

Article

A Game-Theoretic Simulation Framework to Support Strategic Competition Education in Health Service Markets

Salim Yılmaz ^{1,2,*} and Ahmet Murat Günal ³¹ Department of Healthcare Management, Faculty of Health Sciences, Acıbadem Mehmet Ali Aydınlar University, 34638 Istanbul, Türkiye² Department of Healthcare Management, Graduate School of Health Sciences, Acıbadem Mehmet Ali Aydınlar University, 34638 Istanbul, Türkiye³ Department of Nutrition and Dietetics, Faculty of Health Sciences, Halic University, 34060 Istanbul, Türkiye; ahmetmuratgunal@halic.edu.tr

* Correspondence: salim.yilmaz@acibadem.edu.tr

Abstract

Strategic competition in health service markets requires managers to make pricing, marketing, and investment decisions under uncertainty, yet educational programs in healthcare management and dietetics lack experiential tools for teaching these competencies within a game-theoretic framework. This study develops and computationally validates SY142-Game-Theory-1, a computational simulation framework that models strategic competition between two asymmetric healthy living centers as a 36-month repeated Prisoner's Dilemma, integrating demand decomposition, net present value analysis, employee satisfaction dynamics with burnout thresholds, reputation feedback, and stochastic shock events. The simulation produces a valid and distinctly asymmetric Prisoner's Dilemma structure in which the established provider faces the classical temptation to defect while the new entrant's rational incentive aligns with cooperation; Axelrod-style tournaments across 22 strategies (96,800 simulations) identify Forgiving Tit-for-Tat as the top-performing strategy; Monte Carlo validation ($n = 1000$) confirms a statistically significant cooperation premium of 24.1% over Nash equilibrium; and sensitivity analyses across four parameters demonstrate robustness of all qualitative findings. The open-source framework bridges game theory, simulation-based learning, and health service management education, providing a computationally validated foundation for teaching strategic decision-making in competitive healthcare environments, with empirical evaluation of learning outcomes reserved for future work.

Keywords: game theory; Prisoner's Dilemma; health service management; simulation-based learning; Axelrod tournament; net present value; asymmetric duopoly; Monte Carlo simulation; strategic competition; healthcare education

MSC: 91A20; 91A80; 90B50

Academic Editors: Banafsheh Behzad and Matteo Cavaliere

Received: 10 May 2026

Revised: 18 June 2026

Accepted: 30 June 2026

Published: 3 July 2026

Copyright: © 2026 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the [Creative Commons Attribution \(CC BY\)](https://creativecommons.org/licenses/by/4.0/) license.

1. Introduction

Healthcare service markets worldwide have undergone substantial transformation in recent decades, driven by the expansion of private sector provision, increasing consumer health awareness, and intensifying competition among providers. In Türkiye, this trend has been particularly pronounced: the private sector's share of total hospital beds

rose from 7.53% to 21.00% between 2002 and 2022, while private outpatient visits increased from 4.58% to 15.07% and inpatient admissions grew from 10.10% to 30.63% [1]. Policy changes—including the 2005 regulation permitting private hospitals to contract with the Social Security Institution and the 2008 General Health Insurance system—facilitated this expansion, creating a competitive landscape in which providers must make strategic decisions regarding pricing, marketing, and service differentiation [1–4]. The growing prevalence of obesity and diet-related chronic conditions [5,6] has further fueled demand for preventive health services, wellness programs, and nutritional counseling, giving rise to a rapidly expanding market segment of healthy living centers and private dietetic practices. These developments have been further accelerated by the COVID-19 pandemic, which reshaped healthcare delivery models and consumer expectations around personal wellness [7]. Pricing in health service markets is therefore not a routine administrative task; a thematic review by Sirur and Pillai [8] shows that providers must weigh several interacting forces at once when setting prices, which calls for managerial judgment beyond clinical training.

Despite the growing need for strategic thinking and financial acumen among health service managers, educational programs in healthcare management and allied health disciplines have been slow to integrate these competencies into their curricula. In the field of dietetics, Cluskey et al. [9] found that coursework in management often leaves students unconvinced of why such skills matter or of how they carry over to the many settings in which dietitians work—a concern that remains relevant nearly two decades later. More recently, a scoping review of private practice dietetics identified workforce development as a critical gap, noting that the rapid growth of private practice has outpaced educational preparation [10]. A later assessment of dietetics programs accredited in Australia reached a similar conclusion, finding that students gain too little grounding in running a business, launching a practice, and managing its finances to be ready for independent work [11]. Educators in these programs have voiced the same concern, describing how hard it is to ready graduates for the commercial demands of private practice without eroding the clinical grounding the profession depends on [12]. The Accreditation Council for Education in Nutrition and Dietetics (ACEND) has responded by developing Future Education Model competency standards that explicitly incorporate management, leadership, and organizational skills [13]; however, translating these standards into effective pedagogical tools remains an open challenge. Conspicuously absent from current curricula are opportunities for students to experience the consequences of strategic decisions—such as pricing, marketing investment, and capacity management—in a dynamic competitive environment where outcomes depend on both their own choices and those of rival providers.

Game theory, first formalized by Von Neumann and Morgenstern [14] and further developed by Nash [15], provides a rigorous mathematical framework for analyzing precisely this type of strategic interdependence. In healthcare, game-theoretic models have been applied to study quality competition among regulated providers [16,17], interest balancing in healthcare reform through evolutionary game analysis [18], and resource allocation problems [19]. A systematic review by Rogowski and Lange [20] documented 68 separate healthcare and public-health settings in which the Prisoner's Dilemma appears, which confirms that the conflict between private incentive and collective welfare runs throughout health service markets. Roth [21] has argued that game theory serves not merely as an analytical tool but as an engineering instrument for designing institutions and markets—a perspective that aligns with the pedagogical use of game-theoretic models to teach strategic reasoning. Within the specific context of repeated games, Axelrod's [22] round-robin tournaments of the iterated Prisoner's Dilemma established that strategies which begin cooperatively and then meet defection with measured retaliation, Tit-for-Tat foremost among them, reliably outperform both unbroken cooperation and con-

stant defection. These findings, further developed in his later agent-based modeling research [23], carry direct implications for competitive strategy in service markets where providers interact repeatedly over time. However, the application of these game-theoretic insights specifically to health service management education has received remarkably little attention in the literature.

If game theory supplies the conceptual content of strategic competition, the question that follows is how students might actually experience it; simulation-based learning offers a promising pedagogical bridge between game-theoretic concepts and practical strategic decision-making. Rooted in Kolb's [24] experiential learning theory, simulations enable students to learn by doing—making decisions, observing consequences, and adjusting strategies in response to feedback. Empirical evidence supports the effectiveness of this approach: Thompson and Dass [25] reported, from a sample of 252 students, that simulation produced markedly larger gains in strategic-management self-efficacy than conventional case studies did. Laverie et al. [26] found that student involvement in marketing simulations positively influences learning outcomes, including the development of higher-order thinking skills at procedural and metacognitive levels. Business simulation games have also been shown to generate both cognitive and affective learning outcomes in sustainability education [27], while facilitator-led simulations provide flexible alternatives to commercially hosted platforms [28]. In healthcare-related education specifically, simulation competitions have been used to teach health policy decision-making [29], management strategy simulations have improved entrepreneurial competencies among nursing students [30]; and strategic management simulations have been transferred to medical competency assessment [31]. A recent systematic review of serious games for hospital management cataloged 36 such games and grouped them by the technical, people-oriented, and big-picture skills they target, while pointing out that few of them tackle strategic competition or financial management [32].

The present study addresses this gap by proposing a computational simulation framework—designated SY142-Game-Theory-1 (Version 1)—that models strategic competition between two asymmetric healthy living centers as a 36-month repeated Prisoner's Dilemma. The framework makes two principal contributions: (i) a complete mathematical model of asymmetric duopoly competition incorporating operational, financial, and human resource dynamics, with NPV as the primary performance metric; and (ii) rigorous validation through Axelrod-style round-robin tournaments and Monte Carlo simulation, confirming the emergence of classical Prisoner's Dilemma properties. The framework is designed to be adaptable to various health service contexts and educational settings.

2. Materials and Methods

This section presents the computational simulation framework designed to model strategic competition between two asymmetric healthy living centers operating in a metropolitan market environment calibrated according to current inflation levels and market prices in Türkiye. The framework integrates four interdependent sub-systems—market dynamics, financial computation, human resource management, and stochastic environmental factors—into a 36-month repeated-game structure. The model architecture was designed to balance mathematical rigor with pedagogical accessibility, enabling students and researchers to explore how pricing, marketing, and investment decisions interact under competitive pressure.

All simulations were performed in R version 4.5.2 (R Foundation for Statistical Computing, Vienna, Austria) using base R functions for the simulation engine and ggplot2 [33,34] for visualization. The simulation framework is designated SY142-Game-Theory-1 (Version 1); future versions incorporating additional features and empirical calibration refinements are planned. All analyses used a fixed random seed (2026) for reproducibility.

The complete R code, parameter tables, output data, and simulation workspace are publicly available in an open-source repository (see Data Availability Statement), enabling full reproduction of the reported results. The overall conceptual framework is presented in Figure 1.

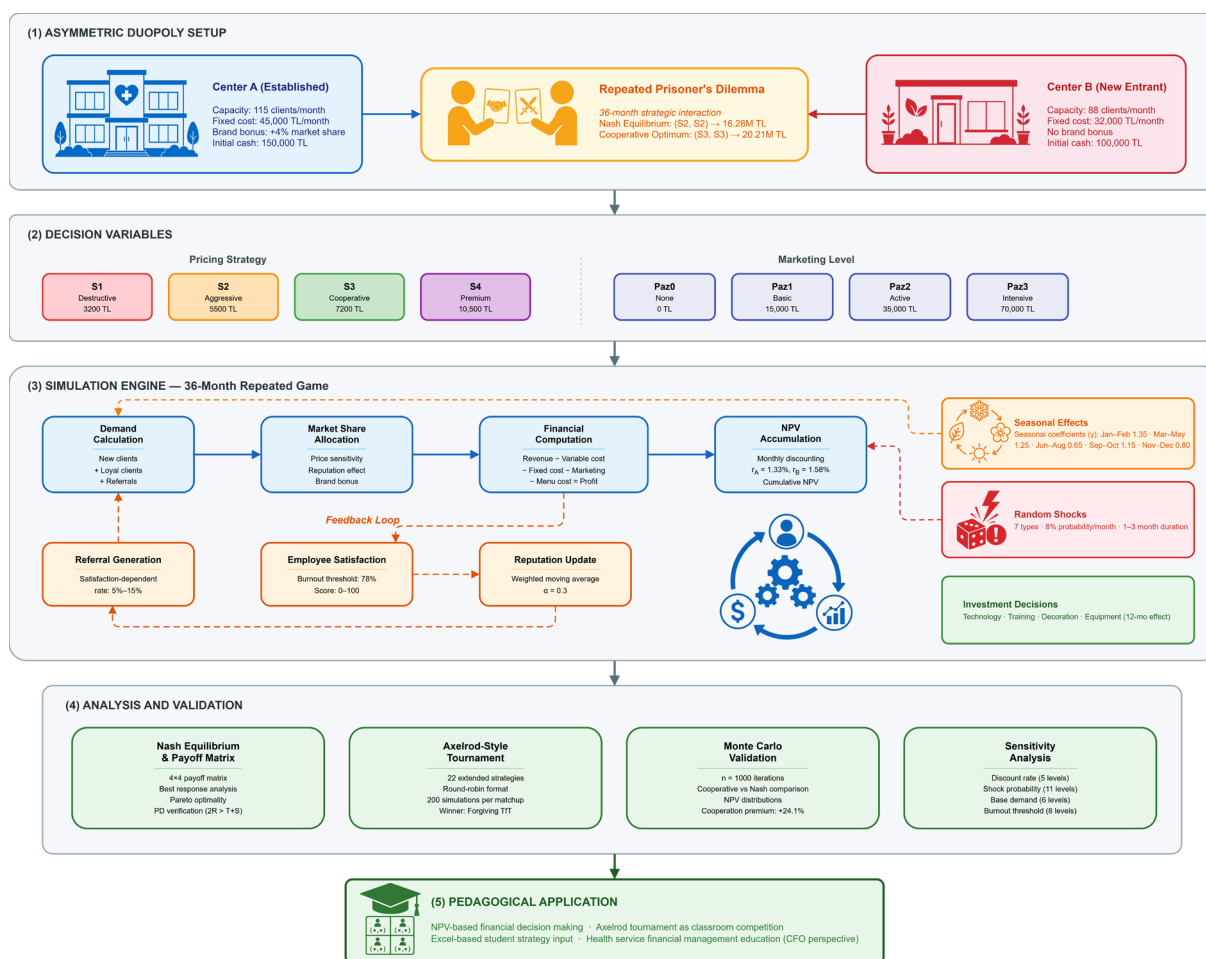


Figure 1. Conceptual framework of the game-theoretic simulation for teaching strategic competition in health service markets.

The framework comprises five layers: (1) asymmetric duopoly setup defining two competing healthy living centers with differentiated characteristics; (2) decision variables including four pricing strategies (S1–S4) and four marketing levels (Paz 0–Paz 3, where Paz denotes the marketing level); (3) simulation engine executing a 36-month repeated game with demand calculation, market share allocation, financial computation, and NPV accumulation, incorporating a feedback loop through employee satisfaction, reputation dynamics, and referral generation, with external inputs from seasonal effects, stochastic shocks, and investment decisions; (4) analysis and validation through Nash equilibrium identification, Axelrod-style tournaments, Monte Carlo simulation, and sensitivity analysis; and (5) pedagogical application for health service management education (Figure 1).

2.1. Simulation Scenario: Asymmetric Duopoly in Health Service Markets

The simulation scenario is situated within the rapidly growing healthy living center market in Türkiye, where private sector expansion, increasing health awareness, and evolving consumer expectations have generated competitive dynamics that health service managers must navigate [1,7]. The model simulates a 36-month ($t = 36$) competitive interaction between two healthy living centers operating within the same metropolitan

catchment area, corresponding to a typical strategic planning horizon for small- to medium-sized health service enterprises. The 36-month horizon is an adjustable parameter rather than a fixed structural assumption, selected to balance strategic richness against computational tractability and pedagogical clarity. While finitely repeated games are theoretically susceptible to end-of-game defection through backward induction, this unraveling is substantially attenuated here: the stochastic shock process and path-dependent reputation and satisfaction dynamics introduce ongoing uncertainty about future payoffs, weakening the sharp terminal-period incentives characteristic of deterministic finitely repeated games. The framework nonetheless includes an Endgame strategy variant in the extended tournament (Section 2.5) that deliberately defects in the final periods, enabling explicit study of end-of-game effects. The two centers are intentionally designed as asymmetric competitors, reflecting common market structures in which an established provider competes against a smaller market entrant [35]. Table 1 presents the characteristics of the competing centers.

Table 1. Center characteristics comparison.

Parameter	Center A (Established)	Center B (New Entrant)	Rationale
Monthly Capacity (K_i)	115 clients	88 clients	Staff and facility size differential
Fixed Monthly Cost (FC_i)	45,000 TL	32,000 TL	Location and overhead differential
Brand Bonus (B_i)	+4% market share	0%	Established brand recognition
Monthly Discount Rate (r_i)	1.33% (annual 16%)	1.58% (annual 19%)	Cost of capital differential
Initial Cash Reserve	150,000 TL	100,000 TL	Operating buffer capacity
Initial Satisfaction ($Sat_i(0)$)	70 points	75 points	Smaller team, closer relationships
Initial Reputation ($Rep_i(0)$)	72 points	65 points	Brand heritage vs. new entrant

TL = Turkish Lira. Capacity represents maximum monthly client relationships. Satisfaction and reputation scored on a 0–100 scale.

Values reflect typical operating parameters for healthy living centers in metropolitan Türkiye (Table 1). The asymmetry between centers is a deliberate design choice serving both realism and pedagogical objectives. In real health service markets, new entrants typically face structural disadvantages relative to established competitors, including lower capacity, limited brand recognition, higher cost of capital, and weaker reputation—conditions that Center B’s parameters reflect. Center B compensates with certain advantages inherent to smaller operations: lower fixed costs, higher initial employee satisfaction due to closer team dynamics, and greater strategic agility. This asymmetric configuration ensures that identical strategies produce different outcomes depending on which center adopts them, compelling students to consider how structural position shapes strategic effectiveness. In the pedagogical implementation, each student team manages both Center A and Center B across separate simulation rounds, enabling them to experience strategic decision-making from both the established provider’s and the new entrant’s perspective. This dual-role design develops the capacity to formulate context-dependent strategies rather than relying on a single prescriptive approach—a competency particularly relevant for health service managers who may transition between institutional and entrepreneurial settings throughout their careers.

Each center simultaneously selects a pricing strategy and marketing level at each period. Pricing strategies represent distinct competitive postures observed in the Turkish healthy living center market. Table 2 presents the pricing parameters.

Table 2. Pricing strategy parameters.

Strategy	Package Price (TL)	Variable Cost (TL)	Contribution Margin (TL)	Attractiveness (c_i)
S1 (Destructive)	3200	280	2920	1.60
S2 (Aggressive)	5500	500	5000	5.50
S3 (Cooperative)	7200	1200	6000	1.00
S4 (Premium)	10,500	1100	9400	0.25

TL = Turkish Lira per monthly package. Contribution margin = Package price – Variable cost. The attractiveness coefficient c_i reflects the price-demand elasticity: lower prices attract more clients but generate less revenue per client.

Attractiveness coefficients (c_i) determine base market share allocation via Equation (1) (Table 2). Marketing investment is selected from four levels as shown in Table 3.

Table 3. Marketing investment levels.

Level	Monthly Cost (TL)	Market Share Effect $ME(m)$
Paz 0 (None)	0	0.00
Paz 1 (Basic)	15,000	+0.02
Paz 2 (Active)	35,000	+0.05
Paz 3 (Intensive)	70,000	+0.08

TL = Turkish Lira per month. Paz: Marketing level (from Turkish pazarlama). Market share effects are additive and subject to competitive neutralization (40% offset; see Equation (2)).

The market share effect $ME(m)$ enters the net marketing calculation in Equation (2) (Table 3). Demand in the healthy living center market exhibits seasonal variation reflecting cultural and lifestyle patterns in Türkiye. Table 4 presents the seasonal demand coefficients.

Table 4. Seasonal demand coefficients.

Season	Months	Coefficient $\gamma(t)$	Rationale
New Year Resolution	January–February	1.35	Weight loss resolutions
Spring	March–May	1.25	Pre-summer preparation
Summer Vacation	June–August	0.65	Holiday season, reduced demand
Autumn	September–October	1.15	Back-to-work routines
Year-End	November–December	0.80	Holiday spending competition

Coefficients calibrated based on observed patterns in urban Turkish wellness and nutrition service demand. Values above 1.00 indicate above-average demand; values below 1.00 indicate below-average demand.

Coefficients multiply the base demand parameter $Q = 130$ in Equation (5) (Table 4). The simulation incorporates stochastic shock events representing external factors that periodically disrupt normal market operations. The shock-generation process is defined as follows: in each month t , the occurrence of a shock follows a Bernoulli process with probability $p = 0.08$ (corresponding to an expected frequency of approximately one shock per year). Conditional on a shock occurring, its type is drawn from a discrete uniform distribution over the seven defined shock types, each with equal probability $1/7$. Each shock's effect magnitude and duration are deterministic conditional on its type, as specified in Table 5. Shocks affecting different months operate independently, and a shock's multi-month effects (where applicable) persist for the specified duration regardless of subsequent shock realizations. Table 5 presents the shock parameters.

Table 5. Shock event parameters.

Shock Type	Duration (Months)	Primary Effect	Magnitude
Economic Crisis	3	Demand reduction	−25%
Competitor Scandal	1	Competitor market share loss	−15%
Viral Success	2	Own market share gain	+12%
Social Security Support	2	Demand increase	+20%
Star Transfer	3	Own market share gain	+8%
Employee Illness	1	Capacity reduction	−20%
Influencer Collaboration	2	S4 effectiveness bonus	+5%

Base shock probability = 8% per month. Effects apply to the center experiencing the shock unless otherwise specified. Shock types are mutually exclusive within a single month; multiple shocks from different months may overlap.

Each month, a shock occurs independently with probability $p = 0.08$ (approximately one event per year), affecting either demand, market share, or operational capacity (Table 5).

Additionally, centers may make optional investment decisions at any month, with each investment type available once and producing effects for 12 months. Four investment types are defined: Technology (60,000 TL; capacity +15%), Training (40,000 TL; satisfaction +10, referral rate +15%), Decoration (50,000 TL; S4 market share bonus +3%), and Equipment (80,000 TL; referral rate +10%, S4 bonus +2%).

The parameters in Tables 1–5 were established in two stages. The authors began from real market conditions in the Turkish healthy living center sector, anchoring package prices, variable and fixed costs, and capital costs to prevailing values in metropolitan Türkiye at the time of calibration. These starting values were then adjusted with the balance of the game in mind: parameters were revised through the systematic experimentation described in Section 4.1 until neither center held an insurmountable advantage and sound strategic reasoning was rewarded. A smaller number of parameters draw on established theory and the empirical literature rather than local market data, including the burnout threshold and satisfaction–capacity relationship [36] and the menu-cost mechanism for price stickiness [37]. The resulting values should therefore be understood as calibrated for the game rather than as direct measurements of the market. Because price levels, demand conditions, and regulatory arrangements change over time, the parameters do not claim to reproduce real-world figures at any given moment; they are bounded to the simulation, yet they are not disconnected from reality, since they originate from observed market conditions and remain within plausible ranges.

Adapting the framework to another national or regional context follows the same logic and cannot rely on rescaling alone. Price and cost levels should first be re-expressed in the local currency and price level, ideally informed by local per capita income or consumption data; the seasonal coefficients should be revised to match local cultural and climatic patterns; and regulatory parameters such as the Social Security Institution support mechanism should be replaced with their local equivalents. Rescaling, however, is only the starting point. Because the fifteen equations interact in ways that are sensitive to parameter values, any adaptation must be followed by re-running the simulation and re-examining the resulting equilibria, Prisoner’s Dilemma conditions, and competitive balance, as reported in Section 3, to confirm that the adapted game remains fair and strategically valid. The discrete table structure and the open-source repository are intended to make precisely this cycle of recalibration and revalidation practical.

2.2. Demand and Market Share Model

Market share allocation follows an additive attractiveness model [38], in which the base share of each center is modified by competitive factors. For center i competing against center j , the market share is:

$$MS_i(t) = \frac{c_i}{c_i + c_j} + B_i + M_i^{net}(t) + R_{ij}(t) + I_i(t) + S_i(t) \quad (1)$$

where

c_i = attractiveness coefficient of center i 's pricing strategy (1.60 for S1, 5.50 for S2, 1.00 for S3, 0.25 for S4),

B_i = brand bonus of center i (0.04 for Center A, 0 for Center B),

M_i^{net} = net marketing effect after competitive neutralization,

R_{ij} = reputation differential effect relative to competitor j ,

I_i = investment bonus (active for S4 pricing only),

S_i = exogenous shock effect.

The net marketing effect captures competitive neutralization, whereby each firm's marketing expenditure partially offsets the competitor's impact [39]:

$$M_i^{net}(t) = ME(m_i) - 0.40 \times ME(m_j) \quad (2)$$

where $ME(m) \in \{0.00, 0.02, 0.05, 0.08\}$ is the market share effect for marketing levels 0 through 3, respectively. The neutralization coefficient of 0.40 reflects the empirical observation that defensive marketing reduces, but does not fully eliminate, the attacker's advantage.

The reputation differential is modeled as:

$$R_{ij}(t) = 0.05 \times \frac{Rep_i(t) - Rep_j(t)}{100}. \quad (3)$$

Final market shares are bounded to $[0.05, 0.95]$ and normalized to sum to unity.

Demand Decomposition. Total demand for each center comprises three client acquisition channels:

$$D_i(t) = N_i^{new}(t) + N_i^{loyal}(t) + N_i^{ref}(t). \quad (4)$$

New clients are attracted through market share competition:

$$N_i^{new}(t) = Q \times \gamma(t) \times \delta(t) \times MS_i(t) \quad (5)$$

where $Q = 130$ is base monthly demand, $\gamma(t)$ is the seasonal coefficient (Table 4), and $\delta(t) = 1 + \sum_k d_k(t)$ is the cumulative demand multiplier from active shocks.

Loyal clients represent returning clients from the previous period, modulated by price stability and a strategy-specific retention multiplier:

$$N_i^{loyal}(t) = N_i(t-1) \times \alpha \times \lambda(\Delta p) \times \varphi(s_i) \quad (6)$$

where $N_i(t-1)$ is the number of clients served in the previous month, $\alpha = 0.02$ is the base loyalty rate, $\lambda(\Delta p)$ is the loyalty factor dependent on the magnitude of price change [37]:

$$\lambda(\Delta p) = \begin{cases} 1.00, & \text{if } \Delta p = 0 \text{ (no price change)} \\ 0.38, & \text{if } |\Delta p| = 1 \text{ (one-level change)} \\ 0.08, & \text{if } |\Delta p| \geq 2 \text{ (multi-level change)} \end{cases} \quad (7)$$

and $\varphi(s) \in \{0.80, 0.92, 1.00, 1.05\}$ for strategies S1 through S4, respectively, is a satisfaction multiplier reflecting higher retention at premium price points.

Referral clients represent word-of-mouth acquisitions [40] modulated by employee satisfaction and active investments:

$$N_i^{ref}(t) = N_i(t-1) \times \rho_i(t) \times \psi_i(t) \quad (8)$$

where $\rho_i(t) = 0.01 + \sum_e k$ is the referral rate augmented by active Training ($e = +0.15$) and Equipment ($e = +0.10$) investments, and ψ is the referral multiplier:

$$\psi_i(t) = \begin{cases} 1.15, & \text{if } Sat_i \geq 70 \\ 0.30, & \text{if } Sat_i < 30 \\ 1.00, & \text{otherwise} \end{cases}$$

This three-component demand structure ensures that performance depends not only on competitive pricing (new clients) but also on operational consistency (loyal clients) and human resource management (referral clients). Actual clients served are bounded by effective capacity:

$$N_i(t) = \min\{D_i(t), K_i(t)\}$$

where $K_i(t)$ is the effective capacity.

2.3. Financial Model and Net Present Value

Monthly profit aggregates revenue and cost components [41]:

$$\Pi_i(t) = N_i(t) \times [P(s_i) - UC(s_i)] - FC_i - MC_i - \mu_i - IC_i \quad (9)$$

where $P(s)$ is the package price, $UC(s)$ is the unit variable cost, FC_i is fixed cost (45,000 TL for A, 32,000 TL for B), MC_i is marketing cost (0–70,000 TL), μ_i is menu cost, and IC_i is investment cost. Menu costs create pricing stickiness: $\mu = 0$ for no change, 4000 TL for one-level change, and 10,000 TL for multi-level changes.

Net present value accumulates discounted monthly profits:

$$NPV_i = \sum_{t=1}^{36} \frac{\Pi_i(t)}{(1+r_i)^t} \quad (10)$$

where r_i is the monthly discount rate ($r_A = 0.0133$, $r_B = 0.0158$). NPV serves as the primary performance metric, reflecting the time value of money and differential risk profiles of the two centers [42].

2.4. Employee Satisfaction and Reputation Dynamics

Employee satisfaction is a central mechanism linking operational decisions to long-term performance, reflecting the well-documented relationship between employee well-being and service quality in healthcare [43].

Capacity utilization is defined as:

$$U_i(t) = \frac{N_i(t)}{K_i(t)}. \quad (11)$$

When utilization exceeds the burnout threshold $\Theta = 0.78$, satisfaction decays:

$$\omega_i(t) = \frac{U_i(t) - \Theta}{1 - \Theta}, \quad Sat_i(t+1) = Sat_i(t) - \beta \times \omega_i(t) \times 10 \quad (12)$$

where $\beta = 0.8$ is the decay rate and $\omega \in [0, 1]$ is the normalized overtime measure. When utilization is below the threshold, satisfaction recovers:

$$Sat_i(t+1) = \min(100, Sat_i(t) + \xi). \quad (13)$$

where $\xi = 3.0$ is the monthly recovery rate. Premium pricing (S4) imposes an additional monthly satisfaction penalty $\sigma = 1.0$ ($Sat_i(t) = Sat_i(t) - \sigma$).

Training investments provide $+10/12 \approx 0.83$ points per month over their 12-month duration. Satisfaction is bounded to $[0, 100]$.

Effective capacity is modulated by employee satisfaction:

$$K_i(t) = \bar{K}_i \times \kappa_i(Sat_i) \times \eta_i(t) \times \zeta_i(t). \quad (14)$$

where $\bar{K}_i$ is nominal capacity (115 for A, 88 for B), κ is the capacity-satisfaction multiplier, η accounts for Technology investment effects (+15%), and ζ accounts for shock effects (e.g., Employee Illness: −20%). The multiplier κ is defined as:

$$\kappa_i(\text{Sat}_i(t)) = \begin{cases} 1.10, & \text{if } \text{Sat}_i(t) \geq 70 \\ 0.90, & \text{if } \text{Sat}_i(t) < 20 \\ 1.00, & \text{otherwise} \end{cases}$$

This mechanism creates a critical feedback loop: aggressive pricing increases demand, raising utilization above Θ , which reduces satisfaction; if satisfaction falls below 20, capacity contracts by 10%, further increasing utilization. This “burnout spiral” penalizes sustained aggressive strategies. Conversely, centers maintaining satisfaction above 70 benefit from a “virtuous cycle” of expanded capacity, reduced pressure, and sustained high satisfaction.

Reputation evolves according to a discrete-time additive update process that incorporates pricing consistency and employee satisfaction effects. For center i , the scalar formulation is [44]:

$$\text{Rep}_i(t) = \text{Rep}_i(t-1) + \pi_{p,i}(t) + \pi_{s,i}(t). \quad (15)$$

For a system with n centers, this can be expressed in vector–matrix form as:

$$\mathbf{Rep}(t) = \mathbf{Rep}(t-1) + \boldsymbol{\pi}_p(t) + \boldsymbol{\pi}_s(t)$$

where

$$\mathbf{Rep}(t) = \begin{bmatrix} \text{Rep}_1(t) \\ \text{Rep}_2(t) \\ \vdots \\ \text{Rep}_n(t) \end{bmatrix}, \quad \boldsymbol{\pi}_p(t) = \begin{bmatrix} \pi_{p,1}(t) \\ \pi_{p,2}(t) \\ \vdots \\ \pi_{p,n}(t) \end{bmatrix}, \quad \boldsymbol{\pi}_s(t) = \begin{bmatrix} \pi_{s,1}(t) \\ \pi_{s,2}(t) \\ \vdots \\ \pi_{s,n}(t) \end{bmatrix}.$$

Equivalently, the system can be written in compact linear form:

$$\mathbf{Rep}(t) = \mathbf{I} \mathbf{Rep}(t-1) + \boldsymbol{\pi}_p(t) + \boldsymbol{\pi}_s(t).$$

or as a disturbance-driven process:

$$\mathbf{Rep}(t) = \mathbf{Rep}(t-1) + \boldsymbol{\varepsilon}(t), \quad \boldsymbol{\varepsilon}(t) = \boldsymbol{\pi}_p(t) + \boldsymbol{\pi}_s(t).$$

The pricing consistency component is defined as:

$$\pi_{p,i}(t) = \begin{cases} -1.0 & \text{if price changed (trust penalty)} \\ +0.5 & \text{if stable (consistency reward)} \end{cases}.$$

The satisfaction-driven component is defined as:

$$\pi_{s,i}(t) = \begin{cases} +0.3 & \text{if } \text{Sat}_i(t) > 70 \\ -0.5 & \text{if } \text{Sat}_i(t) < 50 \\ 0 & \text{otherwise} \end{cases}.$$

In vectorized indicator-function form, these components can be written as:

$$\boldsymbol{\pi}_p(t) = -1.0 \cdot \mathbf{1}_{\Delta p \neq 0} + 0.5 \cdot \mathbf{1}_{\Delta p = 0},$$

$$\boldsymbol{\pi}_s(t) = 0.3 \cdot \mathbf{1}_{\text{Sat} > 70} - 0.5 \cdot \mathbf{1}_{\text{Sat} < 50}.$$

Reputation is bounded to the interval $[0,100]$ through a projection operator:

$$\mathbf{Rep}(t) = \min(100, \max(0, \mathbf{Rep}(t)))$$

This asymmetric structure—where the loss from instability exceeds the gain from consistency—reflects the well-documented negativity bias in consumer perceptions. The resulting reputation differential feeds back into market share through $R_{ij}(t)$, completing the dynamic feedback loop between operational decisions and competitive outcomes.

2.5. Strategy Space Design

Two strategy sets are defined: a base set of 10 strategies and an extended set of 22 strategies. The base set comprises four fixed strategies (S1–S4 at constant price with no marketing) and six dynamic strategies:

Tit-for-Tat (TfT): Begins with S3 (cooperation) and subsequently mirrors the opponent's previous pricing choice [22].

Forgiving Tit-for-Tat: Cooperates (S3) by default; retaliates with S2 only if the opponent plays S1 (destructive); forgives S2 (aggressive) if the own NPV falls behind the opponent's—reflecting bounded retaliation.

Grim Trigger: Cooperates (S3) until the opponent deviates to S1 or S2, then permanently switches to S2 for all remaining periods.

Seasonal: Adjusts pricing to seasonal demand patterns—plays S2 during high-demand seasons ($\gamma \geq 1.15$) and S3 during low-demand seasons.

Adaptive: Combines seasonal adjustment with satisfaction monitoring—switches to S3 if employee satisfaction falls below 60, regardless of seasonal conditions.

Satisfaction-Aware (SatAware): Prioritizes employee well-being—plays S4 when satisfaction drops below 40 (to reduce volume pressure), S2 during high-demand seasons when satisfaction is above 70, and S3 otherwise.

The extended set of 22 strategies adds marketing-level variations (Paz 0 = no marketing; Paz 2 = active marketing) for each fixed strategy and additional behavioral variants, including Aggressive TfT, Permanent TfT, Alternating, and Endgame Aggressive strategies.

2.6. Axelrod Tournament Framework

Following Axelrod's [22] iterated Prisoner's Dilemma tournament methodology, all strategies compete against every other strategy (and themselves) in a round-robin format. For the base tournament, 10 strategies produce $10 \times 10 = 100$ matchups; for the extended tournament, 22 strategies produce $22 \times 22 = 484$ matchups. Each matchup in the extended tournament is simulated 200 times with independent stochastic shock realizations, yielding 96,800 simulation runs, to obtain stable mean NPV estimates. Strategy performance is evaluated by average NPV across all opponents, reflecting robustness against diverse competitive approaches rather than optimization against any single opponent [23].

2.7. Monte Carlo Simulation Design

To assess the stochastic robustness of equilibrium outcomes, 1000 independent simulations are conducted for each of two baseline scenarios: the cooperative outcome (S3, S3) and the Nash equilibrium (S2, S2). Each simulation uses an independent random shock sequence while holding strategies constant. This design allows estimation of NPV distributions, computation of confidence intervals, assessment of winning probabilities, and statistical comparison of equilibrium outcomes.

2.8. Sensitivity Analysis Design

Systematic sensitivity analyses examine model robustness across four key parameters, with all analyses using the cooperative baseline (S3, S3) and 100 Monte Carlo simulations per parameter value:

- (i) **Discount rate:** Monthly rates from 1.0% to 3.0% (annual 12.7–42.6%) in five steps, testing whether the Prisoner's Dilemma structure and cooperation benefits are preserved across varying costs of capital.
- (ii) **Shock probability:** Monthly probabilities from 0% to 20% in eleven steps, assessing how increasing environmental uncertainty affects mean outcomes and outcome variance.

- (iii) **Base demand:** Monthly demand levels from 80 to 180 clients in six steps, examining how market size affects competitive dynamics and the point at which capacity constraints become binding.
- (iv) **Burnout threshold:** Capacity utilization thresholds from 60% to 95% in eight steps, testing the sensitivity of employee satisfaction dynamics and their downstream effects on reputation and market share.

2.9. Prisoner's Dilemma Verification

The simulation is designed to produce a Prisoner's Dilemma structure in the payoff matrix. Following standard game-theoretic conventions [22,45], we verify the following conditions using the payoff values for Center A (the analogous conditions hold symmetrically for Center B):

Condition 1 (Ordering).

$$T > R > P > S$$

where T (temptation) is the payoff from unilateral defection against a cooperator, R (reward) is the mutual cooperation payoff, P (punishment) is the mutual defection payoff, and S (sucker) is the payoff from cooperating while the opponent defects.

Condition 2 (Collective rationality).

$$2R > T + S$$

This condition ensures that mutual cooperation is collectively superior to alternating exploitation, making sustained cooperation viable in the repeated game.

Nash equilibrium is identified by computing best-response functions for each player and finding strategy combinations where neither player can improve their payoff through unilateral deviation [15]. Pareto optimality is assessed by checking whether any alternative strategy combination can improve one player's outcome without worsening the other's.

3. Results

The results are organized to follow the logical progression of game-theoretic analysis: from the static payoff structure (Section 3.1) through equilibrium verification (Section 3.2), to dynamic strategy evaluation via tournament competition (Section 3.3), stochastic robustness assessment (Section 3.4), temporal dynamics illustration (Section 3.5), and parametric sensitivity testing (Section 3.6). This sequence mirrors the validation pipeline of the SY142-Game-Theory-1 framework, demonstrating that the simulation produces theoretically consistent outcomes at each level of analysis.

3.1. Payoff Matrix and Nash Equilibrium

Table 6 presents the complete 4×4 payoff matrix showing 36-month NPV outcomes for all 16 strategy combinations. Each cell reports the mean NPV (in million TL) from 100 Monte Carlo simulations, with Center A's payoff listed first.

Table 6. 36-month NPV payoff matrix (Million TL).

A\B	S1 (Destructive)	S2 (Aggressive)	S3 (Cooperative)	S4 (Premium)
S1 (Destructive)	4.32/3.93	1.38/9.27	5.42/7.18	6.39/3.70
S2 (Aggressive)	11.77/1.18	8.60/7.65	12.10/2.28	12.59/0.79
S3 (Cooperative)	8.21/4.47	3.05/9.48	10.72/9.48	14.62/5.84
S4 (Premium)	5.09/5.02	1.91/9.71	7.35/11.49	17.82/15.45

Values represent the mean NPV from 100 Monte Carlo simulations per strategy combination. Format: Center A NPV/Center B NPV. All values in million TL. Standard deviations range from 0.03M to 0.25M TL across cells.

Three observations emerge from the payoff structure. First, mutual cooperation (S3, S3) generates total industry NPV of 20.21M TL, substantially exceeding the mutual defection outcome (S2, S2) at 16.28M TL, a 24.1% welfare differential. This 16.28M TL total and the associated 24.1% differential are drawn from the Monte Carlo means reported in Section 3.4, whereas the corresponding deterministic values in the Table 6 payoff matrix are 16.25M TL and 24.3%. Second, the premium strategy combination (S4, S4) achieves the highest total NPV of 33.27M TL, but this outcome requires mutual trust and is not sustained by dominant strategy incentives. Third, Center A achieves higher NPV than Center B in most strategy combinations, reflecting its structural advantages in capacity, brand recognition, and cost of capital. Center B nonetheless prevails in five of the sixteen combinations, namely (S1, S2), (S1, S3), (S3, S2), (S4, S2), and (S4, S3), each arising when Center A forgoes aggressive (S2) pricing. Center B's aggressive play (S2) overtakes any non-aggressive Center A, whereas its cooperative play (S3) overtakes only Center A's destructive (S1) or premium (S4) positioning.

Best-response analysis reveals that Center A's best response is S2 (Aggressive) against S1, S2, and S3, and S4 (Premium) against S4. Center B's best response is S2 against S1 and S2, S3 against S3, and S4 against S4. Two pure-strategy Nash equilibria are identified at the intersection of these best responses: (S2, S2) with payoffs of 8.60M and 7.65M TL, and (S4, S4) with payoffs of 17.82M and 15.45M TL. The (S2, S2) equilibrium constitutes the primary Nash equilibrium in the Prisoner's Dilemma sense, as S2 is the dominant strategy for Center A against three of four opponent strategies. The coexistence of two pure-strategy Nash equilibria—(S2, S2) and (S4, S4)—merits clarification, as it may appear to complicate the Prisoner's Dilemma interpretation. These two equilibria are qualitatively different in nature. The (S2, S2) equilibrium is the defection-based equilibrium characteristic of the Prisoner's Dilemma: it is reached through dominant-strategy reasoning, since S2 is each center's individually rational response across most opponent strategies, yet it yields a collectively suboptimal outcome. The (S4, S4) equilibrium, by contrast, is a coordination equilibrium: it is Pareto-superior and self-enforcing only if both centers simultaneously commit to premium positioning, but it is not supported by dominant-strategy incentives, since either center can profitably deviate when it expects the other to cooperate at S3. Thus, while (S4, S4) is technically a Nash equilibrium, it is not robust to the strategic uncertainty that characterizes real competitive interaction, whereas (S2, S2) represents the risk-dominant outcome toward which myopic best-response dynamics converge. This distinction is precisely what makes the repeated-game framework valuable: it shows how reciprocity-based strategies can shift play away from the inefficient (S2, S2) equilibrium toward cooperative outcomes.

3.2. Prisoner's Dilemma Verification and Pareto Optimality

To verify the Prisoner's Dilemma structure, the payoff matrix is mapped to the standard PD framework using S2 as defection (D) and S3 as cooperation (C). For each center, four canonical payoffs are extracted: T (temptation to defect), R (reward for mutual cooperation), P (punishment for mutual defection), and S (sucker's payoff for cooperating against a defector).

For Center A: $T_A = 12.10$ M TL (play S2 while B plays S3), $R_A = 10.72$ M TL (both play S3), $P_A = 8.60$ M TL (both play S2), and $S_A = 3.05$ M TL (play S3 while B plays S2).

Condition 1 (Ordering).

$$T = 12.10 > R = 10.72 > P = 8.60 > S = 3.05.$$

Condition 2 (Collective rationality).

$$2R = 21.44 > T_A + S_A = 15.15.$$

Both conditions are satisfied for Center A, confirming a classical Prisoner's Dilemma structure from the established provider's perspective.

For Center B, the full-precision payoff values reveal an asymmetric incentive structure: $T_B = 9.4798\text{M TL}$ (play S2 while A plays S3), $R_B = 9.4835\text{M TL}$ (both play S3), $P_B = 7.65\text{M TL}$ (both play S2), and $S_B = 2.28\text{M TL}$ (play S3 while A plays S2). Critically, $R_B > T_B$: Center B achieves marginally higher NPV under mutual cooperation than under unilateral defection, by approximately 3,700 TL. This means that Center B does not face a strict Prisoner's Dilemma—its individually rational response to a cooperating opponent is to cooperate rather than defect. This asymmetry arises because Center B's smaller market share and limited capacity constrain its ability to capture additional clients through aggressive pricing; the revenue gains from defection are offset by menu costs and reputation damage. The remaining conditions ($R_B > P_B > S_B$ and $2R_B > T_B + S_B$) are satisfied, and the collective rationality condition holds for both centers.

The game thus exhibits an asymmetric Prisoner's Dilemma structure: Center A faces the classical cooperation–defection tension (with a temptation premium of $T_A - R_A = 1.38\text{M TL}$), while Center B's rational incentive aligns with cooperation. This asymmetry implies that the risk of competitive escalation is driven primarily by the established provider's incentive to exploit its market power—a finding with direct pedagogical relevance for understanding how structural position shapes strategic behavior in health service markets.

The efficiency loss from strategic rivalry is 19.4%: mutual cooperation (S3, S3) yields 20.21M TL in total industry NPV compared to 16.28M TL under the Nash equilibrium (S2, S2). The Pareto-optimal outcome is (S4, S4) at 33.27M TL—the highest total welfare among all 16 strategy combinations. However, this outcome is not a Nash equilibrium: if one center plays S4 while the other deviates to S2, the deviator captures disproportionate market share through aggressive pricing (e.g., Center A earns 12.59M TL by playing S2 against Center B's S4, while Center B's payoff collapses to 0.79M TL). This vulnerability to unilateral defection makes the (S4, S4) outcome unstable without binding coordination mechanisms. The simulation thus generates a payoff landscape in which the collectively optimal outcome is unattainable through rational self-interest, the cooperative outcome (S3, S3) offers substantial welfare gains over Nash but remains vulnerable to defection by Center A, and the Nash equilibrium (S2, S2) is the only self-enforcing outcome in the single-shot game—precisely the strategic tension that Axelrod's [22] repeated-game framework and reciprocity-based strategies are designed to resolve.

3.3. Strategy Tournament Rankings

The Axelrod-style round-robin tournament evaluated 22 strategies—comprising 4 fixed pricing strategies, 6 dynamic behavioral strategies, and 12 additional variants incorporating marketing-level variations and alternative behavioral rules—each competing against all others (including itself) over 200 simulations per matchup, yielding a total of 96,800 simulation runs. Strategy performance is measured by average NPV across all opponents, reflecting robustness against diverse competitive approaches rather than optimization against any single opponent [23].

Forgiving Tit-for-Tat achieves the highest average NPV (10.87M TL), followed by Grim Trigger (10.83M TL) and standard Tit-for-Tat (10.72M TL). These top three strategies share a common behavioral signature: they initiate with cooperation and employ conditional retaliation proportional to the opponent's aggression, consistent with the classical findings of Axelrod's [22] iterated Prisoner's Dilemma tournaments. The superiority of Forgiving TfT over standard TfT (a margin of 0.15M TL) demonstrates the value of selective forgiveness—retaliating only against destructive (S1) behavior while tolerating aggressive (S2) play when it serves long-term interests. Context-dependent strategies (Adaptive, SatAware, Seasonal) cluster in the middle tier (10.39M–10.49M TL), confirming that

incorporating operational awareness improves performance but does not surpass reciprocity-based approaches. Among fixed strategies with marketing-level variations, S2 with no marketing ($S2_{Paz0}$; 10.66M TL) outperformed S2 with active marketing ($S2_{Paz2}$; 9.98M TL), suggesting that combining aggressive pricing with marketing expenditure erodes net profitability through cost escalation without proportional revenue gains. The worst-performing strategy was S1 with active marketing ($S1_{Paz2}$; 3.02M TL), confirming that the combination of destructive pricing and high fixed marketing costs is unsustainable under any competitive conditions. A base tournament restricted to the 10 core strategies (4 fixed + 6 dynamic) produced the same top-three ranking order, confirming the robustness of these findings across strategy set composition (Figure 2).

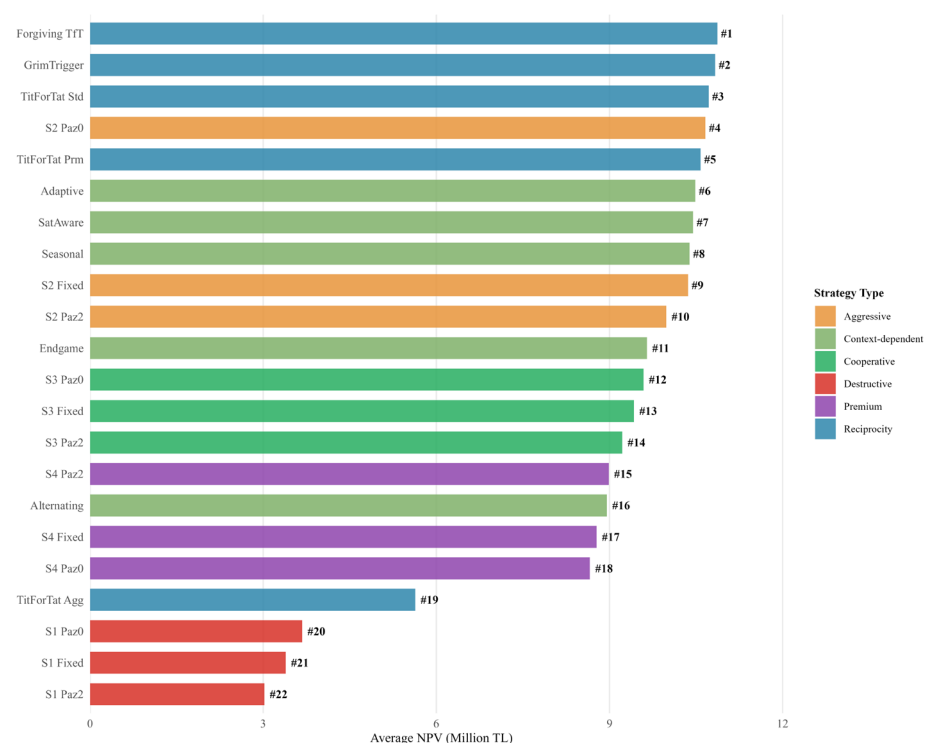


Figure 2. Extended strategy tournament results showing average NPV (million TL) across all opponent matchups for 22 strategies ($n = 200$ simulations per matchup). Reciprocity-based strategies (blue) occupy the top three positions, followed by context-dependent strategies (green). Color coding distinguishes strategy families: reciprocity-based (blue), context-dependent (green), cooperative fixed (green), aggressive fixed (orange), premium fixed (purple), and destructive fixed (red).

3.4. Monte Carlo Validation

One thousand independent Monte Carlo simulations were conducted for both the cooperative (S3, S3) and Nash equilibrium (S2, S2) scenarios to assess the stochastic robustness of equilibrium outcomes. Each simulation draws an independent random shock sequence while holding strategies constant, isolating the effect of environmental uncertainty from strategic choice. Table 7 presents the summary statistics.

Table 7. Monte Carlo summary statistics ($n = 1000$ simulations per scenario).

Metric	Cooperation (S3, S3)	Nash Equilibrium (S2, S2)
Mean NPV Center A (M TL)	10.731	8.634
SD NPV Center A (M TL)	0.144	0.121
CV Center A (%)	1.34	1.40
Mean NPV Center B (M TL)	9.475	7.650

SD NPV Center B (M TL)	0.112	0.091
CV Center B (%)	1.18	1.19
Total Industry NPV (M TL)	20.206	16.285
Center A Win Rate	100%	100%
Cooperation Premium	+24.1%	(baseline)

SD = standard deviation; CV = coefficient of variation. Win rate indicates the proportion of simulations in which Center A achieves higher NPV. *Cooperation premium* = $(Total\ NPV_{Coop} - Total\ NPV_{Nash}) \times 100 / Total\ NPV_{Nash}$.

The cooperation scenario yields a total industry NPV of 20.21M TL compared to 16.28M TL under the Nash equilibrium—a cooperation premium of 24.1%. Both centers benefit substantially: Center A gains 24.3% (10.73M vs. 8.63M TL) and Center B gains 23.8% (9.48M vs. 7.65M TL). The low coefficients of variation (1.2–1.4% across all conditions) confirm that the fundamental competitive dynamics dominate stochastic shock effects, making comparative conclusions highly reliable despite environmental uncertainty (Table 7).

A Welch two-sample *t*-test confirms that the NPV difference between cooperation and Nash scenarios is statistically significant for both Center A ($t = 353.4$, $p < 0.001$) and Center B ($t = 399.6$, $p < 0.001$).

The tight clustering of NPV distributions ($CV = 1.2$ – 1.4%) confirms that stochastic shocks introduce limited variance relative to the structural determinants of competitive outcomes, and that the 200 simulations per matchup used in the tournament analysis (Section 3.3) provide more than adequate statistical precision for strategy ranking (Figure 3).

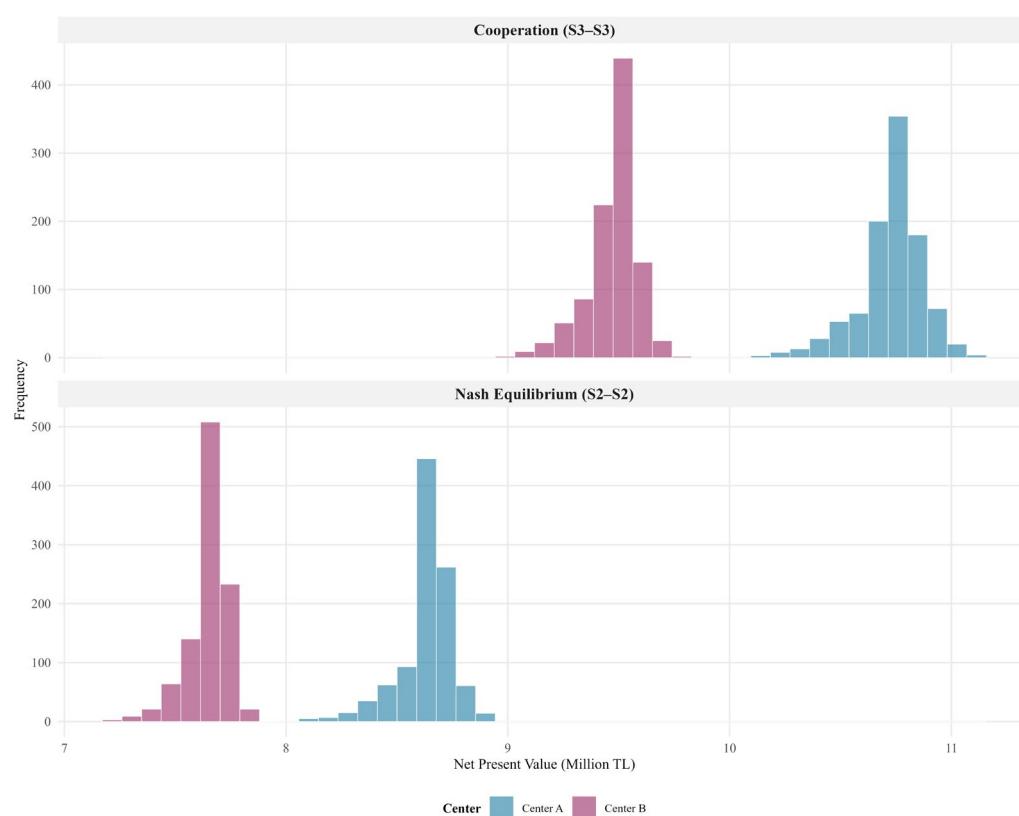


Figure 3. Monte Carlo NPV distributions for both centers under cooperation (S3–S3, upper panel) and Nash equilibrium (S2–S2, lower panel), based on 1000 independent simulations per scenario. The rightward shift in both distributions under cooperation illustrates the welfare premium. Minimal overlap between Center A (blue) and Center B (pink) distributions within each scenario confirms that Center A’s structural advantages translate into consistent—not occasional—performance differences.

3.5. Illustrative Scenario: 36-Month Simulation Dynamics

To demonstrate the temporal dynamics of the simulation, a representative 36-month run under cooperation (S3, S3) is presented in Figure 4, illustrating the evolution of four key performance indicators.

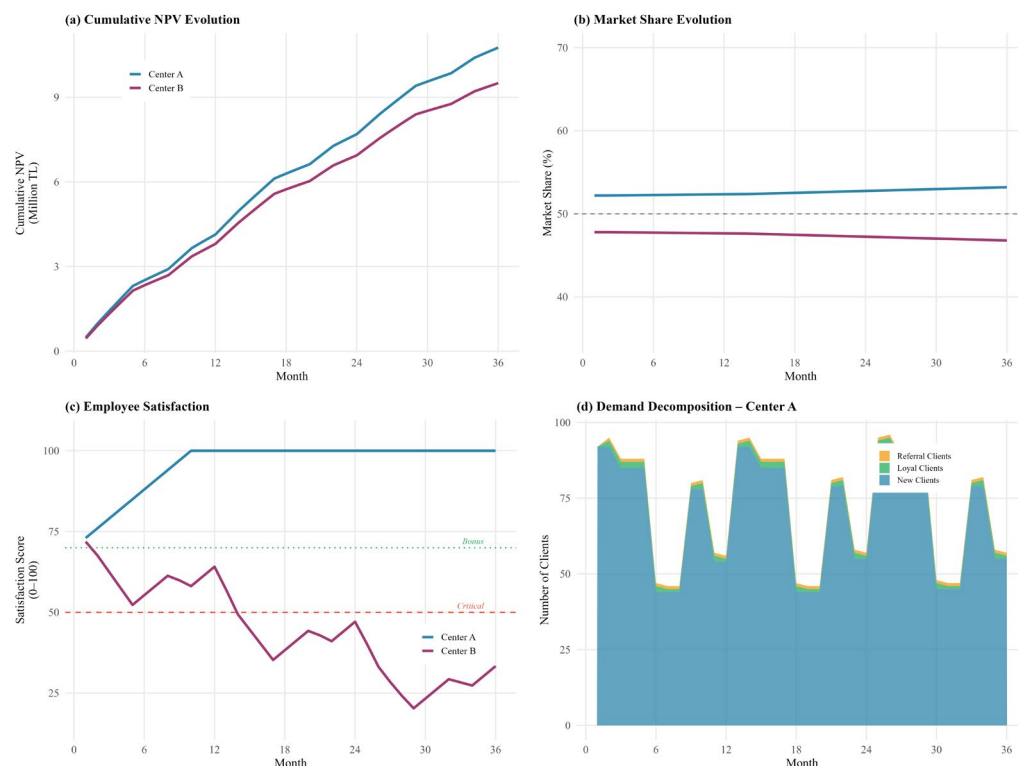


Figure 4. Illustrative 36-month simulation dynamics under cooperation (S3–S3). **(a)** Cumulative NPV evolution showing gradual divergence as Center A’s structural advantages compound over time; **(b)** market share allocation demonstrating remarkable stability at approximately 53%/47%, with temporary perturbations from stochastic shocks; **(c)** employee satisfaction trajectories, where Center A maintains satisfaction above the capacity bonus threshold ($Sat \geq 70$) while Center B experiences seasonal fluctuations near the critical threshold ($Sat = 50$, dashed line); **(d)** demand decomposition for Center A, distinguishing new client acquisition (market share-driven), loyal client retention, and referral generation (satisfaction-driven).

Several patterns emerge from these dynamics. Cumulative NPV trajectories are nearly parallel during the first six months, after which Center A gradually pulls ahead—reaching 10.76M TL by month 36 compared to Center B’s 9.50M TL, a 13.2% performance gap reflecting the compounding effect of the 4% brand bonus and lower discount rate. Market share remains remarkably stable at approximately 53%/47%, with brief perturbations around stochastic shock events that quickly revert to baseline—confirming that the cooperative strategy produces a stable competitive equilibrium. Employee satisfaction diverges substantially: Center A maintains comfort (averaging 96.2 points) due to its ample capacity margin, while Center B experiences periodic stress during high-demand seasons when utilization approaches the 78% burnout threshold, averaging 44.4 points. Importantly, Center B’s satisfaction remains above the critical 20-point threshold that would trigger the capacity contraction mechanism, confirming that the simulation parameters produce challenging but viable operating conditions for the smaller center. The demand decomposition reveals that new client acquisition dominates Center A’s demand (approximately 80%), with loyal clients providing a stable secondary stream and referrals contrib-

uting a small but consistent supplement modulated by employee satisfaction—illustrating the three-channel demand structure described in Section 2.2 (Figure 4).

3.6. Sensitivity Analysis

Systematic sensitivity analyses across four key parameters confirm the robustness of the model's qualitative findings. All analyses use the cooperative baseline (S3, S3) with 100 Monte Carlo simulations per parameter value.

The discount rate sensitivity (Figure 5a) demonstrates that while absolute NPV levels are sensitive to the cost of capital, the qualitative findings—including the Prisoner's Dilemma structure and cooperation benefits—are preserved across the entire tested range (annual 12.7–42.6%). The parallel decline in both centers' NPV curves confirms that the discount rate affects the level of outcomes without distorting their relative ranking.

The shock probability analysis (Figure 5b) reveals that increasing environmental uncertainty from 0% to 20% monthly shock probability has negligible impact on mean NPV (Center A: 10.76M to 10.69M TL, a 0.7% change) but substantially increases outcome variance (SD from 0 to 0.26M TL). This pattern arises because positive and negative shocks approximately cancel in expectation, affecting risk rather than return. The NPV gap between centers remains stable at approximately 1.26M TL across all shock levels, indicating that Center A's structural advantage is robust to market uncertainty.

The base demand analysis (Figure 5c) reveals a strong positive relationship with NPV, with an important nonlinearity: both centers benefit approximately linearly from demand growth between $Q = 80$ and $Q = 140$, after which Center B's curve flattens as its capacity constraint (88 clients) becomes binding. At $Q = 180$, Center A achieves 14.08M TL while Center B reaches only 11.01M TL, yielding a widening NPV gap of 3.07M TL compared to 0.39M TL at $Q = 80$. This finding highlights the strategic importance of capacity investment and suggests that Center B's competitive position deteriorates in high-growth markets unless accompanied by capacity expansion.

The burnout threshold analysis (Figure 5d) produces the most pronounced nonlinear effect among the four parameters. Center A maintains high satisfaction (above 96 points) across all tested thresholds (60–95%) due to its comfortable capacity margin. Center B, however, exhibits a sharp transition: satisfaction averages 25.2 points at $\Theta = 0.60$, rises gradually to 53.3 at $\Theta = 0.80$, then jumps to 92.7 at $\Theta = 0.85$. This threshold effect occurs because Center B's typical capacity utilization hovers near 78%—when the burnout threshold is set below this level, satisfaction declines persistently; when set above, Center B operates comfortably within its capacity. The baseline parameter of $\Theta = 0.78$ was selected to realistically position this transition point, creating meaningful operational pressure for the capacity-constrained center while maintaining viable business conditions.

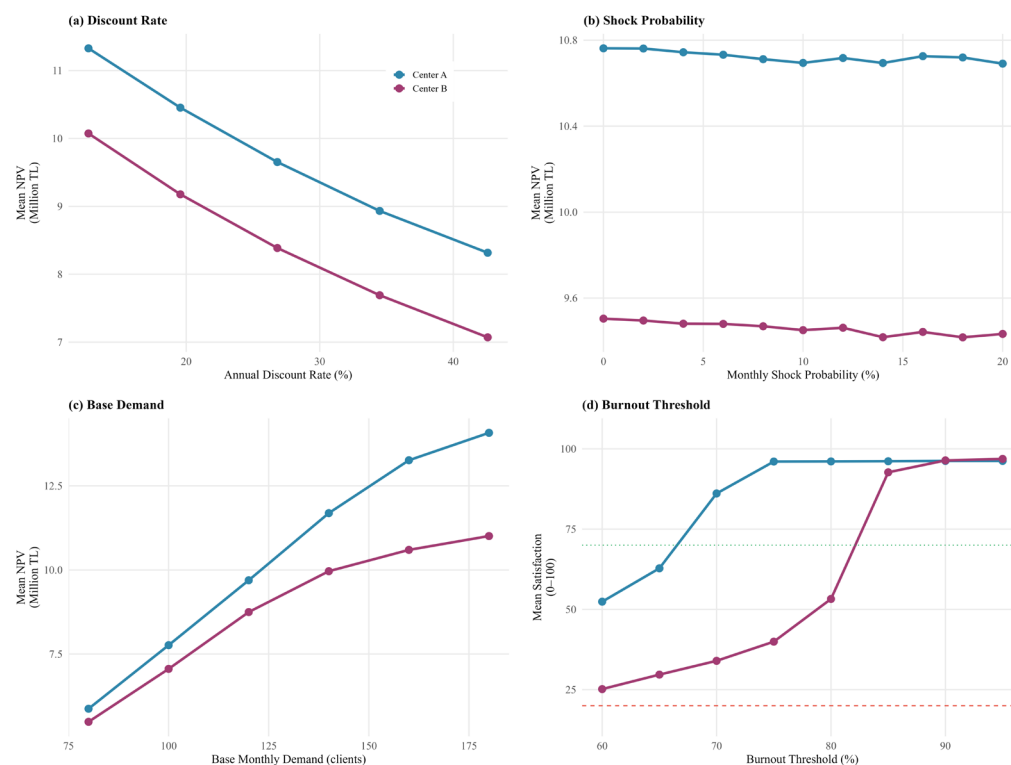


Figure 5. Sensitivity analysis results across four key parameters under cooperation (S3–S3). (a) Discount rate: mean NPV declines monotonically from 21.40M TL (annual 12.7%) to 15.39M TL (annual 42.6%), with both centers affected proportionally; (b) shock probability: mean NPV remains nearly constant ($\pm 0.7\%$) while standard deviation increases from 0 to 0.26M TL as monthly shock probability rises from 0% to 20%, confirming that shocks affect risk but not expected performance; (c) base demand: NPV increases strongly for both centers, with Center B’s curve flattening above $Q = 140$ as its capacity constraint becomes binding, while Center A continues to benefit from market growth; (d) burnout threshold: Center A maintains high satisfaction (>96) across all thresholds due to its comfortable capacity margin, while Center B exhibits a sharp nonlinear transition between $\theta = 0.80$ and $\theta = 0.85$, below which satisfaction deteriorates rapidly.

4. Discussion

4.1. A Balanced and Strategically Valid Game as a Prerequisite for Instruction

Our aim in this study is not to advance game-theoretic theory or to demonstrate learning gains, but to show that the proposed simulation forms a balanced, fair, and strategically meaningful competitive environment. That property is a precondition for using it as a teaching tool. A simulation meant to teach strategic decision-making has to reward sound reasoning rather than chance or a hidden parameter bias; if outcomes were predetermined, or if one center could win regardless of its decisions, the exercise would lose its instructional value. The analyses reported here, namely Nash equilibrium identification, Prisoner’s Dilemma verification, Axelrod-style tournament evaluation, Monte Carlo robustness testing, and four-way sensitivity analysis, together establish that the simulation meets this standard. They show that the game has a genuine strategic structure, one in which different decisions lead to materially different and theoretically coherent outcomes.

This framing clarifies why parameter calibration, rather than an arbitrary modeling choice, is the core contribution of the work. The fifteen interdependent equations that govern demand, market share, finance, employee satisfaction, and reputation are highly sensitive to their parameter values: a small change in a single coefficient can collapse the competitive balance, producing either a trivial game with a dominant winning strategy or a

degenerate one in which decisions do not matter. Starting from observed market values in the Turkish healthy living center sector, we identified a configuration that is realistic, balanced, and game-theoretically valid only after extensive, systematic experimentation. The sensitivity analyses (Section 3.6) show that this configuration is stable, preserving the qualitative strategic structure across plausible parameter ranges rather than depending on a single fragile setting.

4.2. Game-Theoretic Properties of the Calibrated Environment

The calibration process produced a competitive environment with several noteworthy game-theoretic properties. The most striking is the emergence of an asymmetric Prisoner's Dilemma structure in which the established provider (Center A) faces the classical temptation to defect ($T_A - R_A = 1.38\text{M TL}$), whereas the new entrant (Center B) does not: Center B's cooperative payoff marginally exceeds its defection payoff ($R_B = 9.4835\text{M} > T_B = 9.4798\text{M TL}$). This asymmetry was not imposed directly but emerged from the interaction of the structural differences between competitors: capacity constraints, brand advantages, and cost-of-capital differentials. While the classical Prisoner's Dilemma literature, including Axelrod's foundational tournaments [22] and Rapoport and Chammah's original formalization [45], typically assumes symmetric payoff structures, the calibrated environment demonstrates that realistic competitive asymmetries can alter not only the magnitude but also the direction of strategic incentives. This resonates with Rogowski and Lange's [20] systematic review, which identified 68 Prisoner's Dilemma applications in healthcare and noted that many rest on the simplifying assumption of symmetric players. From a pedagogical standpoint, this asymmetry is valuable rather than problematic: it confronts students with the realization that the "correct" strategy depends on one's structural position, which is the kind of contextual judgment the simulation aims to cultivate.

The Axelrod-style tournament results reproduce a classical finding: reciprocity-based strategies outperform both unconditional cooperation and persistent defection. Across 22 strategies and 96,800 simulation runs, Forgiving Tit-for-Tat ranked first (10.87M TL), which indicates that selective forgiveness, cooperating by default and retaliating only against the most aggressive behavior, performs best in this stochastic environment, consistent with Axelrod's conclusions [22,23]. The narrow margin between Forgiving Tft and standard Tft (0.15M TL) suggests that, under noisy signals where stochastic shocks can mimic deviations, forgiveness buffers against unnecessary retaliatory spirals. That the game reproduces this well-established result on its own is itself a form of validation, since it confirms that the simulation behaves as a genuine repeated strategic interaction rather than an arbitrary scoring system.

The cooperation premium of 24.1% (20.21M vs. 16.28M TL in total industry NPV), statistically significant ($t > 350$, $p < 0.001$) across 1000 Monte Carlo simulations, measures the welfare cost of strategic rivalry in the calibrated environment. Gong et al. [18], applying evolutionary game simulation to China's healthcare reform, likewise found that cooperative equilibria yield higher welfare but need institutional mechanisms to sustain them. Our framework complements such macro-level analyses by offering a micro-level environment in which this cooperation–competition tension can be experienced and examined directly. As Roth [21] argued, game theory is not only an analytical instrument but also an engineering tool for designing institutions and environments, and the calibrated simulation is one instance of such design, built to make an abstract strategic tension concrete and explorable.

4.3. Instructional Design and Application

4.3.1. A Proposed Implementation Pathway

We built the calibrated environment to drive a strategic-competition learning activity for students in healthcare management and in nutrition and dietetics, fields in which a well-documented gap separates clinical training from the business and financial competencies that practice demands. Cluskey et al. [9] observed that management training in dietetics often fails to convey the importance or the applicability of management skills, a concern later echoed by Donnelly et al. [11], who found that accredited curricula give inadequate exposure to business management, entrepreneurship, and financial decision-making, and by educators who report inconsistent implementation of these competencies across institutions [12]. The ACEND Future Education Model standards, which explicitly include management and leadership skills [13], signal a growing recognition of this gap. Our framework addresses it by embedding strategic and financial reasoning in a competitive environment whose consequences are made immediately visible through NPV, in line with Kolb's [24] experiential learning theory and with evidence that simulation improves self-efficacy and higher-order thinking relative to traditional instruction [25,26].

We describe the intended instructional design here as a prospective application, not as a result established by this paper. The framework treats “teaching strategic competition” as the development of four competencies: reasoning about strategic interdependence; weighing short-term gains against long-term value through NPV; tracing how operational decisions propagate through satisfaction and reputation, that is, systems thinking; and distinguishing individually rational from collectively efficient outcomes. It supports three modes of engagement for different audiences. In the decision-environment mode, students choose strategies through a spreadsheet or browser interface and interpret outcomes without touching the underlying equations; in the modeling mode, they examine the governing equations; and in the computational mode, they work directly with the open-source code.

The activity is built around a dual-role structure: each team manages both the established Center A and the new entrant Center B in separate rounds, and so experiences firsthand how structural position reshapes effective strategy. Role-switching of this kind has precedent in health-policy simulation, where McFarland et al. [29] showed the engagement and learning value of competitions that assign teams to different system roles, and in management simulation more broadly, where Lim et al. [30] reported gains in entrepreneurial attitudes among nursing students.

The activity ends with a class-wide Axelrod-style tournament and a structured debriefing on the winning strategies and the rationale for cooperation. The same feedback logic that operates inside the simulated market, where satisfaction and reputation feed back into competitive position, therefore also operates at the level of the learning activity.

Among existing game-based approaches to healthcare management education, the most comprehensive review is that of Chatzea et al. [32], who identified 36 serious games but found that most target operational skills such as scheduling and resource allocation rather than strategic competition, with financial dimensions especially underdeveloped. Our framework occupies this underserved space: its NPV-based metric integrates pricing, marketing, investment, and cost decisions into a single financial outcome that mirrors the perspective of a chief financial officer, and its open-source implementation offers the transparency and flexibility that Heyworth-Thomas [28] identified as advantages of facilitator-led simulations over proprietary platforms.

4.3.2. What the Simulation Is Designed to Teach

Before turning to the specific concepts the simulation is intended to teach, we outline how a learning activity built on it might be organized. Figure 6 sketches a proposed pedagogical pathway for classroom deployment of the calibrated simulation, from the initial briefing through strategy design, gameplay, the class-wide tournament, and a closing debriefing.

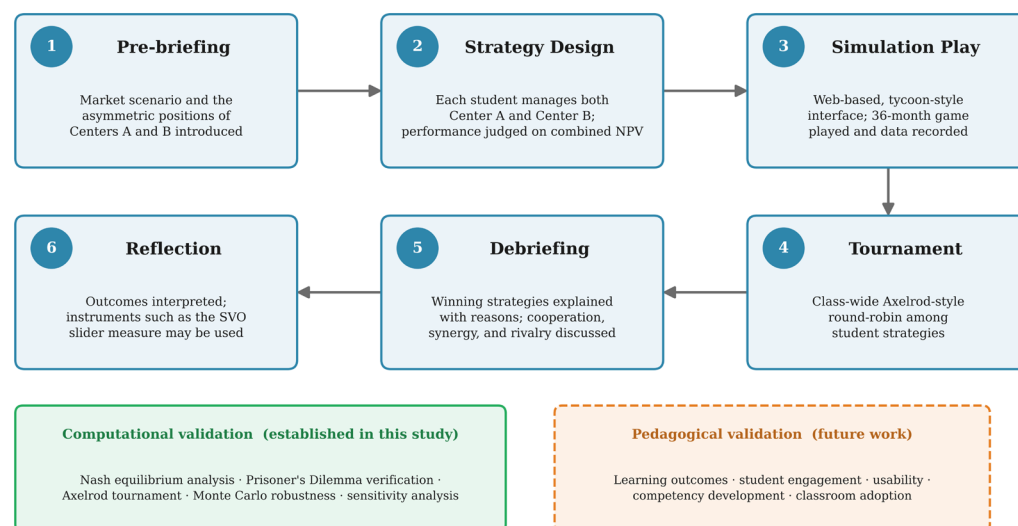


Figure 6. A proposed pedagogical implementation pathway for classroom deployment of the calibrated simulation. The sequence is illustrative and non-prescriptive: students are briefed on the asymmetric market scenario, design strategies for both Center A and Center B (evaluated on combined NPV), play the 36-month game through a web-based interface, compete in a class-wide tournament, and engage in a structured debriefing and reflection. The lower bands distinguish the computational validation established in this study from the pedagogical validation that remains for future work.

We present this pathway as a possibility rather than a validated protocol; what the present study contributes is the calibrated and computationally validated game on which such an activity would depend. The simulation's value as a learning environment rests on the correspondence between its mechanisms and the real strategic and financial concepts they represent. We make this correspondence explicit in Table 8, which links each simulation component to the real-world concept it models and to the reasoning it is intended to develop in students. We present these as intended learning outcomes rather than demonstrated ones; their empirical assessment belongs to the separate study described above.

Table 8. Correspondence between simulation components, the real-world concepts they represent, and their intended learning outcomes.

Simulation Component	Real-World Concept Represented	Intended Learning Outcome
Pricing strategy (S1–S4)	Price competition and differentiation	Explain how price level shapes both demand and profit, and evaluate the trade-off between short-term gains and long-term value erosion from aggressive pricing
Marketing investment (Paz 0–Paz 3)	Marketing expenditure and competitive neutralization	Assess the cost–benefit trade-off of marketing expenditure and account for a competitor's partial neutralization of one's own marketing
Net present value (NPV)	Time value of money and financial decision-making	Apply discounted cash-flow reasoning to compare strategies over time and interpret outcomes from a chief financial officer's perspective
Employee satisfaction and Human-resource management and the capacity–burnout	Human-resource management and the capacity–welfare link	Trace how sustained overuse of capacity triggers burnout and reduces capacity, and anticipate this feedback loop when setting strategy

Reputation dynamics	Brand and reputation management	Explain how price consistency and customer satisfaction build reputation, and predict how reputation feeds back into market share
Stochastic shocks	Market uncertainty and risk	Recognize how external shocks disrupt plans, and design strategies that remain robust to events outside the firm's control
Dual-role (Center A and Center B)	Structural position and strategic context	Compare how the same strategy yields different outcomes by structural position, and adapt strategy to leading versus entering a market
Repeated game and tournament	Cooperation, reciprocity, and long-term thinking	Evaluate the long-run value of cooperation, the deterrent role of retaliation, and the long-term cost of exploiting a competitor

Each mechanism in the simulation was included not for descriptive completeness but because it carries a specific instructional purpose. Pricing strategy exposes the tension between short-term volume gains and long-term value erosion; the net present value metric compels students to reason about the time value of money from a chief financial officer's perspective; the employee satisfaction and burnout loop demonstrates that operational pressure has downstream consequences for capacity and competitive position; and the repeated-game tournament structure makes the long-run cost of exploiting a competitor visible. The dual-role design, in which each student manages both the established Center A and the new entrant Center B, is intended to teach that effective strategy is conditional on structural position rather than universal. Social value orientation, which shapes whether students approach the game cooperatively or competitively, may be examined through instruments such as the SVO Slider Measure [46], an approach that has been applied in game-theoretic studies of cooperative and competitive decision-making in both crisis and traffic settings [47,48].

The purpose of this paper is to establish that the game underlying these intended outcomes is balanced, fair, and strategically valid. A learning activity built on an arbitrary or unbalanced game would forfeit its instructional value; this is why the calibration and validation reported in the preceding sections were a necessary first step, and why we conducted the simulations in this study before undertaking the empirical educational evaluation that will follow.

4.4. Limitations and Future Research

The main limitation concerns evidence of learning. This paper establishes the computational and game-theoretic validity of the simulation, but it does not test pedagogical effectiveness. Whether the environment produces measurable gains in students' strategic reasoning, financial literacy, or self-efficacy must be determined through controlled educational research with pre-post designs, following approaches such as those of Tompson and Dass [25] and Laverie et al. [26]. That evaluation is the focus of separate, ongoing work; we deliberately address the soundness of the underlying game first.

A further boundary of the framework is its use of static strategy selection: each center commits to a single pricing strategy for the full 36-month horizon. This keeps the game analytically tractable and easy to teach, but it does not capture the dynamic adjustment that real managers make. Later versions (SY142-Game-Theory-2 and beyond) will add month-by-month strategy revision, which will allow adaptive decision-making in response to observed competitor behavior and market feedback.

The two-player structure also limits what the model can represent, since real markets often involve more than two competitors. We chose a duopoly to isolate the essential Prisoner's Dilemma tension and to keep the game clear; multi-player extensions, which would allow the study of coalition formation and free-riding, are planned for later versions.

Contextual calibration is another consideration. The parameters reflect current market conditions in metropolitan Türkiye, including Turkish Lira price levels, local seasonal demand patterns, and institutional features, such as the Social Security Institution support mechanisms. The mathematical structure is general, but applying it to other national contexts would require recalibration. The modular parameter architecture (Section 2.1) and the open-source repository are intended to make this straightforward, and guidance for cross-context recalibration is given in Section 2.1.

The stochastic shock model is also a simplification. It treats positive and negative shocks as equally probable, so their expected impact on mean NPV is approximately zero. Some real environments instead show systematic biases toward adverse disruptions or favorable trends; adding trend components or regime-switching dynamics would improve realism at the cost of greater complexity.

A final consideration is competitive balance. In the calibrated baseline, the established provider (Center A) consistently outperforms the new entrant (Center B) across Monte Carlo realizations, reflecting the structural disadvantages deliberately built into Center B. This realistically captures the difficulty facing market entrants, but it may shape the experience of students assigned only to Center B. The dual-role design offsets this by having every team manage both centers, and future versions may add equalizing mechanisms, such as subsidies for new entrants or staged capacity-investment options, that let Center B close the structural gap over time.

5. Conclusions

This study presented SY142-Game-Theory-1, a computational simulation framework that models strategic competition between two asymmetric healthy living centers as a 36-month repeated Prisoner's Dilemma. Three results stand out. The competitive interaction produces a valid and distinctly asymmetric Prisoner's Dilemma, in which the established provider faces the classical temptation to defect while the new entrant's rational incentive aligns with cooperation. Reciprocity-based strategies, and Forgiving Tit-for-Tat in particular, consistently outperform both unconditional cooperation and persistent defection. Mutual cooperation yields a 24.1% welfare premium over the Nash equilibrium, a measure of the cost of strategic rivalry in health service markets.

These results concern the design of the game rather than its effect on learners. The framework's value for education lies in making strategic and financial reasoning visible through a single NPV outcome, which suits courses such as Health Services Financial Management, Strategic Management in Healthcare, and Health Economics and gives students hands-on experience with discounted cash flow analysis, cost–revenue evaluation, and long-term investment appraisal, competencies that bodies such as ACEND increasingly expect of dietetics graduates [13]. Whether this translates into measurable gains in students' strategic reasoning, financial literacy, or self-efficacy remains to be tested empirically, and that evaluation is the focus of separate, ongoing work.

Beyond a single course, the same environment can support inter-university tournaments of the kind described by McFarland et al. [29] and professional development for practicing managers, and its open-source implementation lets other groups recalibrate it for related health service settings. Used in these ways, the framework provides health service management education with a rigorous and transparent setting in which abstract economic concepts become concrete managerial decisions.

Author Contributions: Conceptualization, S.Y.; methodology, S.Y.; software, S.Y.; validation, S.Y.; formal analysis, S.Y.; investigation, S.Y.; resources, S.Y.; data curation, S.Y.; writing—original draft preparation, S.Y.; writing—review and editing, S.Y. and A.M.G.; visualization, S.Y.; supervision,

A.M.G.; project administration, S.Y.; funding acquisition, S.Y. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding. Acibadem Mehmet Ali Aydinlar University only provided financial support for the article processing charge.

Data Availability Statement: The simulation source code (R), output data (CSV), and computational workspace are publicly available at: <https://github.com/sy142/SY142-Game-Theory-1> (accessed on 18 June 2026).

Acknowledgments: During the preparation of this manuscript, the authors used ChatGPT 5.5 (OpenAI) for the purposes of generating illustrative icons embedded in the conceptual framework diagram (Figure 1), and Claude Opus 4.6 Extended (Anthropic) for the purposes of translation support and error checking. The authors have reviewed and edited all output and take full responsibility for the content of this publication.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

ACEND	Accreditation Council for Education in Nutrition and Dietetics
CV	Coefficient of Variation
NPV	Net Present Value
PD	Prisoner's Dilemma
SD	Standard Deviation
SVO	Social Value Orientation
TfT	Tit-for-Tat
TL	Turkish Lira

References

1. Ünal, E.; Yılmaz, S. Healthcare Sector Dynamics in Turkey (2002–2022): Trends, Breakpoints, and Policy Implications (Privatization in the Hospital Sector). *Healthcare* **2025**, *13*, 622. <https://doi.org/10.3390/healthcare13060622>.
2. Akgis İlhan, O. Türkiye’de Sağlık Hizmetleri ve Hastanelere Erişebilirliğin Mekansal Profili: Sosyal Refah Açısından Bir Analiz. *Ege Coğrafya Derg. (ECD)* **2020**, *29*, 259–271.
3. İncedere, L.; Ünal, E. Tedavi Hizmetlerine Erişim Açısından Özel Hastane Sektörü. In Proceedings of the 8. Sağlık ve Hastane İdaresi Kongresi, Girne, Nordzypern, 10–12 September 2014; pp. 89–90.
4. Boz, C.; Yılmaz, S.; Özsan, H. Gelişmekte Olan Ülkelerin Sağlık Sistemi Göstergelerinin Karşılaştırmalı Analizi. *Health Care Acad. J.* **2022**, *9*, 336–343. <https://doi.org/10.52880/sagakaderg.1180248>.
5. World Health Organization. *Obesity: Preventing and Managing the Global Epidemic*; Report of a WHO Consultation; World Health Organization: Geneva, Switzerland, 2000.
6. Yılmaz, S.; Boz, C.; Eren, F.A.; Günel, A.M. Unraveling the Causal Relationship Between Non-Communicable Diseases, Obesity, and Health Expenditure: Insights from the Toda–Yamamoto Approach. *Healthcare* **2024**, *13*, 1. <https://doi.org/10.3390/healthcare13010001>.
7. Kolakowski, H.; Shepley, M.M.; Valenzuela-Mendoza, E.; Ziebarth, N.R. How the COVID-19 Pandemic Will Change Workplaces, Healthcare Markets and Healthy Living: An Overview and Assessment. *Sustainability* **2021**, *13*, 10096. <https://doi.org/10.3390/su131810096>.
8. Sirur, A.J.N.; Pillai, K.R. Pricing of Hospital Services: Evidence from a Thematic Review. *Health Econ. Policy Law* **2024**, *19*, 234–252. <https://doi.org/10.1017/S1744133123000397>.
9. Cluskey, M.; Gerald, B.; Gregoire, M. Management in Dietetics: Are We Prepared for the Future? *J. Am. Diet. Assoc.* **2007**, *107*, 386–389. <https://doi.org/10.1016/j.jada.2006.12.015>.
10. Donnelly, J.; Lane, R.; Walsh, L.; Hughes, R. Private Practice Dietetics: A Scoping Review of the Literature. *Nutr. Diet.* **2024**, *81*, 536–551. <https://doi.org/10.1111/1747-0080.12877>.

11. Donnelly, J.; Walsh, L.; Hughes, R.; Lane, R. Preparing Graduate Dietitians for Private Practice: Analysing Publicly Available Curriculum Information From Accredited Australian Dietetics Courses. *J. Hum. Nutr. Diet.* **2025**, *38*, e70074. <https://doi.org/10.1111/jhn.70074>.
12. Donnelly, J.; Walsh, L.; Hughes, R.; Lane, R. Private Practice Dietetics Workforce Development: Experiences and Perceptions of Australian Academic Educators. *J. Hum. Nutr. Diet.* **2025**, *38*, e70126. <https://doi.org/10.1111/jhn.70126>.
13. Worsfold, L.; Kattelman, K.; Wright, J.; Gregoire, M.; Cowie, E.; Swain, J.; Wang, L.; AbuSabbah, R. Development of the Competencies for the Future Education Model Accreditation Standards for Graduate Degree Programs in Nutrition and Dietetics. *J. Acad. Nutr. Diet.* **2026**, *126*, 156353. <https://doi.org/10.1016/j.jand.2026.156353>.
14. Von Neumann, J.; Morgenstern, O. *Theory of Games and Economic Behavior*; Princeton University Press: Princeton, NJ, USA, 1944.
15. Nash, J.F. Equilibrium Points in N-Person Games. *Proc. Natl. Acad. Sci. USA* **1950**, *36*, 48–49. <https://doi.org/10.1073/pnas.36.1.48>.
16. Bisceglia, M.; Cellini, R.; Grilli, L. Regional Regulators in Health Care Service under Quality Competition: A Game Theoretical Model. *Health Econ.* **2018**, *27*, 1821–1842. <https://doi.org/10.1002/he.3805>.
17. Bisceglia, M.; Cellini, R.; Grilli, L. Quality Competition in Healthcare Services with Regional Regulators: A Differential Game Approach. *Dyn. Games Appl.* **2019**, *9*, 1–23. <https://doi.org/10.1007/s13235-018-0245-y>.
18. Gong, H.; Wang, X.; Zhang, T.; Li, J.; Chen, B. How Can China's New Health Care Reform Promote the Balance of Interest Game?—Based on Game Evolution and Simulation Analysis. *Risk Manag. Healthc. Policy* **2023**, *16*, 1435–1454. <https://doi.org/10.2147/RMHP.S422296>.
19. Okeke, S.I. Innovative Mathematical Application of Game Theory in Solving Healthcare Allocation Problem. *Proc. Niger. Soc. Phys. Sci.* **2025**, *2*, 161–168. <https://doi.org/10.61298/pnspsc.2025.2.161>.
20. Rogowski, W.; Lange, O. The Prisoner's Dilemma: An Adequate Concept for Ethical Analysis in Healthcare? A Systematic Search and Critical Review. *J. Bus. Ethics* **2022**, *177*, 63–77. <https://doi.org/10.1007/s10551-020-04643-w>.
21. Roth, A.E. The Economist as Engineer: Game Theory, Experimentation, and Computation as Tools for Design Economics. *Econometrica* **2002**, *70*, 1341–1378. <https://doi.org/10.1111/1468-0262.00335>.
22. Axelrod, R.M. *The Evolution of Cooperation*; Basic Books: New York, NY, USA, 1984.
23. Axelrod, R.M. *The Complexity of Cooperation: Agent-Based Models of Competition and Collaboration*; Princeton University Press: Princeton, NY, USA, 1997.
24. Kolb, D.A. *Experiential Learning: Experience as the Source of Learning and Development*, 2nd ed.; Pearson Education, Inc.: Englewood Cliffs, NJ, USA, 2015.
25. Tompson, G.H.; Dass, P. Improving Students' Self-Efficacy in Strategic Management: The Relative Impact of Cases and Simulations. *Simul. Gaming* **2000**, *31*, 22–41. <https://doi.org/10.1177/104687810003100102>.
26. Laverie, D.A.; Hass, A.; Mitchell, C. Experiential Learning: A Study of Simulations as a Pedagogical Tool. *Mark. Educ. Rev.* **2022**, *32*, 3–17. <https://doi.org/10.1080/10528008.2020.1843360>.
27. Gatti, L.; Ulrich, M.; Seele, P. Education for Sustainable Development through Business Simulation Games: An Exploratory Study of Sustainability Gamification and Its Effects on Students' Learning Outcomes. *J. Clean. Prod.* **2019**, *207*, 667–678. <https://doi.org/10.1016/j.jclepro.2018.09.130>.
28. Heyworth-Thomas, E.M. Creating Experiential Learning Opportunities in Enterprise Education: An Example of a Facilitator-Led Business Simulation Game in a Taught Setting. *J. Work.-Appl. Manag.* **2023**, *15*, 173–187. <https://doi.org/10.1108/JWAM-02-2023-0018>.
29. McFarland, L.; Milstein, B.; Hirsch, G.; Homer, J.; Andersen, D.; Irving, R.; Reineke, E.; Niles, R.D.; Cawvey, E.; Desai, A.; et al. NASPAA Student Simulation Competition: Reforming the U.S. Health Care System Within a Simulated Environment. *J. Public Aff. Educ.* **2016**, *22*, 363–380. <https://doi.org/10.1080/15236803.2016.12002253>.
30. Lim, J.Y.; Kim, J.; Kim, S. The Effects of the Start-Up NurseS Program on Nursing Students Using Management Strategy Simulation. *Nurse Educ. Today* **2021**, *105*, 105020. <https://doi.org/10.1016/j.nedt.2021.105020>.
31. Satish, U.; Streufert, S.; Barach, P. Assessing and Improving Medical Competency: Using Strategic Management Simulations. *Simul. Gaming* **2001**, *32*, 156–163. <https://doi.org/10.1177/104687810103200204>.
32. Chatzea, V.E.; Panagiotakis, C.; Vidakis, N.; Fanourgiakis, J. Be Ahead of the Game! A Systematic Review on Serious Games Aiming to Enhance Hospital Management Knowledge and Health Care Administrative Skills Acquisition. *Games Health J.* **2026**, *15*, 28–41. <https://doi.org/10.1177/2161783X251361157>.
33. Wickham, H. Programming with Ggplot2. In *Elegant Graphics for Data Analysis*; Springer: Berlin/Heidelberg, Germany, 2016; pp. 241–253.
34. Wickham, H.; Chang, W.; Wickham, M.H. Package “Ggplot2”. Create Elegant Data Visualisations Using the Grammar of Graphics. Version 2. Available online: <https://ggplot2.tidyverse.org/reference/ggplot2-package.html> (accessed on 5 May 2026).

35. Porter, M.E. *Competitive Strategy: Techniques for Analyzing Industries and Competitors*; Free Press: New York, NY, USA, 1980.
36. Maslach, C.; Schaufeli, W.B.; Leiter, M.P. Job Burnout. *Annu. Rev. Psychol.* **2001**, *52*, 397–422. <https://doi.org/10.1146/annurev.psych.52.1.397>.
37. Mankiw, N.G. Small Menu Costs and Large Business Cycles: A Macroeconomic Model of Monopoly. *Q. J. Econ.* **1985**, *100*, 529–537. <https://doi.org/10.2307/1885395>.
38. Luce, R.D. *Individual Choice Behavior: A Theoretical Analysis*; Wiley: Hoboken, NJ, USA, 1959.
39. Dorfman, R.; Steiner, P.O. Optimal Advertising and Optimal Quality. *Am. Econ. Rev.* **1954**, *44*, 826–836.
40. Buttle, F.A. Word of Mouth: Understanding and Managing Referral Marketing. *J. Strateg. Mark.* **1998**, *6*, 241–254. <https://doi.org/10.1080/096525498346658>.
41. Gapenski, L.C.; Reiter, K.L. *Healthcare Finance: An Introduction to Accounting & Financial Management*, 6th ed.; Health Administration Press: Chicago, IL, USA; Association of University Programs in Health Administration: Washington, DC, USA, 2016.
42. Brealey, R.A.; Myers, S.C.; Allen, F. *Principles of Corporate Finance*, 13th ed.; McGraw-Hill Education: Columbus, OH, USA, 2020.
43. Maslach, C.; Leiter, M.P. Understanding the Burnout Experience: Recent Research and Its Implications for Psychiatry. *World Psychiatry* **2016**, *15*, 103–111. <https://doi.org/10.1002/wps.20311>.
44. Fombrun, C.J. *Reputation: Realizing Value from the Corporate Image*; Harvard Business School Press: Brighton, MA, USA, 1996.
45. Rapoport, A.; Chammah, A.M. *Prisoner's Dilemma: A Study in Conflict and Cooperation*, 2nd ed.; University of Michigan Press: Ann Arbor, MI, USA, 1970.
46. Murphy, R.O.; Ackermann, K.A.; Handgraaf, M.J.J. Measuring Social Value Orientation. *Judgm. Decis. Mak.* **2011**, *6*, 771–781. <https://doi.org/10.1017/S1930297500004204>.
47. Peng, F.; Sun, H.; Sun, C.; Shi, H.; Lu, W.; Li, H.; Yang, J.; Chen, S. Game-Theoretic Lane-Change Decision-Making for Autonomous Vehicles Based on Social Value Orientation. *Electronics* **2026**, *15*, 1914. <https://doi.org/10.3390/electronics15091914>.
48. Shi, X.; Qiu, L.; Fang, Z.; Liu, X.; Du, Y. A Game Mechanism of Individual Value Decision-Making Based on SVO Differences. *Complexity* **2020**, *2020*, 6530847. <https://doi.org/10.1155/2020/6530847>.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.