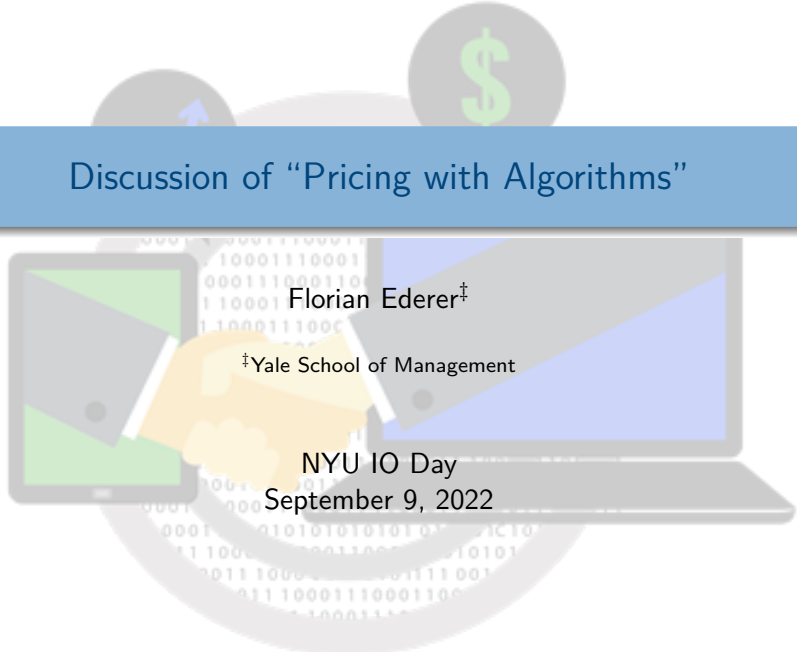
Discussion of "Pricing with Algorithms"



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NYU IO Day
September 9, 2022

Why aren't these folks discussing this paper?

A quick summary

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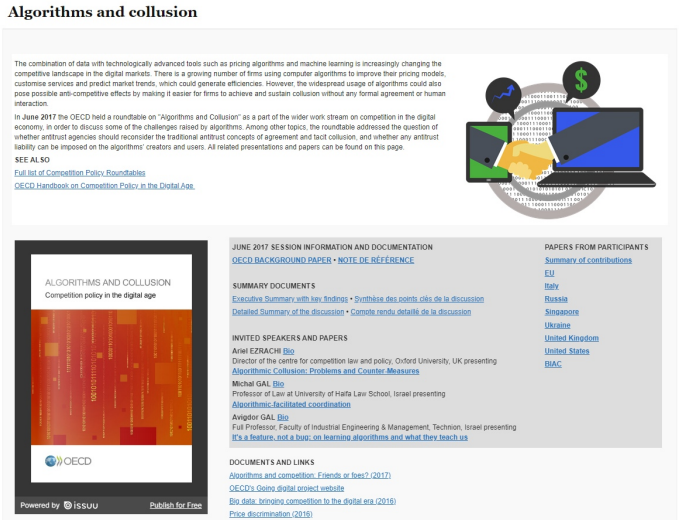
- Well, actually, under a specific set of assumptions:
  - Two firms
  - Finite set of prices
  - Repeated interaction
  - Markov perfect equilibrium
  - (Infinitely) fast learning of other firm's algorithm
  - Discrete adjustments to the algorithm of the other firm

Great Policy Importance



Algorithms and collusion

The combination of data with technologically advanced tools such as pricing algorithms and machine learning is increasingly changing the competitive landscape in the digital markets. There is a growing number of firms using computer algorithms to improve their pricing models, customise services and predict market trends, which could generate efficiencies. However, the widespread usage of algorithms could also pose possible anti-competitive effects by making it easier for firms to achieve and sustain collusion without any formal agreement or human interaction.

In **June 2017** the OECD held a roundtable on "Algorithms and Collusion" as a part of the wider work stream on competition in the digital economy, in order to discuss some of the challenges raised by algorithms. Among other topics, the roundtable addressed the question of whether antitrust agencies should reconsider the traditional antitrust concepts of agreement and tacit collusion, and whether any antitrust liability can be imposed on the algorithms' creators and users. All related presentations and papers can be found on this page.

SEE ALSO

Full list of Competition Policy Roundtables

OECD Handbook on Competition Policy in the Digital Age

ALGORITHMS AND COLLUSION
Competition policy in the digital age

OECD

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JUNE 2017 SESSION INFORMATION AND DOCUMENTATION

OECD BACKGROUND PAPER • NOTE DE RÉFÉRENCE

SUMMARY DOCUMENTS

Executive Summary with key findings • Synthèse des points clés de la discussion

Detailed Summary of the discussion • Compte rendu detaillé de la discussion

INVITED SPEAKERS AND PAPERS

Ariel EZRACHI Bio
Director of the centre for competition law and policy, Oxford University, UK presenting
Algorithmic Collusion: Problems and Counter-Measures

Michal GAL Bio
Professor of Law at University of Haifa Law School, Israel presenting
Algorithmic-facilitated coordination

Avigdor GAL Bio
Full Professor, Faculty of Industrial Engineering & Management, Technion, Israel presenting
It's a feature, not a bug: on learning algorithms and what they teach us

DOCUMENTS AND LINKS

Algorithms and competition: Friends or foes? (2017)

OECD's Going digital project website

Big data: bringing competition to the digital era (2016)

Price discrimination (2016)

PAPERS FROM PARTICIPANTS

Summary of contributions

EU

Italy

Russia

Singapore

Ukraine

United Kingdom

United States

BIAC

"[T]he use of pricing algorithms by professional sellers is common, if not ubiquitous."

Antitrust Lawsuits and Algorithmic Pricing

- Antitrust authorities have successfully prosecuted cases of both horizontal and vertical collusion facilitated by pricing algorithms.
  - US District Court of Northern California held David Topkins, a director of a company selling posters online, liable for agreement with other merchants on levels of prices and specific algorithms to be used.
  - The same court found Trod Limited and its director liable for a similar infringement.
  - UK CMA found two merchants selling on Amazon liable for an agreement not to compete on prices and to adjust the settings of a re-pricing algorithm available on Amazon.

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- But these are cases where the pricing algorithms **facilitated explicit agreements** rather than **generated pure tacit collusion** which is not covered by current antitrust rules.
  - How big is the problem of anti-competitive pricing?
  - How widespread is it?
  - Is there a path towards making collusion by autonomous artificial agents unlawful (Harrington 2018)?

What do we already know about algorithms and tacit collusion?

- Extremely active literature with theoretical, experimental, and empirical results
- Supracompetitive prices in theory (and simulations)
  - Salcedo (2015): When demand shocks occur much more frequently than algorithm revisions, the long-run profits of two duopolists from **any equilibrium** are close to those of a monopolist.
  - Brown & Mackay (2021): Supracompetitive prices, including the fully collusive prices, **can be supported** with algorithms that are simple linear functions of rivals' prices.
  - Asker, Fershtman & Pakes (2021): Asynchronous learning (only learning about return from chosen action) **can lead** to pricing close to monopoly levels.
  - Hansen, Misra & Pai (2021): If the informational value of price experiments is high, long-run prices are supracompetitive and the full information joint-monopoly outcome is **possible**.
  - And many more including Klein (2021), Johnson, Rhodes & Wildenbeest (2021), Banchio & Mantegazza (2022), Mulsolf (2022),...
- Supracompetitive prices in practice?
  - Assad, Clark, Ershov & Xu (2022): Adoption of algorithmic pricing increases margins in non-monopoly gas station markets.

A Very Strong Result

- Paper has an incredibly strong result ("algorithmic tacit collusion conjecture")
  - So strong that it's hard to believe that it would apply in practice.
  - It has the flavor of "crazy" results like contestable markets or the Coase conjecture.
- What would break the result?
  - In some ways it's less interesting to know that the result is robust and ...
  - ... more instructive to know what would break it.
  - This could also inform antitrust policy.
- What assumptions are crucial?
  - Markov perfect equilibria, multiple firms, asynchronous adjustment of algorithms, ...
- Ideally, as a reader, I would like to see a more extensive discussion of why supracompetitive prices due to algorithmic pricing are **possible** in other papers but **inevitable** in this paper (and in Salcedo (2015)).
  - Role of fast price reaction (and frequent demand shocks in Salcedo (2015))?

A number of other results

- Pure monopoly for low discount factors
  - In contrast to standard repeated games setting, with low discount factors repeated play of the monopoly outcome emerges as the unique SPE.
  - I have absolutely no intuition for this result. Why?!?
- But with high discounting we are back to large payoff sets as is typical for repeated games.
  - What's going on?
- Asymmetry of Theorem 2
  - If one of the players is close to the monopoly payoff then the other firm should be playing the monopoly price too so why is there only a result for one of the sellers?
  - Discussing why the other firm might not be near monopoly profits would be helpful.

Experimentation

- Experimentation is limited to a very short time
  - Authors calculate the precise expected payoffs in Section 5.2 without ignoring initial convergence
  - But result still "only" holds for small interval between price adjustments
- Non-stationarity
  - Many real world pricing algorithms always experiment a bit due to non-stationarity in the environment.
  - What if the other algorithms engaged in some occasional bouts of experimentation at other time periods?
  - Would the algorithm designer still know the rival's algorithm at the time the algorithm is revised?

What does this mean for antitrust law?

> *"Absent concerted action, independent adoption of the same or similar pricing algorithms is unlikely to lead to antitrust liability even if it makes interdependent pricing more likely. For example, if multiple competing firms unknowingly purchase the same software to set prices, and that software uses identical algorithms, this may effectively align the pricing strategies of all the market participants, even though they have reached no agreement." — DOJ Antitrust Division (2017)*

> *It is no defense to suggest that algorithms, programmed for autonomy, have learned and executed anticompetitive behavior unbeknownst to the corporation. The software is always a product of its programmers - who of course have the ability to (affirmatively) program compliance with the Sherman Act. — Gosselin, Jones & Martin (2017)*

Should there be a per se prohibition on certain pricing algorithms (or, equivalently, on pricing algorithms having certain properties) that support supracompetitive prices?

Conclusion

- What this paper says
  - Under certain assumptions algorithmic pricing inevitably leads to supracompetitive or even monopoly prices.
- Implications
  - Suggests that antitrust policy may require new rules for dealing with tacit collusion generated by algorithms
  - But we may learn more from when tacit collusion fails

But most importantly ...

Antitrust

~~Anti-trust~~

Thank You!

References I