Algorithms and Collusion

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1. Algorithms: Concepts and Applications

2. Risk of Algorithmic Collusion

3. Challenges for Competition Law Enforcement

4. Regulation of Algorithms
Algorithms:
Concepts and Applications
"An algorithm is an unambiguous, precise, list of simple operations applied mechanically and systematically to a set of tokens or objects. (...) The initial state of the tokens is the input; the final state is the output."

How can algorithms be represented?

- Plain language
- Diagrams
- Voice instructions
- Computer codes
  - Automatic
  - Fast processing
  - Complex calculation
Programming principles

• Artificial intelligence
  – Detailed algorithms that mimic human intelligence

• Machine learning
  – Algorithms that iteratively learn from data

• Deep learning
  – Artificial neural networks that replicate the activity of human neurons…
Machine Learning (ML) vs Deep Learning (DL)

ML requires manual features engineering, while in DL feature engineering is automatic…
Applications of algorithms

Business
- Predictive analytics
- Process optimisation
- Increase supplier power

Consumers
- Consumer information
- Decision-making optimisation
- Increase buyer power

Government
- Crime detection
- Determine fines and sentences

Positive impact on static and dynamic efficiency
Pro-competitive business applications of algorithms

Predictive analytics
- Supply-chain optimisation
- Target ads
- Fraud prevention

Optimisation of business processes
- Product innovation
- Risk management
- Recommendations
- Dynamic pricing
- Price differentiation
- Product Customisation
Risk of Algorithmic Collusion
Algorithmic collusion consists in any form of anti-competitive agreement or coordination among competing firms that is facilitated or implemented through means of automated systems.
## Impact of algorithms on the likelihood of collusion

<table>
<thead>
<tr>
<th>Relevant factors for collusion</th>
<th>How algorithms affect collusion?</th>
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<tbody>
<tr>
<td>Structural characteristics</td>
<td></td>
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<tr>
<td>Number of firms</td>
<td>±</td>
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<tr>
<td>Barriers to entry</td>
<td>±</td>
</tr>
<tr>
<td>Market transparency</td>
<td>+</td>
</tr>
<tr>
<td>Frequency of interaction</td>
<td>+</td>
</tr>
<tr>
<td>Demand variables</td>
<td></td>
</tr>
<tr>
<td>Demand growth</td>
<td>0</td>
</tr>
<tr>
<td>Demand fluctuations</td>
<td>0</td>
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<tr>
<td>Supply variables</td>
<td></td>
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<tr>
<td>Innovation</td>
<td>–</td>
</tr>
<tr>
<td>Cost asymmetry</td>
<td>–</td>
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</table>

+ positive impact;  – negative impact;  0 neutral impact;  ± ambiguous impact.
Transparency and frequency of interaction

Result: In a perfectly transparent market where firms interact repeatedly, when the retaliation lag tends to zero collusion can always be sustained as an equilibrium strategy.

Intuition: If markets are transparent and companies react instantaneously to any deviation, the payoff from deviation is zero.

$$\text{ICC: } \int_0^\infty e^{-rt} \pi^M dt \geq \int_0^{T+L} e^{-rt} \pi^D dt + \int_{T+L}^\infty e^{-rt} \pi^C dt$$
However, even if collusion is an equilibrium strategy, firms may fail to coordinate...

**Cartel umbrella effect:**
- In industries with many players, each firm has an incentive not to participate in the agreement in order to benefit from the “cartel umbrella”.

*Structural measures might still be effective...*
Role of algorithms as facilitators of tacit collusion

• Any collusive arrangement requires:
  – A meeting of minds
  – A structure to implement and govern firms’ interaction:
    • Common policy
    • Monitoring
    • Punishment mechanism

• Some algorithms may eliminate the need of explicit communication during the initiation and implementation stages
Monitoring algorithm

Description: Collect and process information from competitors to monitor their compliance and, eventually, to punish deviations.

Legend:

\[ \bar{p} \text{ <collusive price}> \]
\[ p_i \text{ <price set by firm i}> \]
Description: Coordinate a common policy or parallel behaviour, for instance by programming prices to follow a leader.

Legend:

$/p$ <collusive price>

$/p_i$ <price set by firm $i$>
Signalling algorithm

Description: to disclose and disseminate information in order to announce an intention to collude or negotiate a common policy.

Legend:

/\ s <tentative signal>

/s_i <signal sent by firm i>
Self-learning algorithm

Description: maximise profits while recognising mutual interdependency and readapting behaviour to the actions of other market players

...
Summary of the risks of algorithmic collusion

- Change market characteristics
- Transparency
- High frequency trading

Algorithms

- Govern collusive structures
  - Signal & negotiate common policy
  - Coordinate common policy
  - Monitor & punish
  - Optimize joint profits

Increase likelihood of collusion
Replace explicit communication

Tacit collusion
Challenges for

Competition Law Enforcement
Competition enforcement gap?

• Discussion at the OECD Competition Committee:
  – **Algorithms as ancillary practices to collusion**: antitrust law covers instances where algorithms are used as tools to amplify traditional horizontal agreements
  – However, what about the potential impact of algorithms on **tacit collusion**?

Is there an enforcement gap?
Competition enforcement gap?

The only time we look at tacit collusion is when we look at ex ante analysis of mergers. Here we have an interesting question about legality and policy (...) The fact that [algorithms] can change the market characteristics gives rise to concern. That concern cannot be attacked under 101. Should we do something about it?

Ariel Ezrachi

(... if we don’t know the importance and the magnitude of the problem then it is very difficult to conclude that there is an enforcement gap.

BIAC

Competition laws were designed to deal with human facilitation of parallel conduct. (...) However, in a world in which tacit collusion becomes or is operated on a larger scale, maybe we need to rethink the reasons why we decided not to tackle tacit collusion in the first place.

Michal Gal
The concept of agreement

- Identifying an “agreement” is a prerequisite to enforce the law against collusion
- The concept of “agreement” is usually broadly defined, in order to ensure a wide reach of competition rules
  - In the EU the term “agreement” involves simultaneously:
    - A common will
    - Some form of manifestation
  - In the US is involves solely a common will or a “meeting of minds”
“Meeting of algorithms”

(...) computer technology that permits rapid announcements and responses has blurred the meaning of 'agreement' and has made it difficult for antitrust authorities to distinguish public agreements from conversations among competitors. Borenstein (1997)
**“Meeting of algorithms” – examples**

<table>
<thead>
<tr>
<th>Offer</th>
<th>Acceptance</th>
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<tbody>
<tr>
<td>1 Firm intermittently sets a higher price for brief seconds (costless signal)</td>
<td>Competitor increases price to the value signalled</td>
</tr>
<tr>
<td>2 Firm programs algorithm to mimic the price of a leader</td>
<td>The leader, recognising this behaviour, increases the price</td>
</tr>
<tr>
<td>3 Firm publicly releases a pricing algorithm</td>
<td>Competitor downloads and executes the same pricing algorithm</td>
</tr>
<tr>
<td>4 Firm programs an anti-competitive price to be triggered whenever the competitor’s price is below a threshold</td>
<td>Recognising the algorithm, the competitor always keeps the price above the threshold</td>
</tr>
<tr>
<td>5 Firm uses ML algorithm to maximise joint profits (for instance, by accounting for the spillovers on competitors’ profits)</td>
<td>Competitor reacts with the same strategy</td>
</tr>
</tbody>
</table>

Can a “meeting of algorithms” amount to an anti-competitive agreement?
Challenges with tacit collusion

• Competition rules do not forbid collusive outcomes, but only the means to achieve collusion

• Establishing tacit collusion as an infringement of competition law requires:
  – Evidence of parallel conduct AND
  – “Plus factors” (communication, information exchanges, price announcements, signalling…)
Possible approaches using existing antitrust tools

Market studies & investigations
- Obtain empirical evidence of algorithmic collusion
- Identify problematic markets and sectors
- Define appropriate measures

Ex-ante merger control
- Reconsider the threshold of intervention
- Evaluate the impact of transactions on market transparency and high frequency trading
- Account for multi-market contacts in conglomerate mergers

Commitments & remedies
- Design remedies to prevent the use of algorithms as facilitating practices
- Apply “notice-and-take-down” processes
- Introduce auditing mechanisms for algorithms?
Competition cases

• The case of online sale of posters on Amazon marketplace (DOJ & CMA)
  – The conspirators designed dynamic pricing algorithms, which were programmed to act in conformity with their agreement
  – First case of algorithmic collusion detected by a competition authority and resulting in criminal prosecution

Today’s announcement represents the Division’s first criminal prosecution against a conspiracy specifically targeting e-commerce (…) We will not tolerate anticompetitive conduct, whether it occurs in a smoke-filled room or over the Internet using complex pricing algorithms.

Assistant Attorney General Bill Baer (DoJ)
Competition cases

• Investigation of the airline tariff case by the DoJ
  – Airline companies used a computer platform to signal price changes and exchange detailed information.
  – The case was closed with a settlement agreement.

• Information gathering by the Federal Antimonopoly Service of Russia
  – Information collected from users and developers of price-optimisation software suggests that resellers are using different price-setting products, some of which pose a threat of facilitating coordination.
  – The FAS Russia is now doing dawn raids based on the information gathered and complains received.
Competition cases

• Two investigations by the *Italian Competition Authority*
  – Online comparison websites and sellers of the advertised products entered into partnership agreements that could raise conflicts of interest.
  – The AGCM accepted binding commitments by the parties to make the comparison website more clear and transparent.

• Investigation by the *Ukrainian Competition Authority*
  – The distribution networks under investigation were setting prices using private information about competing networks.
  – The exchange of information was supported by a market research agency and it was conducted mostly through online means.
Regulation of Algorithms
Risks of algorithmic selection

- Information bias
  - “Echo chambers”
  - Product recommendations

- Censorship
  - Content-control software

- Manipulation
  - Feedback scores
  - Rankings of search engines’ results

- Privacy rights
  - Target ads

- Property rights
  - Collection of data protected by IP rights

- Discrimination
  - Price discrimination
Market failures

• Can the risks of algorithmic selection be addressed through market competition?

<table>
<thead>
<tr>
<th>Imperfect Information</th>
<th>Barriers to entry</th>
<th>Spill-overs</th>
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</thead>
<tbody>
<tr>
<td>Lack of algorithmic transparency</td>
<td>Scale economies of IT infrastructures</td>
<td>Nature of knowledge as a public good</td>
</tr>
<tr>
<td>Algorithms as trade secrets</td>
<td>Scope economies of datasets</td>
<td>Spill-overs of a variety of information</td>
</tr>
<tr>
<td>Complexity of program codes</td>
<td>Network economies in online platforms</td>
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First measures to improve algorithmic transparency and accountability

- New FTC Office of Technology Research and Investigation responsible for studying algorithmic transparency
- EU Commissioner Vestager’s statement advocating for compliance by design with data protection and antitrust laws
- German Chancellor Merkel’s public statement:

  The algorithms must be made public, so that one can inform oneself as an interested citizen on questions like: what influences my behaviour on the internet and that of others? (...) These algorithms, when they are not transparent, can lead to a distortion of our perception, they narrow our breadth of information.
Difficulties in enforcing algorithmic transparency and accountability

- Public disclosure of algorithms may reduce incentives for investment and innovation
- Disclosing a complex program code may not suffice as a transparency measure
- Transparency and accountability are challenging when decisions are taken autonomously by the algorithm
- Enforcement cost of reviewing and supervising algorithms

Risk that algorithmic transparency facilitates further algorithmic collusion
Regulations to prevent algorithmic collusion

- Extreme forms of algorithmic collusion enabled by deep learning may be hard to prevent through competition law.
- As a result, some regulatory interventions to prevent algorithmic collusion might be considered in the future.

*Risk of competitive impact*
What type of regulation should we think of if at all? We call it smart regulation. Just as you can use algorithms on the side of the companies, you could use algorithms on the side of the competition agencies. Smart regulation would be just about defining certain boundaries but not having strict rules that could actually undermine the action on the market.

Ariel Ezrachi

However, there is an interesting way around it: you don’t necessarily have to audit algorithms. You can audit data. (...) if a company comes and provides the data that was used as input, provides the algorithm, and the output let’s say the prices that were determined is public knowledge, then it’s very easy to determine whether the algorithm was used based on the open data that was available.

Avigdor Gal
Algorithms and Collusion

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Thank you!