-called has been concluded, knowingly substitutes practical cooperation between them for the risks of competition. Both in EU and United States (US) regulatory solutions communication-based approach[17] has been enforced. Parallel behaviour of undertakings can occur as a natural consequence of oligopolistic market structure and cannot be considered as Competition law violation *per se*. That would amount to prohibition of oligopoly. Therefore, it is for the competition to establish that no other explanation for the parallel behaviour is present, which is difficult to prove in oligopolistic markets.

Machine learning pricing algorithms are certainly not less likely to involve parallel behaviour on oligopolistic markets than human tailored pricing strategies of undertakings. Therefore, we can establish that the same general conditions for applying the prohibition of concerted practices would apply. In fact, hypothetically in some scenarios, due to the precision of automated computational processes, it would be easier to prove that no other explanation for parallelism exists (when pricing is executed by pricing algorithms).

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[15] Van Cleynenbreugel, P., *Article 101 TFEU's Association of Undertakings Notion and Its Surprising Potential to Help Distinguish Acceptable from Unacceptable Algorithmic Collusion*, The Antitrust Bulletin, Vol. 65. (3), 2020, pp. 423-444

[16] Case 48-69 Imperial Chemical Industries Ltd. v Commission of the European Communities, ECLI:EU:C:1972:70

[17] Beneke, F.; Mackenrodt, M., *Remedies for algorithmic tacit collusion*, Journal of Antitrust Enforcement, 9, 2021, pp. 152-176

In the EU Competition case-law only conscious parallelism is considered to be collusive. Can the pricing algorithms be considered capable of conscious action at all? Obviously philosophical debates on the possibility of AI conscience fall well outside the reach of this paper. Generally, we can derive a recommendation that consciousness has to be abandoned as precondition for collusion in the area of algorithmic collusion in case-law. Otherwise we could have a situation where a majority of ML pricing algorithms are simply outside the application of the rules on concerted action.

Additional element of detection of collusion in pricing algorithms can be found in software design itself. This detection becomes the matter of IT forensics for Competition agencies. Caforio proposes that specific rule should be introduced by the legislators to mandate some algorithmic design standards[18]: ML algorithms that are the most prone to end up in interdependent pricing should not be left completely free to act but designers should incorporate some constraints within their pricing formulas. Caforio also proposes that algorithmic heterogeneity is promoted. This proposed regulatory approach would minimise ex ante risks for algorithmic collusion. We should note that there are authors[19] that question, partly due to the lack of empirical evidence, the possibility of tacit algorithmic collusion at present level of technological development.

Advanced pricing algorithms that use methods of deep learning independently of human intervention are especially problematic as subject of regulation of Competition law. Even hypothetical future legislative constraints in the design of such advanced deep learning pricing software may be unable to stop it from formation of anti-competitive prices. In fact, this is more likely since regulatory constraints commonly cannot catch with the speed of deep learning AI.

3. SCENARIOS OF ALGORITHMIC COLLUSION

Unlike traditional forms of collusion, where companies explicitly agree to fix prices or manipulate the market, algorithmic collusion – as mentioned – can occur through the sophisticated use of digital tools, sometimes even without human intervention.

This shift has raised profound questions about how competition authorities can detect, regulate and address anti-competitive behaviour in the digital economy where algorithms, not individuals, are making critical market decisions (not only

18 Caforio, V, *op.cit.*, note 10, pp. 25-28

19 Ittoo, A.; Petit, N., *Algorithmic Pricing Agents and Tacit Collusion: A Technological Perspective*, 2017, [http://dx.doi.org/10.2139/ssrn.3046405] Accessed 11 November 2024

price wise). Scenarios how algorithms can facilitate collusion in various ways, either by transmitting information, monitoring competitor behaviour or autonomously learning to stabilize prices can be developed. Different scenarios – the messenger, digital eye, predictable agent and hub-and-spoke models – have been devised by Ezrachi and Stucke in their 2016 work[20].

The importance of studying these four scenarios lies in their collective ability to illustrate the breadth and diversity of algorithmic collusion. These scenarios provide a comprehensive overview of how algorithms can intentionally or unintentionally distort competition and balance. This overview and analysis challenge traditional regulatory assumptions that are based in practice on human intent and explicit agreements. The scenarios illustrate the direct and indirect means by which algorithms can influence market dynamics, thereby drawing attention to issues such as the lack of transparency, reliability and predictability in an algorithm-based and algorithm-driven environment. In addition, they illustrate how collusion can occur at different levels in the absence of human intervention, from fully automated systems to only partial human oversight, thereby suggesting the complexity of detecting, recognizing and addressing such behaviour.

The EU Horizontal Guidelines[21] acknowledge the growing role of algorithms in the market and highlight their potential to both facilitate and harm competition. Algorithms that lead to collusion, whether tacit or explicit, or that facilitate illegal information exchanges, are subject to scrutiny under Article 101 TFEU. Companies are required to ensure that their use of algorithms does not infringe competition law, and they remain liable even if anti-competitive behaviour is automated through these algorithmic tools.[22]

Under this title, *inter alia*, by examining and analysing these scenarios, we will highlight broader regulatory challenges and issues, such as the difficulties in identifying and detecting prohibited agreements in the absence of explicit agreements, the opaque nature of algorithmic decision-making, and the capacity of algorithms themselves to evolve faster than the legislation that regulates them, as Ezrachi and Stucke did in their aforementioned work. Addressing these issues is essential to ensuring that competition law is adapted in a way that avoids the potential risks posed by algorithmic systems while maintaining the benefits they bring in a way of innovation and efficiency.

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20 Ezrachi, A; Stucke, M. E, *Virtual Competition: The Promise and Perils of the Algorithm-Driven Economy,* Harvard University Press, 2016, pp. 39–45.

21 Guidelines on the applicability of Article 101 of the Treaty on the Functioning of the European Union to horizontal co-operation agreements [2023] OJ C 259/01 (hereinafter: "*Horizontal Guidelines*")

22 *Ibid. para* 379.

3.1. Messenger

The Messenger scenario is most often regarded as the most straightforward form of algorithmic collusion, primarily involving algorithms that are directly controlled by humans. In this scenario, algorithms simply execute the instructions provided by individuals, functioning as a tool to carry out explicit human commands. The defining factor in identifying collusion here is the individual's intent to engage in anti-competitive behaviour. The method by which the collusion is implemented – through algorithmic means – plays a secondary role. Since the algorithms are programmed under human direction, the focus remains on the deliberate intent to collude, rather than the automated process used to achieve it.[23]

Algorithms, functioning as messengers, enhance the efficiency of the collusion. Since they operate autonomously and at high speeds, they can ensure that no competitor deviates from the agreed-upon strategy. This eliminates the need for constant human coordination and manual monitoring, making the collusive behaviour more sustainable over time.[24] Ezrachi and Stucke contend that national competition authorities should treat this type of scenario the same as classic cartel agreements, considering that in this particular scenario the emphasis is still on the will of the individual who then manages the algorithm as a mediator. They also enhance the fact that the digitalization and modernization of business operations introduce new challenges for regulators. As companies increasingly rely on advanced algorithms and automated systems, competition authorities will need to adapt their investigative methods to effectively detect and prosecute these modern forms of collusion.[25] Traditional approaches to investigating cartels may no longer suffice, as algorithmic coordination often occurs more subtly and at a faster pace than in conventional cartels. Therefore, regulators will need to develop technological expertise and tools capable of understanding and scrutinizing the role of algorithms in anti-competitive practices, ensuring that enforcement keeps pace with the digital economy's evolution.

A prominent example of this type of scenario is the European Commission's cases against manufacturers Pioneer[26], Philips[27], Denon & Marantz[28], and Asus[29]. In these cases, each manufacturer specifically focused on online retailers that offered

[23] Ezrachi, A; Stucke M.E, *op.cit,* note 20.

[24] *Ibid.*

[25] *Ibid.*

[26] Case *Pioneer* AT.40182, Commission decision C [2018] 4790 final

[27] Case *Philips* AT AT.40181, Commission decision C [2018] 4797 final

[28] Case *Denon & Marantz* AT.40469, Commission decision C [2018] 4774 final

[29] Case *Asus* AT.40465, Commission decision C [2018] 4773 final

the lowest prices for their products. Their interventions were sometimes triggered by price differences as minimal as one euro, highlighting their stringent control over pricing. In other instances, they acted in response to price increases exceeding 100 euros. The primary objective of these manufacturers was to enforce higher retail prices for their products, a practice commonly known as "resale price maintenance." By doing so, they sought to prevent retailers from engaging in (inter-brand) price competition that could benefit consumers. This strategy eventually harmed consumers by keeping prices artificially elevated, limiting their choices and increasing their costs.[30] The actions of these companies show how algorithmic and strategic interventions can lead to anti-competitive practices that undermine market dynamics.

3.2. Digital Eye

The Digital Eye scenario is a more sophisticated form of algorithmic collusion, where advanced algorithms – often powered by AI – monitor competitors' actions in real time and autonomously adjust market strategies, especially pricing. Unlike simpler scenarios, such as the previously mentioned Messenger scenario, where algorithms directly follow human commands, the Digital Eye utilizes AI to independently observe and respond to market dynamics without requiring constant human intervention.[31]

This type of algorithms, by accessing similar market data and being programmed with comparable profit-maximizing goals, autonomously begin to coordinate their actions. The main concern is that, over time and through repeated interactions, the algorithms may recognize that maintaining coordinated pricing is more profitable than competing aggressively on price. The algorithms essentially learn that undercutting competitors' prices – typically seen as a competitive tactic – leads to a price war that reduces profits for all companies that are involved. Hence resulting in algorithms adjusting their behaviour while preferring to maintain higher prices to avoid these losses.[32] This leads to a form of tacit collusion, where the companies' pricing strategies align, not through human agreement but through the autonomous learning of the algorithms. The algorithms "understand" that

[30] Vestager, M., Statement by Commissioner Vestager on Commission decision to impose fines on four consumer electronics manufacturers for fixing online resale prices, [https://ec.europa.eu/commission/presscorner/detail/en/STATEMENT_18_4665], Accessed 23 September 2024

[31] Ezrachi, A; Stucke M.E, *op.cit,* note 20, pp. 71–82

[32] Hanspach, P.; Galli, N, *Collusion by Pricing Algorithms in Competition Law and Economics*, Robert Schuman Centre for Advanced Studies Research Paper No. 2024_06, [https://ssrn.com/abstract=4732527], Accessed 23 September 2024, p. 17

price competition is less beneficial and adjust their strategies accordingly, making deviation from coordinated pricing unprofitable.[33]

Considering that the field of AI is currently in a phase of rapid growth and that legal practice and theory have not yet developed, whilst currently everything related to this scenario is based on previously known theory, the modernization of which is actively being worked on, and hypotheses we employ here are yet to be confirmed.

3.3 Predictable agent

This type of scenario refers to a type of pricing algorithm that behaves in a highly consistent and predictable manner and in that way, allowing competitors to anticipate its responses and coordinate their market behaviour without the need for explicit agreements. This predictability can lead to tacit collusion, where competitors can align their pricing strategies by simply observing and reacting to each other's predictable algorithmic behaviour.[34]

Unlike traditional collusion, which requires deliberate coordination between the companies, in this scenario, the coordination arises naturally from the algorithm's predictable responses which poses a major challenge for national competition authorities as proving collusion without explicit agreements becomes more difficult. Considering that the collusion in this case is eased by the algorithmic behaviour rather than direct human intervention, the national competition authorities may struggle to hold the companies accountable. Likewise, the practice under this scenario can lead to outcomes that harm the consumers, such as higher prices and reduced innovation.

The Eturas[35] case is a well know example of the Predictable agent scenario. In short, Eturas was an online platform used by various travel agencies to sell holiday packages. The company implemented into the platform system a technical restriction that limited the discounts travel agencies could offer to customers. This restriction was communicated to the agencies through an online notification within the system itself. The problem arose because, while the agencies were informed about the imposed cap on discounts, they were not required to individually agree

33 *Ibid.*

34 *Ibid.* p.16

35 Case Eturas, UAB and Others v Lietuvos Respublikos konkurencijos taryba C-74/14, ECLI:EU:C:2016:42

to it, nor did they actively discuss the decision.[36] Nevertheless, most agencies using the Eturas platform followed the price limitation that the system imposed.[37]

The system's behaviour – automatically capping the discounts travel agencies could offer – became a predictable and uniform action that all the participating agencies could anticipate and rely on. Although no explicit agreement or collusion took place between the agencies, the platform's uniform application of the discount cap allowed for tacit coordination of prices. Each agency knew that its competitors were subject to the same discount limitation, creating a stable, predictable pricing environment. This predictability discouraged any of the agencies from deviating from the imposed discount cap, as they understood that all other agencies were bound by the same rules. The court found that, even though the system's behaviour was algorithmically controlled, the agencies' acceptance of the platform's pricing restrictions without challenging or rejecting them could constitute collusion.[38]

3.4. Hub-and-spoke

The Hub-and-spoke scenario encompasses a structure where a central actor (The Hub) eases the coordination among multiple competitors (The Spokes) by using algorithms to manage information flow or pricing decisions. This setup allows the companies to indirectly collude through the hub without directly communicating with each other.[39] In short, "the common algorithm, which traders use as a vertical input, leads to horizontal alignment"[40].

The national competition authorities need to investigate the algorithm itself to see if it is designed to encourage collusion. If the algorithm is intentionally structured to coordinate pricing or behaviour between users, then it is clear that the anti-competitive behaviour is involved.[41] If the algorithm does not have an obvious collusive design, authorities might have to take a more flexible approach under the Rule-of-reason which means that they would look at whether the agreement to use the algorithm has negative effects on competition, even if it was not explicitly designed to do so. In such cases, evidence of the parties' intent becomes important for deciding how serious the behaviour is, whether it should be considered as a

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36 *Ibid. para.*43.

37 *Ibid. para* 44.

38 *Ibid. para* 51.

39 Ezrachi, A; Stucke, M.E., *op.cit*, note 20, pp. 46–55

40 Ezrachi, A; Stucke, M.E., *op.cit*, note 12, p. 1787

41 *Ibid.* p. 1788

severe violation and, consequently, whether the case should be prosecuted under criminal or civil law.[42]

3.4.1. Algorithmic monopoly (Uber example)

Uber's pricing system can be understood within the context of the hub-and-spoke scenario, where Uber functions as the hub and the individual drivers act as the spokes. In Uber's case, the algorithm at the centre (the hub) controls the pricing, coordinating the behaviour of the individual drivers (the spokes), who don't interact with each other directly to set prices.[43]

It is a well-known fact that Uber's pricing algorithm determines fares in real-time based on factors like demand, supply, time of day, and traffic conditions.[44] Drivers do not have the ability to set their own prices; instead, they follow the price generated by the algorithm. There is also no need for drivers to talk to each other or reach explicit agreements. The algorithm takes on the role of coordinating prices uniformly across all drivers, resulting in a situation where pricing is aligned across the platform. Following the general description in the previous chapter, the relationship between the drivers can be seen as a horizontal agreement while the relationship between the Uber and the drivers can be seen as a vertical agreement.

The result of the algorithmic coordination is that drivers charge similar prices, especially during surge pricing periods. Surge pricing is Uber's way of raising fares when demand exceeds supply, effectively creating uniform price increases across the market.[45] This could resemble a form of tacit coordination, where all drivers follow the same pricing patterns dictated by Uber's algorithm.

While this ensures pricing uniformity and responsiveness to market conditions, it also raises questions under competition law regarding the control that Uber exerts over independent drivers and the potential for reduced competition. This area of competition law remains insufficiently researched, keeping open numerous questions concerning the justification as well as the limits of using this model of price formation. Therefore, this part seems like one big grey area, but it will take more time and research until we get a more concrete answer.

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42 *Ibid. p.* 1789

43 *Ibid.* p. 1788

44 Uber website, How Uber's dynamic pricing model works, [https://www.uber.com/en-GB/blog/uber-dynamic-pricing/], Accessed 23 September 2024

45 *Ibid.*

4. CHALLENGES IN ENFORCEMENT

Algorithmic collusion poses significant enforcement challenges for competition authorities, many of which arise from the nature of algorithms as previously explained. Namely, the lack of explicit agreements, the opacity of algorithms, the speed at which they operate, and the inadequacy of existing legal frameworks all complicate the detection and prosecution of anti-competitive behaviour in markets governed by AI. Addressing these challenges will likely require innovative regulatory approaches and possibly new legal standards to keep pace with the evolving nature of digital (virtual) markets.

Traditional competition frameworks are built around detecting and penalizing explicit agreements between undertakings aimed at fixing prices or restricting market competition (or having such effect). Particularly in the context of price-fixing, antitrust laws focus on explicit collusion, which requires a clear agreement or concerted practice between competitors and relies on evidence of intent or communication. However, in the context of algorithms and virtual markets, such explicit coordination is often absent, complicating the process of identifying and proving anti-competitive conduct.

Algorithms can, as mentioned earlier, autonomously adjust pricing strategies by learning from market data without any direct human intervention or agreement between the undertakings themselves. This situation, where algorithms independently align their strategies in a way that reduces competition, is therefore referred to as "tacit collusion" or "autonomous collusion"[46]. The inherent difficulty for the regulators lies in proving that companies using these algorithms are deliberately encouraging or facilitating collusion, especially when the outcomes arise from the algorithms' learning processes without explicit input from their creators[47]. This problem of collecting sufficient proof of anti-competitive behaviour will likely need to be addressed in the future, possibly even by novel models for the burden of proof.

Another significant challenge in enforcement lies in the opaque nature of algorithms, especially those powered by machine learning. Contemporary algorithms frequently operate as "black boxes," where even their developers may lack full comprehension of their inner workings or the rationale behind certain decisions. This lack of transparency complicates the ability of competition authorities to investigate and assess the workings of algorithms. When algorithms self-learn and evolve over time, their behaviour may diverge from the intentions of their devel-

[46] Ezrachi, A; Stucke, M.E., *op.cit*, note 12, pp. 1777-1778

[47] Ibid., p. 1780

opers, making it difficult to assign liability[48]. Also, it should be considered that algorithms can evolve over time, learning from market data and optimizing strategies in ways that were not anticipated by their creators. This raises the question of who should be held liable: the company that deployed the algorithm, the developers who created it, or potentially no one if the anti-competitive behaviour was not explicitly programmed?[49]

The regulatory challenge becomes more complex when algorithms are engineered to optimize profits in highly competitive markets. Such systems can autonomously generate anti-competitive outcomes, including price stabilization or parallel conduct, without deliberate intent or direct intervention by the firms employing them. This makes attribution of fault highly problematic, as enforcement authorities must grapple with whether liability lies with the undertakings deploying the algorithms or potentially with the algorithms themselves[50].

Finally, the speeds and scale at which algorithms operate further complicate enforcement. Unlike traditional forms of collusion, which often take time to develop, algorithms can adjust their strategies almost instantly in response to market changes. This makes detection of anti-competitive behaviour more difficult, as algorithms can quickly adapt to evade regulatory scrutiny. Additionally, algorithms operate on a global scale, potentially coordinating prices across multiple jurisdictions, making it harder for national regulators to monitor and enforce competition law effectively[51]. This global nature of algorithmic operations, with algorithms operating across multiple jurisdictions, often leads to cross-border effects that challenge national competition authorities. The enforcement of anti-collusion measures requires international cooperation, which is not always easily achieved due to differences in legal frameworks and enforcement capabilities across countries[52].

Many jurisdictions' current legal frameworks are inadequate to deal with these new forms of collusion. Competition authorities are often limited by laws that focus on human actions and explicit agreements, leaving a regulatory gap in addressing algorithmic collusion. As a result, enforcement agencies may need to rethink how competition law is applied in the digital age, including the possibility of new regulations that account for the capabilities of algorithms and artificial intelli-

48 Ibid., p. 1782

49 Picht, P. G; Leitz, A, *Algorithms and Competition Law - Status and Challenges*, [http://dx.doi.org/10.2139/ssrn.4716705], Accessed 23 September 2024, p. 12

50 Ezrachi, A; Stucke, M.E., *op.cit*, note 12, p. 1784

51 Ibid., p. 1786

52 Picht, P. G; Leitz, A, *op.cit*, note 42, p. 11

gence[53]. Legislators are already introducing reforms to address competition issues in digital markets, with many jurisdictions discussing new proposals to improve enforcement tools and regulations. The question of adequacy of existing tools for competition authorities remains, highlighting the need for future-proof solutions to tackle emerging challenges[54].

5. CONCLUSIONS

This research derives the conclusion that the existing regulatory framework on collusion is generally suitable for application on cases of explicit algorithmic collusion. Provided that the doctrine embraced in *AC-Treuhand II* case would not encompass all possible types of digital facilitators, only regulatory adaptation needed is the extension of legal responsibility to software providers (if algorithmic software is not internally produced), for anti-competitive price-fixing agreement.

Tacit algorithmic collusion as a form of concerted practice on the other hand produces difficult regulatory challenges. Although in certain scenarios precision of automated computational process makes it easier to conclude that no other explanation for parallelism exists (when pricing is executed by pricing algorithms) existing regulatory framework is far from adequate for the application of tacit algorithmic collusion. Major issue in EU Competition law is proof of conscious parallelism. Algorithmic software by using methods of machine learning and deep learning in particular is capable of reaching parallelism without human knowledge that is outside of the conscious human action. Thus even the existence of consciousness parallelism as a long established precondition for collusion in case-law can be debated in scenarios of tacit algorithmic collusion.

Positive and pro-competitive effects of development of pricing algorithms in optimisation, innovation and for consumer-welfare (including dynamic and individual pricing) cannot be disregarded. Automated pricing mechanisms can enhance market efficiency in various scenarios that are covered in this paper. Thus, any regulatory intervention in algorithmic collusion should be executed with the balance between the need of preventing anti-competitive effects of algorithmic collusion with pro-competitive advantages of development of pricing algorithms.

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53 Ezrachi, A; Stucke, M.E., *op.cit*, note 12, p. 1788

54 G7 Compendium of approaches to improving competition in digital markets 08.11.2023, [https://www.jftc.go.jp/en/pressreleases/yearly-2023/November/231108G7_result2EN.pdf] Accessed 23 September 2024, *para.* 86. *et seq.*

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