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Some economic considerations about algorithms and tacit collusion

ICN – CWG SG1 webinar on “Digital cartels and algorithms”

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Stability of collusion

- Digitalization of economy and increased use of algorithms by firms may increase the stability of collusion depending on the markets' characteristics such as:
  - Degree of transparence of the markets (note however that this can also decrease consumers' search cost so that the overall effect on collusion's stability may be ambiguous)
  - Frequency of price adjustments
  - Number of firms, barriers to entry
  - Product differentiation, firms' asymmetries
  - Intensity of innovation

See Ivaldi, Jullien, Rey, Seabright, Tirole (2003) ; Green, Marshall, Marx (2015) ; OECD (2017); Kühn, Tadelis (2017)

- Will there be more markets where collusion is likely to happen? Likely to have consequences in merger cases

Emergence of collusion

- As with human collusion, the ability to communicate may considerably increase the likelihood of collusion emergence (see Crandall et al. (2018) ; Schwalbe (2018))
- However it does not mean that communication is essential for collusion to emerge (see the recent critics from Ezrachi and Stucke (2018))
- Various mechanisms can bring out collusion, from explicit collusion to purely tacit collusion, some of which are not tackled by antitrust law:
  - Explicit communication on the collusion's terms, including price or volume levels, compensation mechanisms, punishment of deviation ;
  - Signaling – could be easier with pricing algorithms?
  - Exchange of information (reduce uncertainty on possible strategies) ;
  - Focal points – possibly subject to human biases – could be more difficult with pricing algorithms?
  - Good analysis of competitors behavior – could be easier with pricing algorithms (3rd case of Ezrachi and Stucke framework – "tacit collusion on steroids")?
  - Convergence "by accident" to a collusive equilibrium – could be easier with pricing algorithms (4th case of Ezrachi and Stucke framework – "the digital eye")?
- Focus on the last two cases – insights from economic and IA research

Tacit collusion “on steroids”? “Interpretable” pricing algorithms

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- Algorithms that rely on a two steps approach “estimation-optimization” (see Calvano et al. (2018) ; Harrington and Harker (2017)), sometimes called “adaptive” algorithms.
- In a specific setting that encompasses many of the traditional pricing games in economy, Milgrom and Roberts (1990) showed that adaptive algorithms (in a narrower mathematical definition) generally converge to outcomes that do not exhibit collusion
- However this result is not directly valid in a machine learning algorithms setting, i.e. algorithms that adapt their behavior to their past performance
- The advantage of such algorithms for antitrust enforcers is that they can make explicit the pricing strategy of the firms -> is it enough to show that the firm (is able to) understands the collusive outcome of its algorithms ?
- Need to be able to understand the underlying code of the algorithm
- No clear picture yet of specific features in such algorithms that should be prohibited
- Even with algorithms, the degree of noise could significantly alter the collusive performance (see Miller (1996)).

Digital eye? – "Non-interpretable" algorithms

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- So-called "black-box" algorithms – examples often quoted are reinforcement algorithms or deep learning algorithms (see Calvano et al. (2018) ; Harrington and Harker (2017), Ezrachi and Stucke (2018))
- Researchers have exhibited cases of algorithmic collusion in simplified settings (mostly 2-players and 2-actions). Note however that (see also Deng (2018)):
  - Certain collusive states can be less favorable than competitive states for one of the firms (see Tesauro and Kephart (2002);
  - Collusion by these algorithms could be attained after numerous steps (100 000 or millions). Is this fast enough for firms to adopt these algorithms? (see Kimbrough and Lu (2003) ; Leibo et al. (2017) ; Calvano et al. (2018));
  - The cooperation between algorithms is not systematic, even if the number of iterations is particularly important and cooperation is mutually beneficial (see for instance Leibo et al. (2017);
  - The performance of learning algorithms will depend crucially on the environment in which they have learned so it may be less efficient if the competitors change its algorithm or if new competitors enter the market (see Waltman and Kaymak (2007), Leibo et al. (2017), Herandez-Leal et al. (2017) and Crandall et al. (2018))
- No evidence that these types of algorithms are currently used by firms: difficulty for them to let go of their price strategies and potential underperformance of these algorithms