How random tweaks in timing can lead to new game theory strategies

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Most game theory models don't reflect the relentlessly random timing of the real world. In some models, players may receive information at the same time, and they act simultaneously. Others may include randomness in terms of sharing information or acting, but that randomness occurs at discrete steps.

But that's not the way the world works, notes economist Justin Grana at the RAND Corporation in Washington, D.C., a former postdoctoral scholar at the Santa Fe Institute (SFI). Competing companies make decisions based on when they receive information, as well as what that information is. Timing can make or break a decision, and randomness evolves continuously, not step-wise.

"We don't know when things will happen," says Grana. "The environment changes according to some kind of random processes, and we have to act at random times. You might get information, and that information causes you to act—or it might cause delays in what you do."

In a new paper in the *Berkeley Electronic Journal of Theoretical Economics*, Grana and his collaborators investigate game theory models that address what happens when players receive information or act at random times, determined as part of a continuous time evolution.

"We wanted to introduce the uncertainty of timing in these scenarios," says Grana. He developed the models with physicist David Wolpert of SFI and economist James Bono.

In the new work, the researchers looked at models of Bertrand competition—scenarios that predict how consumers will respond when sellers set the price of a good. They wanted to know under what circumstances random time fluctuations could lead to collusion, a specific kind of cooperation in which two parties may share information if both benefit.

Imagine two gas stations, for example, facing each other off the same remote exit of the same lonely interstate. The owners buy gas at the same price. Knowing that customers will choose the cheaper option, one owner may lower the price, prompting her competitor to lower his price, and so on until neither station can make excessive profits. In the interest of keeping the businesses alive, the two may instead decide to keep prices high and share the customers equally.

The model could help identify, for example, at what rate the station owners would need to have new information about demand in order to sustain this collusive structure, says Grana. It could predict how fluctuation in that timing could influence the strategic decisions of the players involved.

The model is part of an emerging research interest in a variety of fields—ranging from economics to engineering to air traffic controls—that focuses on how asynchronous events can influence game theory strategies. Although it's too early to see if real-world data lines up with the predictions of such an abstract model, Grana says this exploratory work suggests that small tweaks in timing can make a big difference in decision-making.

"Those changes are rich enough to show that it's worthwhile to explore loosening our assumptions about timing," he says.

More information: Justin Grana et al, Reasoning About 'When'

Instead of 'What': Collusive Equilibria with Stochastic Timing in Repeated Oligopoly, *The B.E. Journal of Theoretical Economics* (2019).
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