Game theory and economics show how to steer evolution in a better direction

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Game chess strategy. Credit: jeshoots, Unsplash, CC BY 4.0 (creativecommons.org/licenses/by/4.0/)

Human behavior drives the evolution of biological organisms in ways that can profoundly adversely impact human welfare. Understanding

people's incentives when they do so is essential to identify policies and other strategies to improve evolutionary outcomes. In a new study publishing November 16th in the open access journal, *PLOS Biology*, researchers led by Troy Day at Queens University and David McAdams at Duke University bring the tools of economics and game theory to evolution management.

From antibiotic-resistant bacteria that endanger our health to control-resistant crop pests that threaten to undermine global food production, we are now facing the harmful consequences of our failure to efficiently manage the evolution of the biological world. As Day explains, "By modelling the joint economic and evolutionary consequences of people's actions we can determine how best to incentivize behavior that is evolutionarily desirable."

The centerpiece of the new analysis is a simple mathematical formula that determines when physicians, farmers, and other "evolution managers" will have sufficient incentive to steward the biological resources that are under their control, trading off the short-term costs of stewardship against the long-term benefits of delaying adverse evolution.

For instance, when a patient arrives in an urgent-care facility, screening them to determine if they are colonized by a dangerous superbug is costly, but protects future patients by allowing superbug carriers to be isolated from others. Whether the facility itself gains from screening patients depends on how it weighs these costs and benefits.

The researchers take the mathematical model further by implementing game theory, which analyzes how individuals' decisions are interconnected and can impact each other—such as physicians in the same facility whose patients can infect each other or corn farmers with neighboring fields. Their game-theoretic analysis identifies conditions under which outcomes can be improved through policies that change

incentives or facilitate coordination.

"In the example of antibiotic-resistant bacteria, hospitals could go above and beyond to control the spread of superbugs through methods like community contact tracing," McAdams says. "This would entail additional costs and, alone, a hospital would likely not have an incentive to do so. But if every hospital took this additional step, they might all collectively benefit from slowing the spread of these bacteria. Game theory gives you a systematic way to think through those possibilities and maximize overall welfare."

"Evolutionary change in response to human interventions, such as the evolution of resistance in response to drug treatment or evolutionary change in response to harvesting, can have significant economic repercussions," Day adds. "We determine the conditions under which it is economically beneficial to employ costly strategies that limit evolution and thereby preserve the value of biological resources for longer."

More information: The economics of managing evolution, *PLOS Biology* (2021). journals.plos.org/plosbiology/ … journal.pbio.3001409

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