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Automatic Harm to Competition?

Pricing Algorithms and Coordination

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From pricing algorithms to…

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- Imagine a parallel universe where technological progress runs in reverse.

- Companies go from selling vast ranges of products online across geographic markets that are continental in scope to…

…the village square

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… selling single products in shops located in close proximity to one another.

Tacit collusion concerns

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The antitrust practitioners in this parallel universe are worried.

- Shouldn't we presume that tacit collusion will inevitably emerge in this setting?

- Do competition authorities have the tools to deal with the emerging risks of tacit coordination?

These are precisely the questions that arise with algorithmic pricing.

Theoretical background (1)

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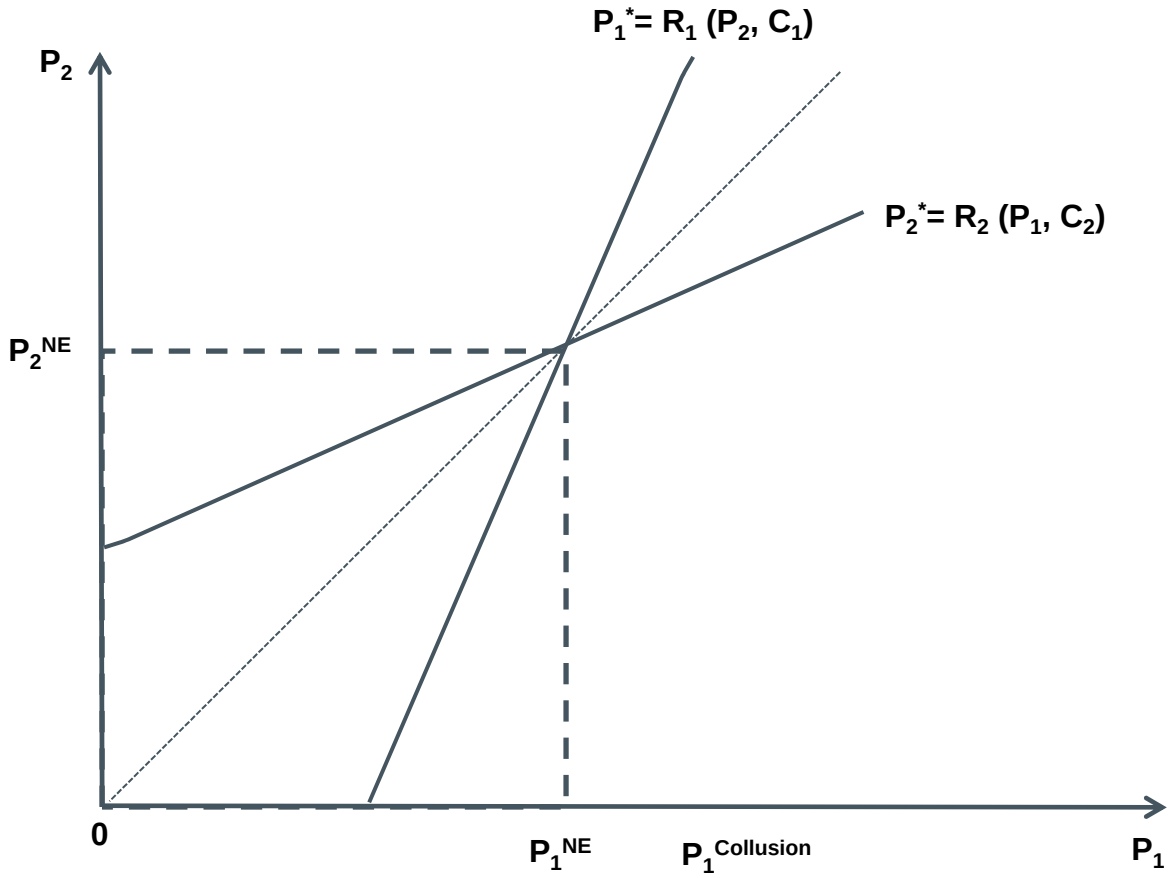
- Firms acknowledging their strategic interdependence when setting price does not imply tacit coordination



Theoretical background (2)

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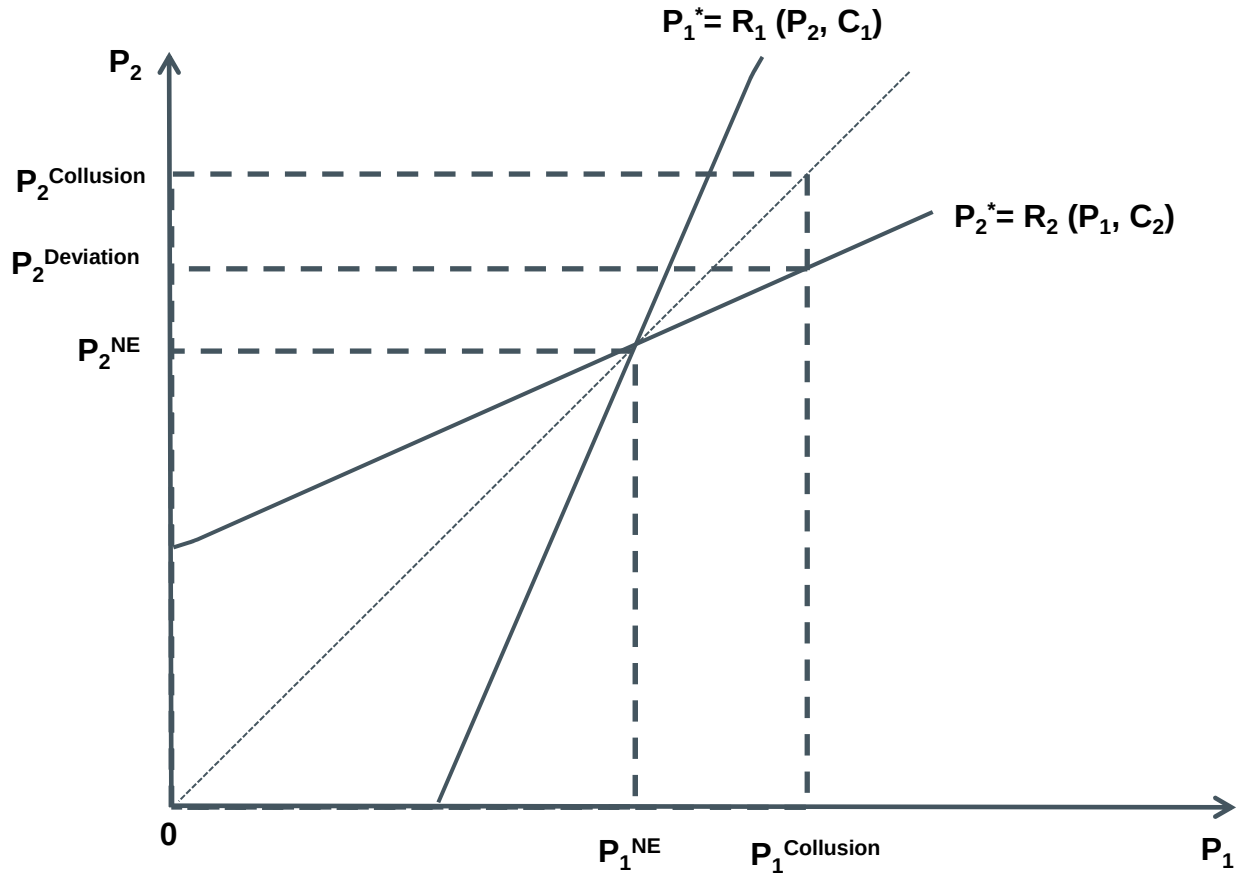
- A defining feature of tacit coordination is that individual firms can increase profits in the short run by taking some other action



Theoretical background (3)

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- Collusion can be an equilibrium in a repeated game if PV of profits from deviating (and being punished) are lower than PV of profits from sticking to collusion
  - Simplest case – revert to one-shot Nash Equilibrium forever if observe deviation
- Deviation gives a higher payoff today and a lower payoff in all subsequent periods.
- Whether a firm prefers to deviate depends on its patience (measured by a discount factor).
- The critical discount factor is the discount factor that leaves a firm indifferent between colluding and deviating
- Economic theory's contribution to assessment of whether collusion is more or less "likely" to arise is insight into factors that affect critical discount factor - and therefore the existence of collusive equilibria.

Theoretical background (4)

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- Factors that reduce the benefit from deviation, lower the critical discount factor

- Basic theoretical motivation for concerns with algorithmic pricing:

  – Algorithmic pricing ➔ exploitation of transparency and faster price reactions ➔ lower critical discount factor ➔ bigger set of collusive equilibria

  – 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.

Can sustain does not mean *will* sustain…

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- Theory of repeated games is silent on how firms reach a collusive agreement (just about sustaining)

- Tacit coordination involves a problem of choosing amongst multiple equilibria
  - The NE of the one shot game repeated every period is always a (subgame perfect) NE of the super game in addition to any collusive equilibria

- This multiple equilibrium problem cannot be glossed over!

Can sustain does not mean *will* sustain…

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- Some commentators link strategic interdependence with the inevitable emergence of tacit coordination.

- Ezrachi and Stucke present an example of gas stations that can monitor and react to each other's prices and suggest that:
  - "*interdependence between gas station operators therefore supports a gradual increase in price and leads to a new equilibrium above competitive levels*". Virtual Competition, Ezrachi and Stucke (2016)

- This is quite a leap from a theoretical perspective!

What types of algorithms may cause concerns?

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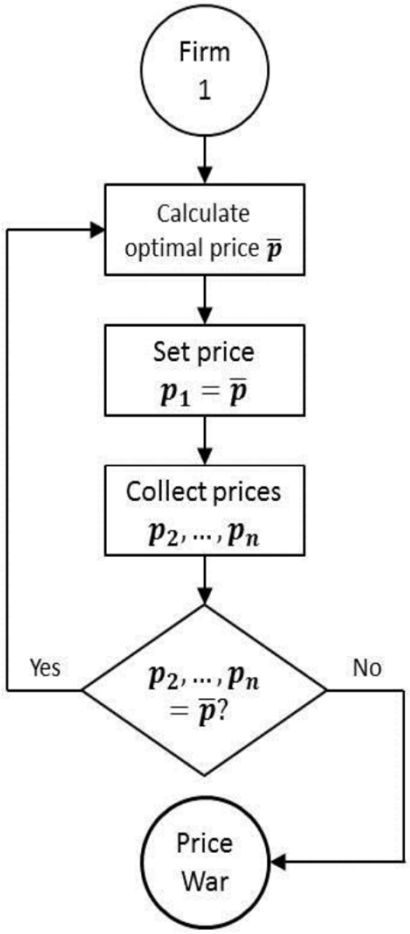
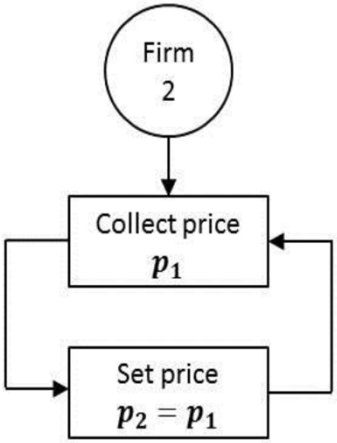
Very simple algorithms?

- E.g. OECD paper presents pair of simple Leader-Follower algorithms
  - Leader:
    - chooses optimal price
    - checks if follower chooses same price
    - If so, chooses new optimal price
    - If not, starts price war (forever?)
  - Follower:
    - chooses same price as leader.





$\bar{p}$ = collusive price
p_i = price set by firm i

Source: OECD

What types of algorithms may cause concerns?

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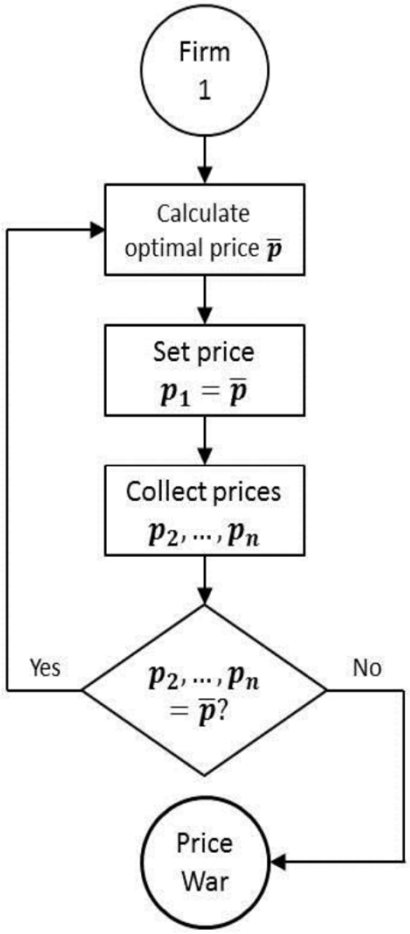
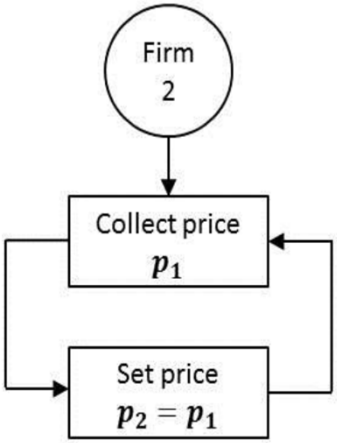
- But what if Follower:
  - "Tests" Leader by undercutting?
  - Makes a mistake?
- How does Leader react?
  - Committed to price war forever?
  - Forgive and forget?
- Need communication?
  - "*The whole point of the doomsday machine is lost if you keep it a secret!*" – Dr Strangelove





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Source: OECD

Simple strategies with BIG threats may prove costly (particularly when errors are possible)

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What types of algorithms may cause concerns?

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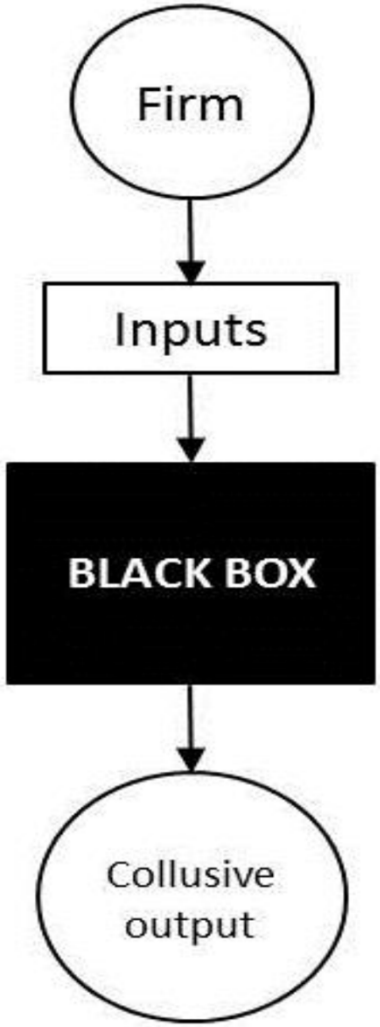
Very complex algorithms?

- Risk that some algorithms with powerful predictive capacity, by constantly learning and readapting to the actions of other market players …will be able to collude without the need for any human intervention (OECD).

- Likely that algorithms learning faster than humans are able through high-speed trial and error to eventually reach a cooperative equilibrium (OECD).



Source: OECD

What types of algorithms may cause concerns?

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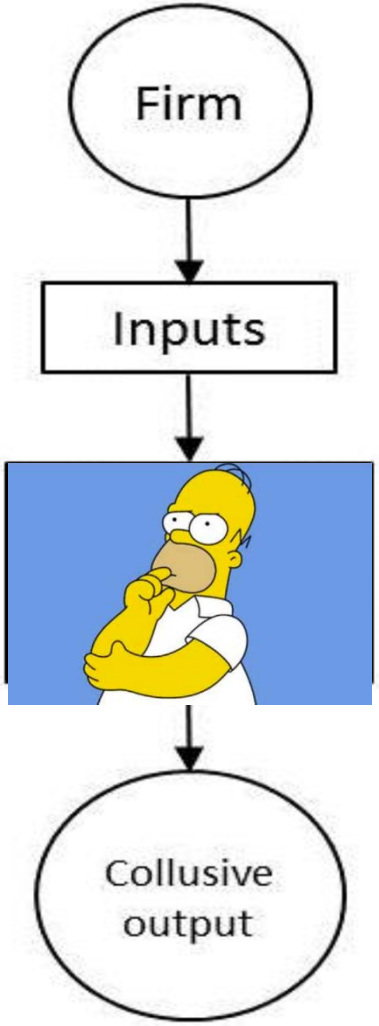

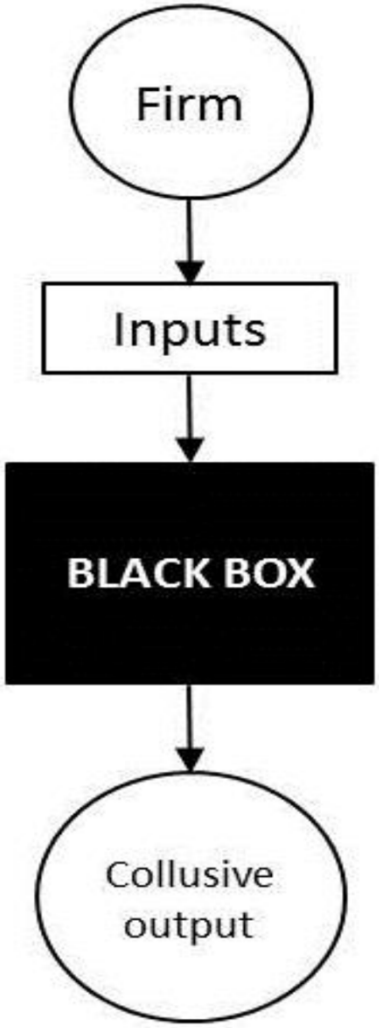

Source: OECD

Ability of algorithms to collude studied in the 80s

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Axelrod (1980) ran an experiment that pitted many algorithms against one another playing a prisoner dilemma, e.g.

- **TIT FOR TAT**: Cooperate on first move, thereafter reciprocate opponent's previous action
- **JOSS**: Like TIT FOR TAT, but 10% of the time it defects if other player cooperated
- **FRIEDMAN**: Cooperative until the other player defects; then it never cooperates again

Some lessons:

- Algorithms that do not exhibit "forgiveness" (like FRIEDMAN) perform poorly.
- Even fairly forgiving algorithms can enter a death spiral due to "echo effects", e.g. TIT FOR TAT vs. JOSS (see next slide)
- TIT FOR TAT won the tournament – but tournament would have been won by TIT FOR TWO TATS (defects only if other defected on last two moves) if it had been entered.
  - "*This should serve as a warning against the facile belief than an eye for an eye is necessarily the best strategy*" - Axelrod
- But TIT FOR TWO TATS performed poorly in a second tournament – where other algorithms were more aggressive!

Even forgiving algorithms can enter a death spiral!

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TABLE 3

Illustrative Game Between TIT FOR TAT and JOSS

moves	1- 20	11111	23232	32323	23232
moves	21- 40	32324	44444	44444	44444
moves	41- 60	44444	44444	44444	44444
moves	61- 80	44444	44444	44444	44444
moves	81-100	44444	44444	44444	44444
moves	101-120	44444	44444	44444	44444
moves	121-140	44444	44444	44444	44444
moves	141-160	44444	44444	44444	44444
moves	161-180	44444	44444	44444	44444
moves	181-200	44444	44444	44444	44444

Score in this game: TIT FOR TAT 236, JOSS 241

Legend: 1 both cooperated
2 TIT FOR TAT only cooperated
3 JOSS only cooperated
4 neither cooperated

Algorithms that *inevitably* collude?

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Salcedo (2015) – interesting paper that considers algorithms that *inevitably* collude

Assumptions about how the algorithms work:

1. **Commitment is feasible**: algorithms cannot be revised in the short-run; but also
2. **Commitment is imperfect**: algorithms can be revised over time
3. **Responsiveness**: algorithms rapidly react to market outcomes
4. **Observability**: rival's algorithm can be fully observed or (decoded)

These are strong assumptions – so does this paper tell us we should be concerned?

Algorithmic countervailing factors

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- Algorithms that facilitate personalised pricing may destabilise collusion
  - Massive increase in complexity of tacit agreements required!
  - Theoretical support for idea “allowing” price discrimination hampers sustainability of collusion - Helfrich and Herweg (2016)

- Algorithms that administer a platform may destabilise collusion
  - e.g. Amazon Buy Box (see next slide)
  - ~80% of purchases on Amazon go through the Buy Box (Chen 2016).
  - Buy Box algorithm is not disclosed by Amazon (but understood to be based on a number of competitive variables, e.g. price, ratings, faster shipping options)
  - Amazon wants a competitive platform
  - Amazon may actively seek to undermine collusion by creating “all or nothing” competition for the Buy Box (e.g. via reducing rotation of Buy Box across sellers).

Algorithms that administer a platform may destabilise collusion

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Policy questions

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When algorithms are used to implement an explicit agreement

- Traditional antitrust rules apply
- "*Companies can't escape responsibility by hiding behind a computer program*" - Vestager

When we have no evidence of explicit collusion

- Limited theoretical and empirical support for extending enforcement tools at this stage
- Stick to the "guy named Bob" test (Ohlhausen speech)
  - "*Is it ok for a guy named Bob to collect confidential price strategy information from all the participants in a market, and then tell everybody how they should price? If it isn't ok for a guy named Bob to do it, then it probably isn't ok for an algorithm to do it either*."
  - Is it ok for guys named Bob to "*adapt themselves intelligently to the existing and anticipated conduct of their competitors*"? (Case 40/73 Suiker Unie EU:C:1975:174, para. 174) - **YES!**

Articles

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