"To Play or Not to Play?": A Review of the Sunk Cost Fallacy in Online Gaming Based on Game Theory and Decision Trees

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Abstract

To explore the pervasive "sunk cost fallacy" within online gaming, focusing on the Chinese gaming market. Methods: This review integrates behavioral economics with applied mathematics tools (game theory and decision trees) to systematically synthesize existing literature on the psychology of sunk costs, prospect theory, and mental accounting. It models irrational behaviors using decision trees with modified utility functions. The application of these theories to real-world incidents in China, such as the proliferation of "gacha" mechanics and the 2021 regulatory restrictions on minors, illustrates how bounded rationality leads to suboptimal equilibria and escalating commitment. Understanding the mathematical thresholds of irrationality is crucial for mitigating digital addiction. The findings provide profound implications for policymakers to design holistic interventions and for developers to foster healthier gaming ecosystems.

Key words

Sunk Cost Fallacy; Behavioral Economics; Game Theory; Online Gaming; Chinese Gaming Market

1. Introduction

The phenomenon of the "sunk cost fallacy" refers to the deeply ingrained human tendency to continue an endeavor once an investment in money, effort, or time has been made, regardless of future outcomes (Arkes & Blumer, 1985). In classical economic theory, rational decision-making dictates that individuals should base their choices solely on marginal costs and marginal benefits, completely ignoring past investments that cannot be recovered. However, empirical evidence consistently demonstrates that humans deviate from this rational baseline. In the realm of online gaming, this cognitive bias manifests profoundly when players persistently engage with a game, not because of the anticipated enjoyment, social interaction, or in-game rewards, but predominantly because of the substantial resources they have already expended. This behavior directly contradicts classical economic theories of rational choice, which posit that decisions should be forward-looking (Simon, 1955).

In recent years, the intersection of behavioral economics and applied mathematics has provided robust and nuanced frameworks for analyzing such irrational behaviors. By employing decision trees and game theory, researchers can mathematically model the deviation from rationality, quantifying the psychological weight of past investments. This review focuses specifically on the Chinese online gaming ecosystem, currently the largest and most lucrative in the world. The Chinese market provides a uniquely rich context for studying these phenomena due to the extreme prevalence of microtransactions-particularly "gacha" games,and the recent implementation of stringent government regulations aimed at curbing gaming addiction (Jiao et al., 2022).

The primary objective of this review is to synthesize the theoretical foundations of the sunk cost fallacy with mathematical modeling techniques, applying them to real-world incidents within China. By doing so, this paper aims to answer several critical questions: How can decision trees and game theory be adapted to model irrational player behavior? What role do specific monetization strategies, like gacha mechanics, play in exacerbating the sunk cost fallacy? And how effective are structural interventions, such as the Chinese government's 2021 gaming restrictions, in mitigating these deep-seated psychological biases? Through a detailed examination of these questions, this review bridges the gap between abstract economic theory and practical, real-world digital behavior.

2. Theoretical Foundations: Behavioral Economics and Sunk Costs

The theoretical underpinning of the sunk cost fallacy is deeply rooted in the foundational concepts of behavioral economics, particularly prospect theory and mental accounting. Developed by Kahneman and Tversky, prospect theory fundamentally challenged the expected utility theory by illustrating that individuals evaluate gains and losses asymmetrically. A core tenet of prospect theory is loss aversion, which posits that the psychological pain of losing is significantly more impactful than the pleasure derived from an equivalent gain (Kahneman & Tversky, 1979). When applied to the context of online gaming, the time, effort, and money a player has already spent are framed as definitive losses if the player decides to quit the game. To avoid the psychological discomfort of realizing these losses, players are compelled to continue playing, attempting to "recover" or justify their sunk costs, even when the game no longer provides positive utility.

Furthermore, Thaler's concept of mental accounting provides a crucial framework for understanding how players categorize, evaluate, and keep track of their investments (Thaler, 1985). According to this theory, individuals do not treat money as perfectly fungible; instead, they assign funds to specific "mental accounts" based on subjective criteria. In games featuring microtransactions, players often open a dedicated mental account for a specific game, a particular character, or a desired virtual item. Closing this account prematurely—by quitting the game or abandoning the pursuit of the item—forces the player to acknowledge a definitive loss within that specific account. Consequently, players engage in what organizational psychologist Barry Staw termed an "escalation of commitment." Staw's seminal research demonstrated that individuals who are personally responsible for a negative outcome are more likely to increase their investment in a failing course of action (Staw, 1976). In gaming, negative feedback, such as a poor game experience, repeated failures to obtain a rare item, or mounting financial strain, paradoxically leads to increased investment as the player desperately tries to turn the failing endeavor into a success.

Recent meta-analyses have further refined our understanding of the sunk cost effect, demonstrating that its magnitude is contingent upon various moderators, including the type of decision and the nature of the investment (Roth et al., 2015). In digital environments, where investments are often continuous and incremental (e.g., spending small amounts of money repeatedly or logging in daily for months), the sunk cost effect can become particularly insidious. The incremental nature of these investments makes it difficult for players to recognize the cumulative magnitude of their sunk costs until they are deeply entrenched in the game's ecosystem.

3. Mathematical Modeling of Irrational Decisions

To rigorously quantify the sunk cost fallacy and the resulting escalation of commitment, applied mathematics—particularly decision trees and game theory—offers essential structural clarity. In a perfectly rational decision tree model, a player at any given decision node evaluates the expected future payoff against the expected future costs. The past is mathematically irrelevant. However, behavioral game theory, which seeks to incorporate psychological realism into strategic models, introduces psychological variables into these equations (Camerer, 1997).

A modified decision tree designed to model an irrational player must incorporate a utility function that explicitly subtracts a perceived penalty for abandoning sunk costs. Mathematically, the perceived payoff (P) at a decision node can be expressed as $P = E - f(S)$, where E is the objectively expected future payoff, S represents the accumulated sunk cost, and $f(S)$ represents a monotonically increasing function denoting the psychological disutility of abandoning the sunk cost (Roth et al., 2015). In this model, as the sunk cost S increases, the penalty term $f(S)$ grows larger. Consequently, the threshold for quitting—the point at which the perceived payoff P becomes negative—becomes artificially and progressively higher. The player requires increasingly severe negative future expectations to overcome the psychological anchor of their past investments.

From a game-theoretic perspective, the player's ongoing engagement with the game can be conceptualized as a sequential, dynamic game played against their "past self" or against the game's probabilistic mechanics. The Nash equilibrium in classical, rational models assumes that all players maximize their expected utility based on forward-looking rationality. However, behavioral models demonstrate how bounded rationality—the idea that human decision-making is limited by cognitive constraints, information asymmetry, and time—leads to suboptimal equilibria (Thaler, 1999). In these suboptimal states, the player is essentially "trapped" in a cyclical pattern of continuous play. They choose the strategy of "continue investing" not because it yields the highest absolute payoff, but because it minimizes the immediate psychological regret associated with the strategy of "quit and accept loss." This mathematical formalization provides a powerful tool for predicting at what point a player is likely to transition from rational engagement to irrational addiction.

4. Real-World Incidents: The Chinese Gaming Context

The Chinese online gaming market, characterized by its massive user base and highly lucrative monetization strategies, serves as a prime real-world laboratory for observing these behavioral models in action. One of the most prominent manifestations of the sunk cost fallacy in this context is the widespread adoption of "gacha" mechanics. Originating from Japanese capsule toy vending machines, gacha systems require players to spend real or virtual currency for a randomized chance to receive a virtual item, character, or upgrade. This monetization strategy effectively exploits the sunk cost fallacy by intertwining it with the psychology of gambling.

Empirical studies focusing on Chinese young adults have shown that players who fail to obtain a desired item often continue spending, driven by the irrational belief that their previous unsuccessful attempts—their sunk costs—have somehow brought them mathematically "closer" to the reward (Tang et al., 2022). This occurs despite the fact that the probabilities in most gacha systems are independent events, meaning past failures do not influence future success rates. The mental accounting of these players becomes distorted; the money spent is viewed as an "investment" toward the specific rare item, and stopping would mean the investment was entirely wasted. This leads to severe escalation of commitment, resulting in well-documented incidents of extreme financial distress among gamers, some of whom have accumulated massive debts to fund their in-app purchases.

The profound societal impact of this widespread escalation of commitment prompted significant real-world incidents, most notably the Chinese government's unprecedented regulatory intervention in 2021. Recognizing the severe psychological addiction and financial burden placed on families, regulators implemented a draconian policy restricting online gaming time for individuals under 18 to merely three hours per week (specifically, one hour on Fridays, Saturdays, Sundays, and public holidays) (Li, 2023). From a mathematical modeling perspective, this policy can be viewed as an external structural break forced upon the player's decision tree. The regulation effectively eliminates the player's agency to continuously choose the "continue playing" branch, forcibly halting the rapid accumulation of sunk costs in terms of time, and indirectly, money.

However, empirical studies conducted post-regulation reveal complex and somewhat troubling behavioral shifts. While the aggregate gaming time on officially regulated platforms decreased, some heavy gamers exhibited alternative, compensatory behaviors. Research indicates a significant migration of these users to short-video platforms, which employ similarly addictive, algorithmically driven content delivery systems (Zhou et al., 2024). Furthermore, a notable percentage of minors circumvented the rules by renting adult accounts or using the identities of older family members. This behavioral adaptation indicates that while the structural intervention disrupted the immediate game-theoretic loop within specific games, the underlying psychological vulnerability to sunk costs and behavioral addiction remained unaddressed. The players simply transferred their mental accounts and escalation tendencies to new, unregulated digital environments.

5. Discussion and Implications

The synthesis of behavioral economics, mathematical modeling, and real-world regulatory outcomes provides profound insights into the mechanics of player behavior and digital addiction. For game developers and publishers, these models highlight the pressing ethical boundaries of modern monetization strategies. Designing games that rely heavily on exploiting sunk cost traps, such as aggressive and opaque gacha systems, may yield substantial short-term financial gains. However, this approach risks long-term player burnout, severe public relations crises, and ultimately invites stringent, sweeping regulatory backlash, as vividly demonstrated by the events in China. Developers must consider the long-term sustainability of their ecosystems, balancing profitability with player well-being by implementing transparent probabilities, spending caps, or guaranteed "pity" systems that cap the maximum possible sunk cost.

For policymakers and regulatory bodies, understanding the mathematical threshold at which players transition from rational consumers to irrational actors is crucial for designing effective interventions. The Chinese regulatory approach, while undeniably effective in reducing aggregate playtime among minors on specific platforms, highlights the limitations of purely structural constraints. Policies that merely impose temporal or financial limits treat the symptom rather than the disease. They fail to address the underlying psychological drivers of addiction, leading to the displacement of addictive behaviors to other platforms, such as short-video applications. Therefore, there is a critical need for holistic policies that combine structural limits with psychological interventions. Educational programs that teach digital literacy, probability, and the specific concept of the sunk cost fallacy could serve as cognitive "nudges," empowering players to recognize their own biases and make more rational decisions within digital environments.

6. Conclusion

The sunk cost fallacy in online gaming is not merely a theoretical curiosity; it is a complex, pervasive phenomenon resulting from the interplay of deeply ingrained psychological biases and highly optimized structural game design. By applying the rigorous frameworks of decision trees and behavioral game theory, this review has mathematically contextualized the irrational escalation of commitment frequently observed in modern players. Grounded in the stark realities of the Chinese gaming market, the proliferation of gacha mechanics, and the recent, unprecedented regulatory shifts, this analysis underscores the absolute necessity of combining classical economic theory with applied mathematics to fully understand and effectively mitigate digital addiction. As the digital landscape continues to evolve, future research must focus on developing dynamic, longitudinal models that track player spending and engagement over time. Furthermore, empirical studies testing the efficacy of cognitive interventions and transparent game design are essential for fostering a healthier, more sustainable digital future.

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