ADRIAN DOERR

Algorithmic Tacit Collusion

Beiträge zum Kartellrecht

Mohr Siebeck

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herausgegeben von

Michael Kling und Stefan Thomas

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Adrian Doerr

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An Analysis under European Competition Law

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To my parents

Preface

This doctoral thesis was accepted by the Law Faculty of Heinrich Heine University Düsseldorf in the summer of 2023 and the *viva voce* took place in January 2024. This work addresses contemporary issues, which are inherently evolving and subject to change. I have endeavoured to incorporate available sources and literature up to and including June 2023.

First and foremost, I am indebted to my supervisor, Professor Dr. Christian Kersting, LL.M. (Yale). His insightful feedback and advice significantly improved the quality of this work. I would also like to extend my gratitude to Professor Dr. Rupprecht Podszun for acting as secondary examiner, his prompt review, and words of encouragement. My thanks further go to Professor Dr. Michael Kling and Professor Dr. Stefan Thomas for including my work in this monograph series.

This thesis was inspired by my time at Pembroke College, University of Oxford, where my former tutor Professor Dr. Ariel Ezrachi introduced me to the world of competition law and its emerging challenges in the digital age. Special thanks are owed to Professor Dr. Jens Scherpe for facilitating my position as visiting researcher at Gonville & Caius College, University of Cambridge, from which my research benefitted greatly.

I would not have been able to complete this work without the steadfast support and encouragement of my friends, whose belief in me gave me the confidence to persevere. I am especially grateful to Dr. Grigory Bekritsky, Dr. Thomas Pelikan, Dr. Catharina von Berg, Dr. Leon Pietschmann, and Swantje Vanti for many late-night discussions, critical comments, and words of wisdom.

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Finally, my deepest gratitude goes to my parents, Monika and Holger Doerr, for their unwavering and unconditional support throughout my life, which

enabled me to pursue the education I have been privileged to receive. I dedicate this thesis to my parents, without whom I would not be who I am today.

London, March 2025 *Adrian Doerr*

Content Overview

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List of Abbreviations

ACCA	Australian Competition and Consumer Act
ACCC	Australian Competition & Consumer Commission
ACM	Association for Computing Machinery (United States)
AktG	Aktiengesetz
ANN	Artificial Neural Network
ARC	Act against Restraints of Competition, → *GWB*
BB	Betriebsberater
BeckOK	Beck'scher Online-Kommentar
BGB	Bürgerliches Gesetzbuch
BGH	Bundesgerichtshof
BKartA	Bundeskartellamt, → *FCO*
CB	Compliance Berater
CCZ	Corporate Compliance Zeitschrift
Ch.	Chapter
CJEU	Court of Justice of the European Union, → *ECJ*
CMA	Competition and Markets Authority
CMS	Compliance Management System
CNC	Comisión Nacional de la Competencia, → *CNMC*
CNMC	Comisión Nacional de los Mercados y la Competencia, → *CNC*
CPU	Central Processing Unit
CR	Computer und Recht
DB	Der Betrieb
De Minimis Notice	Communication from the Commission, Notice on agreements of minor importance which do not appreciably restrict competition under Article 101(1) of the Treaty on the Functioning of the European Union (2014/C 291/01)
DMA	Regulation (EU) 2022/1925 of the European Parliament and of the Council of 14 September 2022 on contestable and fair markets in the digital sector and amending Directives (EU) 2019/1937 and (EU) 2020/1828 = Digital Markets Act
DOJ	United States Department of Justice
EA 2002	UK Enterprise Act 2002
EC Treaty	1992 Treaty of Maastricht = Treaty establishing the European Community
ECHR	European Charta of Human Rights
ECJ	European Court of Justice, → *CJEU*
ECtHR	European Court of Human Rights
EEC	European Economic Community

Enforcement Priorities	Communication from the Commission, Guidance on the Commission's enforcement priorities in applying Article 82 of the EC Treaty to abusive exclusionary conduct by dominant undertakings (209/C 45/02)
EU	European Union
EUMR	European Merger Control Regulation = Council Regulation (EC) No. 139/2004 of 20 January 2004 on the control of concentrations between undertakings
FCO	German Federal Cartel Office, → *BKartA*
FS	Festschrift
FTC	United States Federal Trade Commission
FTCA	US Federal Trade Commission Act
GBE	GB eye Ltd. (in the context of the CMA investigation on online sales of posters and frames); → *Trod*
GC	General Court
GDPR	General Data Protection Regulation
GRUR	Gewerblicher Rechtsschutz und Urheberrecht
GRUR Int	GRUR International
GRUR-Prax	Gewerblicher Rechtsschutz und Urheberrecht in der Praxis
Guidelines on Art. 81(3)	Communication from the Commission, Guidelines on the Application of Art. 81(3) of the Treaty (2004/C 101/08)
Guidelines on Horizontal Cooperation Agreements	Communication from the Commission, Guidelines on the applicability of Article 101 of the Treaty on the Functioning of the European Union to horizontal cooperation agreements (2011/C 11/01)
Guidelines on Vertical Restraints	Commission Notice, Guidelines on Vertical Restraints (C(2010) 2365)
GWB	Gesetz gegen Wettbewerbsbeschränkungen, → *ARC*
Horizontal Cooperation Block Exemption Regulation	Regulation (EU) No. 1217/2010 of 14 December 2010 on the application of Article 101(3) of the Treaty on the Functioning of the European Union to certain categories of research and development agreements
Horizontal Merger Guidelines	Guidelines on the assessment of horizontal mergers under the Council Regulation on the control of concentrations between undertakings (2004/C 31/03) OJ [2004] C31/5
IIC	International Review of Intellectual Property and Competition Law
IR	InfrastrukturRecht
IT	Information Technology
JuS	Juristische Schulung
K&R	Kommunikation und Recht
KSzW	Kölner Schrift zum Wirtschaftsrecht
LG	Landgericht
MDP	Markov Decision Process
MFC (clauses)	Most-Favoured-Customer (clauses)
ML	Machine Learning
N&R	Netzwirtschaften und Recht
NJOZ	Neue Juristische Online-Zeitschrift

NZG	Neue Zeitschrift für Gesellschaftsrecht
NZKart	Neue Zeitschrift für Kartellrecht
OECD	Organisation for Economic Co-operation and Development
OLG	Oberlandesgericht
R&D	Research and Development
RDi	Recht Digital
Regulation No. 1/2003	Council Regulation (EC) No. 1/2003 of 16 December 2002 on the implementation of the rules on competition laid down in Articles 81 and 82 of the Treaty
Regulation No. 17/1962	EC Regulation No. 17/1962 (First Regulation implanting Articles 85 and 86 of the Treaty)
SCP	Structure-Conduct-Performance (Paradigm)
Sherman Act	US Sherman Antitrust Act 1890
Technology Transfer Block Exemption Regulation	Commission Regulation (EU) No. 316/2014 of 21 March 2014 on the application of Article 101(3) of the Treaty on the Functioning of the European Union to categories of technology transfer agreements
TEEC	1957 Treaty of Rome = Treaty establishing the European Economic Community
TEU	Treaty on European Union
TFEU	Treaty on the Functioning of the European Union
TFT	Tit-for-tat
Trod	Trod Ltd. (in the context of the CMA investigation on online sales of posters and frames); → *GBE*
Uber	Uber Technologies, Inc.
UK	United Kingdom of Great Britain and Northern Ireland
US	United States; → *USA*
USA	United States of America
UWG	Gesetz gegen unlauteren Wettbewerb
WRP	Wettbewerb in Recht & Praxis
ZfPW	Zeitschrift für die gesamte Privatrechtswissenschaft
ZHR	Zeitschrift für das Gesamte Handels- und Wirtschaftsrecht
ZinsO	Zeitschrift für das gesamte Insolvenz- und Sanierungsrecht
ZIP	Zeitschrift für Wirtschaftsrecht und Insolvenzpraxis
ZUM	Zeitschrift für Urheber- und Medienrecht
ZWeR	Zeitschrift für Wettbewerbsrecht

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A. Introduction

I. Setting the scene

The advent of new and intelligent, often referred to as 'smart', technology not only opens up new possibilities but also creates certain dangers. *Ezrachi* and *Stucke's* seminal book[1] on the promises and perils of virtual competition has paved the way for a nuanced discussion of several challenging aspects of digitisation as it flags areas of (future) concern. One such area is the danger of algorithmic collusion,[2] specifically algorithmically induced tacit collusion, which shall form the focus of this instant piece of research.

Algorithms are regularly understood to constitute one of the major mechanisms behind the digitisation and a driver for change. In this context, the problems are manifold and so complex that a precise delineation of the research focus is imperative in order to arrive at meaningful and substantiated results. The present piece of research therefore presents an answer to the problem of tacit collusion arrived at by intelligent, self-learning algorithms. It is argued that this problem can be distinguished from the known phenomenon of tacit collusion on conventional offline markets by virtue of its disparately greater economic impact. This therefore calls for regulation that tames the algorithms in order to refocus on the attainment of the objectives of competition law instead of chasing after technological innovation as an end in itself. The solution presented is based on the current regulatory framework, complemented by practical solutions to achieve effective enforcement, and fits the wider competition law framework. Overall, it enables a more flexible, future-proof enforcement of competition laws in light of a quickly developing technological landscape.

[1] *Ezrachi/Stucke*, Virtual Competition.

[2] 'Algorithmic collusion' describes the notion that algorithms may achieve collusive market outcomes from an economic perspective. Whether or not this may be categorised as 'tacit' or 'express' collusion from a competition law perspective will be investigated further in section E.II.

1. Common reception of the issue

Algorithmic collusion has been given wide coverage in both everyday press[3] and academic literature. At the same time, the discussion often remains at a very high level of discourse, does not take a nuanced and differentiated approach, and rather adopts a broad-brush view of algorithms as a whole. This not only fails to appreciate the specific issue of so-called algorithmic collusion by discounting its importance but also hastily arrives at the premature conclusion that no (immediate) action would be required.

Nevertheless, there appears to be a demand to have the issue resolved. Even competition authorities have expressed their concerns, such as the President of the German Federal Cartel Office (hereinafter "FCO"), *Mundt*. He admitted that he does not yet have an answer to situations in which competitors use intelligent algorithms to collude without explicit or even implicit agreement.[4] Similarly, albeit a bit more optimistic, *Vestager*, European Commissioner for Competition, confirmed that "[c]ompetition enforcers [...] need to make it very clear that companies can't escape responsibility for collusion by hiding behind a computer program."[5] In her speech at the FCO, *Vestager* stressed the responsibility of businesses to ensure compliance of their pricing algorithms and offered the possibility that higher fines could ensue where cartels were facilitated by way of algorithms;[6] this in itself does not however present a workable solution[7] and fails to recognise the new dimension of tacit collusion,[8] posing one of the greatest challenges for competition law with regard to artificial intelligence.[9] The only silver lining in her speech would be the concession that

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[3] Salient examples include but are not limited to: *Hennes/Schwalbe*, FAZ, 13 July 2018; *Hirst*, Politico, 28 February 2018; *N. N.*, The Economist, 6 May 2017; *Priluck*, The New Yorker, 25 April 2015; *Stucke/Ezrachi*, Harvard Business Review, 27 October 2016; *Vasant*, MLex, 3 February 2022.

[4] *Mundt*, Wirtschaftswoche, 2017, 24.

[5] *Vestager*, Speech 2017.

[6] *Vestager*, Speech 2017.

[7] On this note, also consider the assertions of *Baer*, former principal deputy associate attorney-general at the US Department of Justice, on the indictment in the *Topkins* case when he said "we will not tolerate anti-competitive conduct, whether it occurs in a smoke-filled room or over the internet using complex pricing algorithms" (as cited by *Lynch*, Financial Times 2017). The statement is a policy statement, a non-substantiated political postulation, presenting no workable solution to the issue.

[8] *Levitt et al.*, EU antitrust enforcement 2.0.

[9] As such, the issue is being considered at length, *inter alia* by the German Monopoly Commission (*Monopolkommission*, XXII. HG) and the UK House of Lords (*HL*, Select Committee AI). See also: *House of Lords*, Select Committee on European Union, Report of Session 2015–2016, Online Platforms and the Digital Single Market, para. 178 ("[R]apid developments in data collection and data analytics have created the potential for new welfare reducing and anti-competitive behaviours by online platforms, including subtle degradations of quality, acquiring datasets to exclude potential competitors, and *new forms of collusion*. While some of these abuses

"we do need to keep a close eye on how algorithms are developing. We do need to keep talking about what we've learned from our experiences. So that when science fiction becomes reality, we're ready to deal with it."[10]

There are no better words to describe what research should focus on, namely, to establish potential solutions in anticipation of a problem that is at the very least imminent if not already present. As such, the topic has been considered not only by competition agencies but also by the Organisation for Economic Co-operation and Development (hereinafter "OECD") and several academics.[11]

Finally, the Competition and Markets Authority (hereinafter "CMA") in the United Kingdom of Great Britain and Northern Ireland (hereinafter "UK") even expressly considered the possibility of bringing cases against fully autonomous software,[12] without specifying how it would do so. Again, it was merely highlighted by *Currie*, its former Chairman, that such technology should – if anything – "work to enhance competition, not close it down".[13] At the same time, national competition authorities are building up expertise in the area,[14] proving the need for a legal reaction of a kind yet to be determined.

What becomes apparent, though, is that there is a lot of speculation surrounding this new topic. In fact, algorithmic collusion has been referred to as the "most complex and subtle way for companies to collude, without explicitly programming algorithms to do so."[15] This is not only because of the superior processing capabilities of computers compared to their human creators but also due to their newly evolving learning capability, which has been specifically noted by the OECD Secretariat.[16] It is not too difficult to see room for concern in these developments. Broken down to its core, *Nigro*, Official at the US Department of Justice (hereinafter "DOJ"), pointed out that tacit collusion without an agreement

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are hypothetical, they raise questions as to the adequacy of current approaches to competition enforcement" [Emphasis added]).

[10] *Vestager*, Speech 2017.

[11] An entire volume of the Antitrust Chronicle has been devoted to the broad field of algorithms; moreover, it was the subject of the International Cartel Conference in Berlin, the OECD Roundtable, the Cresse Conference on Industrial Organization, as well as the Ascola Conference in 2018 (*Schwalbe*, Algorithms, Machine Learning, and Collusion, 2).

[12] *Levitt et al.*, EU antitrust enforcement 2.0. Most recently: *Beioley/Murgia*, Financial Times 2023.

[13] *Curry*, Speech, 3 February 2017.

[14] Indeed, the UK Competition and Markets Authority has its proprietary data unit (*Deng*, Antitrust 2018, 88, 94). Similarly, the French *Autorité de la concurrence* and the German *Bundeskartellamt* launched a joint project on algorithms and their implications on competition and published a report named "Competition Law and Data" on 10 May 2016.
Also, the House of Lords recognised that there may be the potential for welfare-reducing and new forms of anti-competitive conduct: *Ezrachi/Stucke*, Competition Law & Policy Debate 2017, 24, 28; *House of Lords*, Select Committee on European Union, Report of Session 2015–2016, Online Platforms and the Digital Single Market, paras. 178–179.

[15] *Deng*, Antitrust 2018, 88, 88.

[16] *Ibid.*

among participants would not infringe the law and that this would not change in light of technological advances.[17] Yet, this might constitute the very controversy.

Against the backdrop of an ever-increasing pace of technological progress and considerable development in this area,[18] the present thesis is meant to resolve this issue, which – as will be shown – now proves to be more problematic than ever before.

2. Research focus

As it is submitted that a plethora of issues exist in relation to algorithms, it is particularly important to define the research focus very clearly. The instant piece of research concentrates on the challenges presented by autonomous, self-learning algorithms with respect to the creation of tacitly collusive market dynamics only.

Whilst it is necessary for any academic work to actively define the scope of analysis, it is equally important to recognise explicitly what does *not* form part of the investigation. The field of algorithms is indeed a broad one which entails many intricacies and challenges.[19]

One of these is algorithmic price discrimination.[20] The analysis of great amounts of data may allow undertakings to target their customers more precisely than ever before to the extent that individual pricing profiles may be created, which allow undertakings to discriminate between individual customers without grouping them (so-called behavioural discrimination[21] or first-degree or perfect price discrimination[22]). The latter would result in a (nigh on) complete absorption of all consumer surplus.[23] It can facilitate discrimination by product properties, including quantities purchased (second-degree price discrimination),[24] or customer groups (third-degree price discrimination).[25] In some places, it may already be a regular occurrence to price discriminate, for example between on- and off-peak train times, but algorithms may take this discrimination to a whole new level.[26]

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[17] *Ibid.*; *Guniganti*, Global Competition Review, 5 February 2018.

[18] *Deng*, Antitrust 2018, 88, 93.

[19] A comprehensive overview of current issues is provided by *Louven*, WRP 2020, 438; *Podszun/Kersting*, NJOZ 2019, 321.

[20] For a comprehensive analysis of the problem, see *Ezrachi/Stucke*, Virtual Competition, 89–130; applied solutions are developed by *Zurth*, ZWeR 2021, 361, 363–367.

[21] See also: *Bundeskartellamt/Autorité de la concurrence*, Competition Law and Data, 21–22; *Ezrachi/Stucke*, Competition Law International 2017, 125, 129–130.

[22] *McSweeny/Terrel*, Antitrust 2017, 75, 76.

[23] *Ibid.* More on the concept of 'consumer surplus', see section C. I.4.

[24] *Salaschek/Serafimova*, WuW 2019, 118, 119–120 *McSweeny/Terrel*, Antitrust 2017, 75, 76.

[25] *Ibid.*

[26] This has only rarely been observed in practice, though; cf. *European Commission*, Prelimi-

From an economic perspective, such price discrimination may entail positive effects. Indeed, by allowing everyone to pay what they are maximally willing to pay, well-funded customers might cross-subsidise products for less well-funded customers so that overall welfare effects increase. Furthermore, the risk of tacit collusion is minimised since prices are less easy to compare.[27] In addition, social welfare, that is, the combination of consumer and producer surplus, is maximised, albeit in lopsided favour of suppliers.[28] Acknowledging this latter consequence, though, it might not be desirable from a societal perspective to let undertakings absorb the full consumer surplus for their own benefit.[29] Especially if one undertaking were dominant, it could potentially even constitute an abuse of its market position.[30] Whilst the analysis, particularly in relation to the risk of tacit collusion and the potentially negative impact on consumer surplus, follows similar lines to the present work, price discrimination is a detached problem. This is because its economic effects are ambiguous, the ramifications wide-ranging,[31] and the legal analysis separate to that of tacit collusion; importantly, there is an inverse relationship between personalised pricing and (tacit collusion),[32] thus rendering it beyond the scope of the instant piece of research.

Another point that is deeply intertwined with algorithms is the issue of data protection. Given the reliance of algorithms on data for their training and operation, it is imperative to explore in how far data may be accessed and used,[33]

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nary Report on the E-Commerce Sector Inquiry, 54 para. 128; see also: *Picht/Freund*, European Competition Law Review 2018, 403, 407.

[27] *Salaschek/Serafimova*, WuW 2019, 118, 120; *Paal*, GRUR 2019, 43, 45.

[28] *Bundeskartellamt/Autorité de la concurrence*, Competition Law and Data, 21–22.

[29] For a full discussion of this point, see *Woodcock*, Hastings Law Journal 2017, 1371.

[30] For an initial analysis, see *Salaschek/Serafimova*, WuW 2019, 118.

[31] Consider, for example, the impact on the market definition in the context of merger control, as suggested by *McSweeny/Terrel*, Antitrust 2017, 75, 76–78.
Moreover, the application of different evaluation criteria will likely lead to diverging results as to the desirability of price discrimination, as suggested by *Paal*, GRUR 2019, 43, 48.

[32] *Oxera*, When algorithms set prices, 4 ("Markets with characteristics that may make them amenable to collusion tend to be less favourable to personalised pricing. Markets where personalised pricing is prevelvant do not easily lend themselves to collusion."); *Petit*, Journal of European Competition Law & Practice 2017, 361; *Veljanovski*, Pricing Algorithms as Collusive Devices, 11.
Critical of this suggestion: *Ezrachi/Stucke*, Two Artificial Neural Networks Meet in an Online Hub and Change the Future (of Competition, Market Dynamics and Society), 17–23; *Ezrachi/Stucke*, Algorithmic Collusion: Problems and Counter-Measures, 12–16 ("tacitly collude on the posed price to profit from the 'low-value' and loyal customers; behaviorally discriminate for the 'high-value' customers"). *Ezrachi/Stucke* instead see tacit collusion and behavioural price discrimination as complementary, with the latter being an added dimension to the initial problem of tacit collusion. This view would, however, not affect the validity of the subsequent analysis; instead, it goes to show that tacit collusion can be even more problematic than expected. Similar: *Zurth*, ZWeR 2021, 361, 371–372.

[33] For an interesting analysis in the context of Facebook, see *Brinkmann*, Marktmachtmissbrauch durch Verstoß gegen außerkartellrechtliche Rechtsvorschriften, 233–250; consider

and also what price tag is put on it.[34] An undertaking could equally be tempted to protect its superior access to data by anti-competitive means,[35] opening a broad field of further questions.

Linked to this are issues in the context of platform markets, including phenomena such as network effects and market tipping. The more data is accessible for algorithms, the better and more precise the outcomes are;[36] in turn, this would secure a better market standing. A prominent market standing hence appears to correlate with superior algorithms and access to data. Especially platform markets seem to be built on this very understanding and the idea that they need to become the first port of call, the primary platform used by consumers, in order to be profitable.[37] This chain of causality, as intriguing as it is, opens a whole array of consecutive questions that require exploration; yet the investigation of this complex relationship needs to be undertaken elsewhere.

Similarly, the market power that is gained by so-called 'super platforms' and their potential abuse of this power as well as the danger that they could leverage their market position to secure standing in other, unrelated markets and exploit both upstream and downstream markets has also attracted considerable attention of academics[38] and politicians alike. This could require a new approach towards the definition of markets, assessing the contestability of markets, and evaluating market power.[39] Given the breadth of these implications, such deliberations are beyond the scope of this instant work.[40]

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also *Bundeskartellamt/Autorité de la concurrence*, Competition Law and Data, 23–25; *Körber*, NZKart 2019, 187; see further on the importance of data: *Capobianco/Nyseo*, Journal of European Competition Law & Practice 2018, 19, 21.
For an inspirational article providing an introduction to the idea of big data as essential facility: *Lugard/Roach*, Antitrust 2017, 57.

[34] For an inspiring introduction to the issue, see *Malgieri/Custers*, Computer Law & Security Review 2018, 289.

[35] See, for example, considerations of increased M&A activity and potential forms of exclusionary conduct: *Bundeskartellamt/Autorité de la concurrence*, Competition Law and Data, 16–20.

[36] Importantly, this is a function of the scope and scale of the data collected as well as of the sophistication of the algorithm deployed as it will result in a better understanding of the market and its customers respectively; cf. *Bundeskartellamt/Autorité de la concurrence*, Competition Law and Data, 27–28, 47–52.

[37] They thus defy the notion of 'multi-homing', which refers to the idea that a consumer uses various different providers for the same service. An illustrative introduction to the rise of such super-platforms is given by *Kahn*, Yale Law Journal 2017, 710.

[38] E. g., *Ezrachi/Stucke*, Competition Law International 2017, 125, 130–135.

[39] For initial suggestions consider *Capobianco/Nyseo*, Journal of European Competition Law & Practice 2018, 19, 23–25.
Many of the difficulties associated with these platforms originate from the supposedly free nature of the services they offer, which can lead to a misperception of their antitrust compatibility. For a good overview, see: *Newman*, Washington University Law Review 2016, 49.

[40] Consider, for example, the so-called "Amazon effect" (*Hielscher et al.*, WirtschaftsWoche, 18); for further insights on potentially abusive tactics of the so-called GAFA (Google, Amazon,

In light of the vast array of issues that all relate to algorithms, the scope of this piece of research is restricted to the impact of self-learning pricing algorithms on the occurrence of tacit collusion only. In particular, it shall be investigated in how far, if at all, tacit collusion through algorithms may differ from non-algorithmic tacit collusion and what impact this could have on the legal framework. What is noticeable is that all these issues raise fundamental questions as to the scope and objectives of competition law, which is why a consideration of these is inevitable to any debate in this context.[41]

Given the ubiquity of the problem and the inability to confine the issue to a national framework, the analysis that ensues focuses on European competition law. Since Member State competition law regimes will mirror European provisions,[42] the analysis will not lack substance but rather make it more accessible. Where national peculiarities provide intriguing solution approaches, these shall be considered at the appropriate stages and be tested for their feasibility on a European level.

3. Contributions to academic discourse

The present piece of work intends to make some important contributions to the advancement of research concerning the relation between autonomous algorithms and competition law.

First of all, it seeks to provide a comprehensive understanding of the computer-scientific technicalities behind algorithms in general and deep learning in particular to make for a more informed and substantiated discussion.[43] The idea is that, grounded in what is practically feasible, meaningful inferences may be drawn in a sober, unagitated and realistic manner. This overview could also be useful in the broader context and in relation to adjacent issues.

Secondly, the present work is informed by an attempt at a comprehensive, even though necessarily selective, overview of insights from experimental economics[44] and harnesses this economic background to substantiate the argument in favour of revised regulation.

Facebook, Apple) companies, see the introductory article by *Hohensee*, WirtschaftsWoche, 66. In this context, the term 'frenemy' aptly describes the potentially pro- and anti-competitive strategies of such platforms, for an analysis of which refer to *Ezrachi/Stucke*, Virtual Competition, 145–202.

[41] *Ezrachi/Stucke*, Competition Law International 2017, 125, 135.

[42] E. g., *Rehbinder*, in: Immenga/Mestmäcker Vol. II, GWB § 22, paras. 5–9; *Loewenheim*, in: LMRKML, § 22 GWB, paras. 1–13; *Bechtold/Bosch*, § 22 GWB, paras. 3–8.

[43] Previous contributions have often speculated without making use of game-theoretical insights and knowledge from computer scientists or experimental economists, *Hennes/Schwalbe*, FAZ, 13 July 2018.

[44] Particularly experimental economics have hitherto been largely neglected in the practical application of competition law, *Engel*, Wettbewerb als sozial erwünschtes Dilemma, 21.

Thirdly, drawing on existing frameworks, it introduces a new categorisation of algorithms to guide the analysis. Focusing on a very specific issue in this regard, namely the impact of autonomous algorithms on tacit collusion, it tries to avoid falling into the trap of conflating issues and instead intends to concentrate on sharpening the argument in order to help draw relevant, and meaningful conclusions.

Fourthly, this work has ambitious goals in that it not only attempts to provide an overview of different solution approaches; it also seeks to present a workable solution that could be practically implemented as opposed to simply calling for more research or resorting to a 'wait and see' approach.[45] By recommending a specific course of action for competition enforcers and undertakings alike, this work aspires to attain not only academic but also practical value. In so doing it is not confined to the specificities of a national legal framework but set in a broader European context.

Importantly, the solution presented is tied into the existing framework and, as will be explained, should align with the fundamental values and objectives of European competition law, of which the reader is duly reminded. This should ensure that the recommendations are indeed workable and sufficiently robust in order to combat future challenges. Going back to the roots of competition law in Europe and building a solution up from the 'ground' is therefore another contribution and indeed central tenet of this work as it emphasises the need for a teleological understanding and reasoning.

Finally, this piece of research intends to take a holistic approach to the problem of algorithmic tacit collusion instead of casting a light on isolated issues. Indeed, one of its intended contributions lies in taking a step back and bearing the bigger picture in mind. Adopting an interdisciplinary approach towards tacit collusion, drawing on the fields of computer science, economics, policy and the law, answers are hoped to be provided to essential questions previously raised elsewhere[46] but which, as of yet, had not been answered in full. In particular, it is meant to clarify whether and how tacit collusion online compares to its offline equivalent, establish whether or not the potential differences would warrant a different treatment, and answer what form such treatment could take in light of the existing framework and its underlying values and objectives.

In tackling a very specific research question, this research tries to bridge the gap between the different scientific fields involved as well as between academia and practice, thereby aiming to foster more prolific interdisciplinary exchange. By focusing on European law instead of Member State settings it recognises the borderlessness of the algorithmic debate and endeavours to make it more acces-

[45] As suggested, for example, by *Zimmer*, in: Immenga/Mestmäcker Vol. I, AEUV Art. 101 Abs. 1, para. 78.

[46] E. g., *Ezrachi/Stucke*, Competition Law International 2017, 125, 129.

sible so that insights may also be gained by those competition law regimes modelled on the European approach.

II. Course of reasoning

As has been pointed out, the focus of this piece of research is on the impact of autonomous algorithms on tacitly collusive market dynamics. This is a multi-layered issue, which thus requires a step-by-step approach that unfolds the complexity.

In a first step, the knowledge and background of competition law in Europe shall be solidified. In particular, it shall be explored upon what policy ideas and ideology the current antitrust regime has been built. This is necessary in order to find a solution that ties in with the existing regulatory framework, is aligned with its objectives, and will thus not cannibalise the attainment of potentially conflicting objectives. Only a solution that fits the existing framework will be sustainable in the long run.

This is then complemented by a comprehensive definition of the key terms used throughout this work. Importantly, a basic understanding of the functioning of intelligent algorithms shall be provided in order to substantiate the discussion, make it less hypothetical but premised on real observations, and also serves as interface between the disciplines of law and computer science.

Building on this groundwork, the conventional oligopoly problem of tacit collusion is presented, and a game-theoretic background provided for an enhanced understanding. The market dynamic of tacit collusion is explained by way of a game-theoretic model before its treatment under the current regulatory framework is outlined. This is then compared to the US approach, which takes a slightly different approach to the problem; this divergence provides the starting point for the subsequent discussion of a potential solution to the problem.

The novelty of this piece of research consists in the explanation of the effect that the advent of autonomous algorithms could have on the market dynamic. The theoretical possibility is substantiated by a feasibility check from a computer-scientific, game-theoretical, and economic perspective. Following a comparative analysis of the conventional versus the algorithm-driven instances of tacit collusion, it is concluded that there is a need for new measures to pre-empt algorithmically induced tacit collusion.

Given this interim result, the final part of this piece of research suggests a workable solution that focuses on the re-interpretation of the elements that constitute a concerted practice for the purpose of Art. 101 para. 1 Treaty on the Functioning of the European Union (hereinafter "TFEU"), complemented by additional measures to ensure effective enforcement in practice. Moreover, some novel ideas are introduced and probed for their viability and fit within the ex-

isting regulatory framework and its objectives. On this basis, an integrated set of approaches is presented that not only aligns with the principles of European competition law but also bears the bigger picture in mind so as to be sufficiently flexible and sustainable. The necessary inferences of this recommendation are then drawn for the legal framework and its application as well as for undertakings, which underlines the practical value of this work.

III. Results of this research

The instant piece of research contributes to the understanding of algorithmically induced tacit collusion and its impact in three ways.

Firstly, it is concluded that tacit collusion as it has been conventionally known does not present too great a challenge and thus need not be regulated. This is because it can only arise under specific conditions and is inherently unstable,[47] hence the potential harm it may entail is limited. Combined with the difficulties in capturing this dynamic from a legal perspective, legislators appear to accept this enforcement gap.

Secondly, autonomous algorithms not only present a real but importantly imminent risk that could lead to an undesirable economic imbalance on a scale that has been unprecedented hitherto. Therefore, and in line with the fundamental values and objectives of European competition law, the legal framework within which market forces operate needs to be re-adjusted accordingly to bring the system back on track and make it future-proof.

Thirdly, an integrated solution to algorithmically induced tacit collusion must consist of several elements; importantly, it requires a broader understanding of a concerted practice that accounts for algorithmic dynamics, aided by a closer scrutiny of markets and technological developments. Markets need to be monitored more closely in order to raise an initial suspicion more quickly. Competition enforcers need to embrace their own limitations and flip the coin by using presumptions to overcome evidentiary hurdles.

Overall, this work suggests that, where there is a sufficient proliferation of autonomous pricing algorithms on a market, of which undertakings are aware, the uncertainty as to the pricing dynamic is so far reduced that it is effectively removed, which should render the 'entanglement' between those undertakings

[47] Mostly due to incentives to cheat as well as the potential for distrust to arise and the possibility of detection; cf. *Ezrachi/Stucke*, Virtual Competition, 35. Contrast this with: *Levenstein/Suslow*, Journal of Economic Literature 2006, 43, 51–52, who note that duration is bimodal, with some cartels lasting only one year, and twice as many lasting between four and six years; there is also a substantial number of cartels that last considerably longer. Further: *Connor*, Antitrust Institute Working Paper 2009, 30, who identifies a median duration of 57 months (mean: 82 months).

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