Task 1: Computational Exploration with NashPy / GTE

Game Introduction

The Prisoner's Dilemma is a classic two-player game in which each player, Prisoner A and Prisoner B, chooses between two actions: Cooperate (C) or Defect (D). If both cooperate, they each receive a moderate penalty (–1, –1). If one defects while the other cooperates, the defector gains the best outcome (0) while the cooperator suffers the worst (–3). If both defect, they receive an intermediate penalty (–2, –2). This payoff structure illustrates the conflict between collective welfare and individual rationality: although mutual cooperation yields a better joint outcome, self-interest drives both players toward defection (Osborne & Rubinstein, 1994, *A Course in Game Theory*, pp. 14–15).

Reference

Osborne, M. J., & Rubinstein, A. (1994). *A Course in Game Theory*. MIT Press. (Chapter 2, pp. 14–15).

	B: Cooperate (C)	B: Defect (D)
A: C	(–1, –1)	(–3, 0)
A: D	(0, –3)	(–2, –2)

Interpretation

The computed equilibrium is a **pure-strategy Nash equilibrium** in which both players defect (D, D). Although mutual cooperation (C, C) would lead to a better joint outcome, the incentives of each rational player lead them to defect, since defection strictly dominates cooperation. This result illustrates the essence of the Prisoner's Dilemma: rational self-interest can produce socially suboptimal outcomes, a phenomenon central to fields such as economics, political science, and evolutionary biology.

Colab Link

https://colab.research.google.com/drive/1t940dZIMNIwU1ooe1fdBEhBHa5qtxKk3?usp=sharing

Task 2: Existence & Complexity of Equilibria

1. Definition (Nash Equilibrium)

"A Nash equilibrium is a profile of strategies, one for each player, such that each player's strategy is a best response to the strategies of the others."
— Osborne, M. J., & Rubinstein, A. (1994). *A Course in Game Theory*, p.14

- This definition formalizes the idea of strategic stability.
- No player can gain by deviating unilaterally.
- It is the cornerstone concept of non-cooperative game theory.
- Provides the basis for predicting outcomes in strategic interactions.

2. Existence Theorem

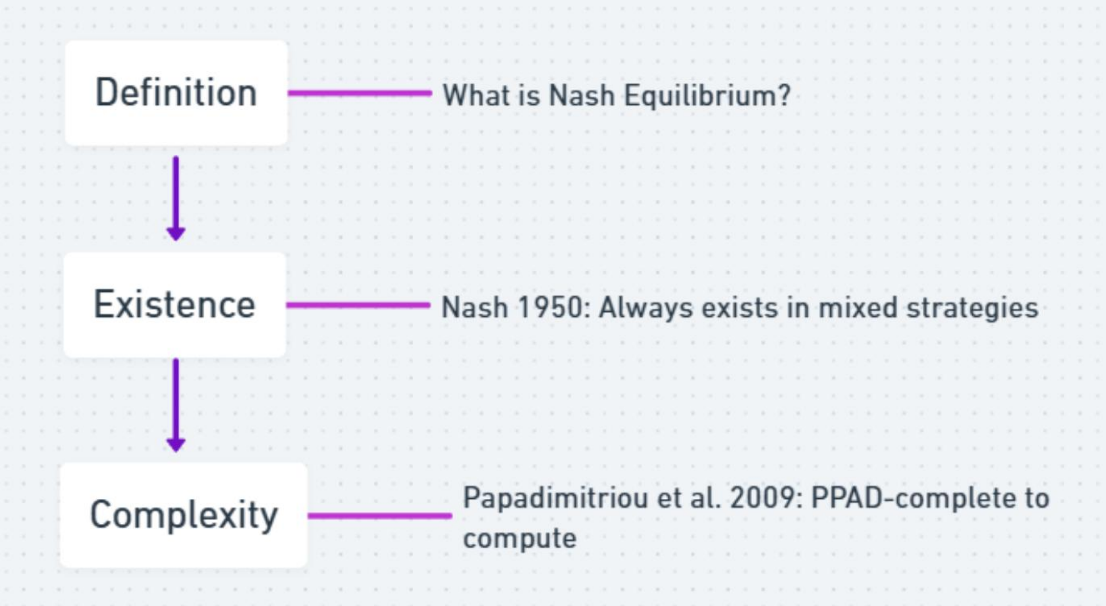
"Every finite game has at least one Nash equilibrium in mixed strategies."
— Nash, J. (1950). *Equilibrium points in n-person games*. *Proceedings of the National Academy of Sciences*, 36(1), 48–49.

- Guarantees that equilibrium always exists, even if not in pure strategies.
- Uses fixed-point theorems (Kakutani's) in proof.
- Ensures theoretical completeness of the concept.
- Allows economists to analyze all finite games with confidence.

3. Complexity Result

"The problem of computing a Nash equilibrium is PPAD-complete."
— Daskalakis, C., Goldberg, P., & Papadimitriou, C. (2009). *The complexity of computing a Nash equilibrium*. *SIAM Journal on Computing*, 39(1), 195–259.

- Shows that finding equilibria is computationally intractable in general.
- PPAD-completeness means no known efficient (polynomial-time) algorithm exists.
- Highlights gap between theoretical existence and practical computation.
- Important for computational economics and algorithmic game theory.

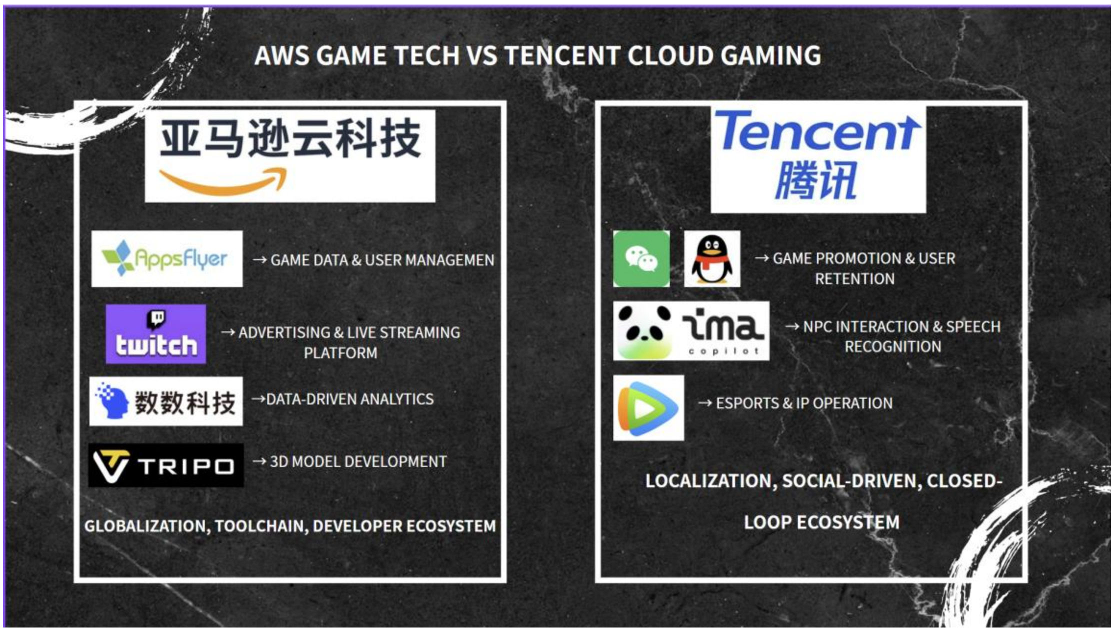


5. Reflection

The existence and complexity of Nash equilibria illustrate a central tension in computational economics. On one hand, Nash's theorem assures us that equilibria always exist, making the concept theoretically robust. On the other hand, the PPAD-completeness result shows that finding these equilibria may be computationally infeasible, especially in large or complex games. This gap implies that while equilibrium analysis provides a valuable framework for reasoning about strategic behavior, its practical application often requires approximation, heuristics, or restrictions to special classes of games. Thus, existence results establish the foundation, while complexity results remind us of the limits of computation in economics.

Task 3: Global Frontier Reflection

Part A: Comparative Reflection



The global gaming industry highlights the promise and peril of applying computational game theory to digital platforms. At Amazon Web Services (AWS) Game Tech, technologies such as Appsflyer, Twitch, Shushu Tech, and Tripo illustrate a data-driven, developer-centered approach that supports global scalability and innovation. In contrast, Tencent Cloud integrates social ecosystems, AI, and esports broadcasting, creating a highly localized and closed-loop model. While both strategies converge on cloud and AI, they diverge in governance and market orientation: AWS emphasizes global infrastructure, while Tencent leverages domestic platforms and social networks. From an ethical and sustainability perspective, these competitive dynamics raise concerns about market concentration and cross-border inequalities (SDG 10), as well as the need for fairness and transparency in digital governance (SDG 16). Computational game theory offers a lens to analyze cooperation and competition, but its application must balance efficiency with inclusivity.

Part B: Liberal Arts & Global Leadership

To “do better together,” global players like AWS and Tencent must recognize that responsible innovation extends beyond competition. Liberal arts education equips us with critical reflection, interdisciplinarity, and ethical awareness to evaluate how technologies reshape society and culture. At Duke Kunshan University (DKU), the joint Sino-American model provides a unique environment for students to navigate global tensions while fostering inclusive leadership. By combining computational economics with ethical reasoning and cross-cultural dialogue, DKU students can help design digital ecosystems that are not only efficient but also equitable. In this way, liberal arts training becomes a foundation for global leadership in computational economics, guiding us to align industry innovation with human-centered values.