Simple heuristics

- How do simple heuristics fit in between learning theories and equilibrium concepts?
  - Differ from EQ concepts in that they can be used to describe sequences of behavior
  - Unlike learning theories, computational capabilities needed to perform them much lower
  - Often also less information needed
- Ad hoc behavioral assumptions
- Biggest problem: Lack of theory that explains which heuristic is used in which situation

Directional Learning

- By Selten and Buchta (1998)
- Main idea: You move in the “direction” where the better results were
- Assumes/implies that strategies are ordered such that there is a meaningful direction
- Exact nature of movement is not specified by Selten/Buchta
- Specification by Huck, Normann, Oechssler (2000): “Trial & Error Learning”

Directional Learning: HNO specification

- Look at the theory in the context of a Cournot oligopoly
- Each firm i chooses output q_i from a "grid" with gridsize δ
- E.g. has to set $q_i = 0, 1, 2, ... \Rightarrow \delta = 1$
- δ can be arbitrarily small
- Profit of firm i in round t is π_i^t

Directional Learning: HNO specification

- Firms set their quantity in round t:

$$q_i^t = q_i^{t-1} + \delta s_i^{t-1}$$

- Where s is a function keeping track of whether the last move improved the own profit or not:

$$s_i^t = sign(q_i^t - q_i^{t-1}) \times sign(\pi_i^t - \pi_i^{t-1})$$

- $+$ extra rules to take care of boundaries of the strategy set
- For technical reasons, add a small error term ϵ. With probability ϵ, $s_i^t = +1$, 0, or -1 with positive probability

Directional Learning: HNO specification

- In the Cournot setting, this process converges to the collusive outcome
- Idea of proof: Look at the area between collusive outcome and Nash outcome. How will duopoly firms react to moves in the last period?

Directional Learning: HNO specification

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- Idea of proof: Look at the area between collusive outcome and Nash outcome. How will duopoly firms react to moves in the last period?
  1. Both moved up $\Rightarrow$ both profits lower $\Rightarrow$ both turn around and move down
  2. Both moved down $\Rightarrow$ both profits high $\Rightarrow$ both both keep moving down
  3. Firm 1 moved up, firm 2 down $\Rightarrow$ π_1 higher, π_2 lower $\Rightarrow$ firm 1 keeps moving up, firm 2 turns and now moved up as well
- However: Case 3 almost never happens: The outcome of each case is both Firms moving in the same direction! Only error by a firm can lead to movement in different directions

Directional Learning: HNO specification

- As a heuristic, Trial & Error Learning is extremely easy to apply
- Informational requirements are also very low:
  - Only need direction of last movement and last change in profits
  - No need to know about other players strategy or profit
  - No need to even know the own profit function at unrealized quantities
  - In fact, players do not even need to know they are playing a game
- Convergance to a non-Nash-EQ is different from the behavior of previous learning theories in Cournot setting

Directional Learning: HNO specification

- Disadvantages:
- Depending on δ, movement is very slow
- Ignores a lot of information (if given) which could be useful
- Requires the game structure to have a meaningful direction