

# Using Game Theory and Price Elasticity in Tourism in the U.S.

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*This research aims to employ game theory along with price and income elasticities of demand to reveal hidden strategies for maximizing revenue among competitors in the hotel market, focusing on New York and San Francisco over 20 years. Results suggest that demand for hotels in New York is characterized by luxury-driven income but responsive pricing, while San Francisco exhibits lower income levels but demonstrates Giffen elasticity. Both markets present opportunities for maximizing revenue per available room through a mutually beneficial strategy whereby average daily rates increase in New York and decrease in San Francisco.*

*Keywords: game theory, average daily rate, revenue per available room, Nash equilibrium*

## **INTRODUCTION**

A lack of comprehensive understanding of game theory and price-income elasticities in hotel demand poses significant challenges in maximizing revenue within the hotel industry. While benchmarking hotel performance against both competitive aggregates and local markets remains a standard practice for hotel managers, the unpredictable responses of competitors create uncertainty. To address this gap, establishing matrix tables between competing players becomes essential. Utilizing such matrices allows hotel managers to gain clearer insights into competitive strategies. Game theory, which explores conflict and cooperation models among decision-makers, is a valuable tool for hoteliers to develop strategic approaches based on data analysis. Thus, this study aims to apply game theory alongside price and income elasticities to enable hoteliers to analyze and forecast both competitive aggregates and local market dynamics more effectively.

The subsequent sections of the paper will delve into the application of game theory and macroeconomics, focusing on price and income dynamics, to develop a theoretical framework for the top two hotel markets in the US: San Francisco and New York. Using game matrices and time series regression analysis, efforts have been made to identify potential win-win scenarios within the context of game theory and the price and income elasticities specific to San Francisco and New York. Lastly, the study will analyze and interpret the findings before presenting concluding remarks.

## LITERATURE

### Game Theory

John von Neumann (2007) introduced game theory to illuminate how individuals navigate decision-making processes and adapt to uncertainty, aiming to maximize their gains. This theory centers around three fundamental concepts: best response, dominant strategy, and Nash equilibrium. The best response refers to the action yielding a player a higher payoff relative to their opponent, while a dominant strategy entails a player's choice leading to a superior payoff regardless of the opponent's move. Nash equilibrium denotes the situation where each player's strategy represents the optimal choice when compared to others'. Game theory employs mathematical models directed at optimizing benefits across various scenarios in the Nobel prize winners (Mossetti, 2006, Neumann, 2007, Nobel Prize winners, 2014).

Drawing from insights by Levin (2016), game theory integrates three economic theories: Decision theory, General Equilibrium theory, and Mechanism Design theory (Hurwicz & Reiter, 2006). Decision theory explains how individuals make choices based on their income, while General Equilibrium theory examines buyer-seller interactions shaped by pricing mechanisms. Mechanism Design theory explores how sellers structure payments to employees based on pricing strategies vis-à-vis buyers. Tran (2015, 2021, 2023) applied game theory in tourism economics to investigate unemployment, luxury hotel demand, and growth models in the US. Tversky and Kahneman (1992) expanded decision theory into prospect theory, shedding light on decision-making under risk considerations. Keynes (1936) developed macroeconomic principles addressing unemployment and government intervention to maintain supply-demand equilibrium. Hurwicz (2007) further advanced Mechanism Design theory, addressing conflict resolution in buyer-seller interactions, encompassing costs, taxes, employee compensation, satisfaction, and auction dynamics.

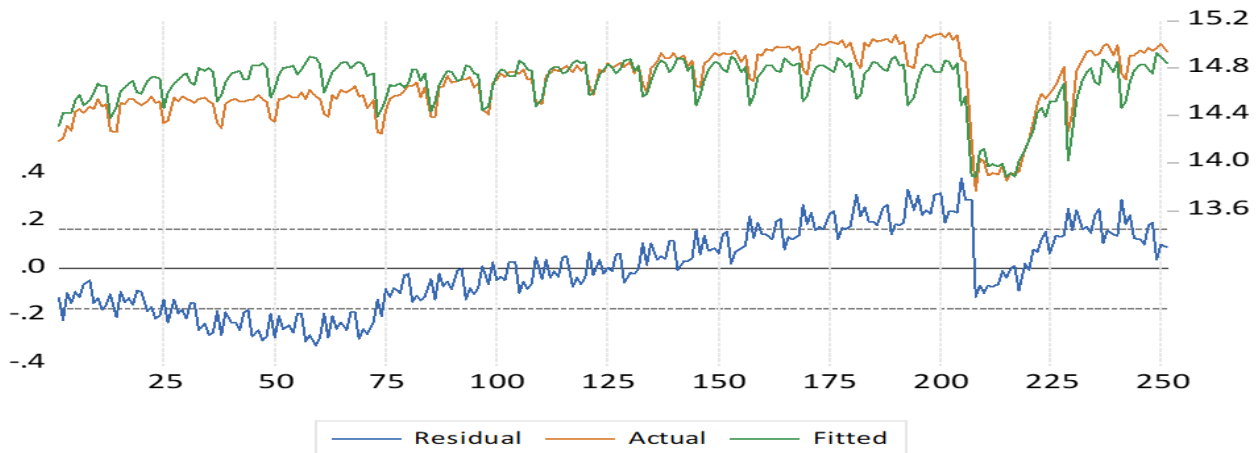
The current study has devised a straightforward game theory model centered on several key concepts: Player 1, Player 2, Average Daily Rate (ADR), Occupancy (OCC), Revenue per available room (RevPAR), and Index. Initially, decision-makers are furnished with general market information encompassing supply, demand, and revenue. Subsequently, they can assess their performance through percent change metrics or compare their hotel's metrics with their competitive set using index ratios.

The strategic game's algorithm comprises six components

1. Set of players: The two players in this game are the New York hotel market and the competing San Francisco market.
2. Action sets: Each player can either increase or decrease ADRs, denoted as "I" and "D" respectively.
3. Strategy Profile: In this two-player game, the strategy profile is defined as the combination of actions chosen by each player.
4. Action profile: Four possible action profiles are identified based on ADR changes.
5. Set of Outcomes: The superset of action profiles constitutes the set of outcomes.
6. Payoff of players: Each player's payoff, measured by RevPAR, is determined by the chosen action profile.

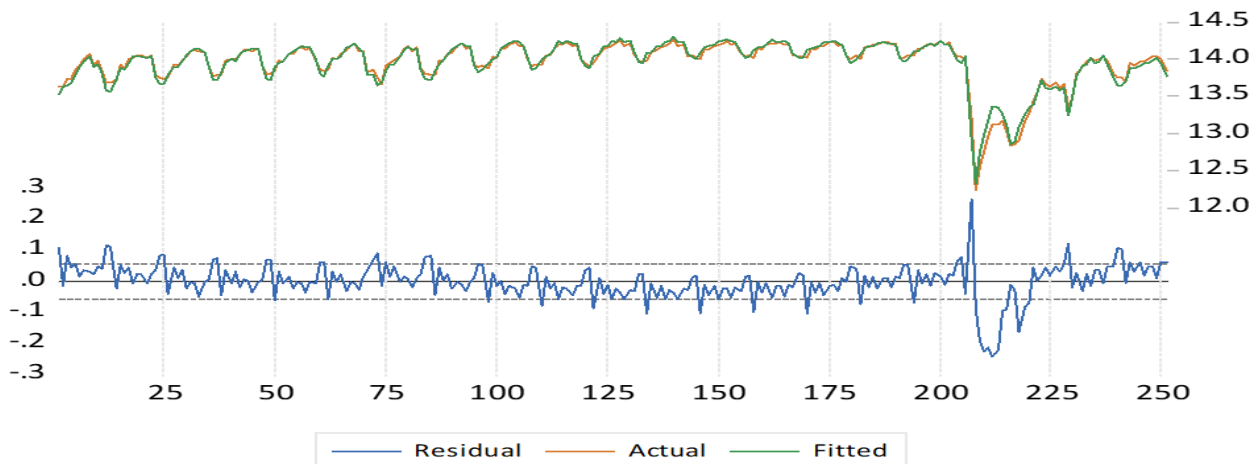
Additionally, the study employs time series analysis to mitigate spurious correlations arising from trends, seasonality, and irregularities in the data. The analysis reveals that (1) insignificant predictor in the model, the ADR growth of New York in Figure 1 since the residual is out of the boundary limit and (2) the significant predictor ADR of San Francisco markets, after incorporating time trend adjustments in Figure 2 since the residual is within the boundary limit.

**FIGURE 1**  
**RELATIONSHIP OF DEMAND, AVERAGE DAILY RATE, AND REVENUE PER AVAILABLE ROOM IN LOG IN NEW YORK DURING THE 20-YEAR PERIOD (2003-2023)**



Source: Author's calculation using E-VIEWS based on data of Smith Travel Research (2024)

**FIGURE 2**  
**RELATIONSHIP OF DEMAND, AVERAGE DAILY RATE, AND REVENUE PER AVAILABLE ROOM IN LOG IN SAN FRANCISCO DURING THE 20-YEAR PERIOD (2003-2023)**



Source: Author's calculation using E-VIEWS based on data of Smith Travel Research (2024)

*Hypotheses*

Within the STAR framework, the graphical representations of Average Daily Rate (ADR) and Revenue per Available Room (RevPAR) logarithms for New York and San Francisco are depicted in Figure 1 and Figure 2, respectively. Based on the insights gleaned from these figures, we propose four research hypotheses as follows:

**H1:** *The price elasticity of demand in New York exhibits elasticity, whereas in San Francisco, it demonstrates Giffen elasticity.*

**H2:** *The income elasticity of demand in New York reflects luxury income, while in San Francisco, it indicates inferior income.*

*H3: New York possesses a dominant strategy associated with an increase in ADR.*

*H4: A Nash equilibrium is reached for both New York and San Francisco when ADR rises in New York and decreases in San Francisco.*

## **METHODOLOGY**

Sample: San Francisco was chosen as a participant in the competitive scenario against an opponent representing the average metrics of New York in the United States' meeting business market, given their prominence as leading business hotel markets in the country.

### **Average Daily Rate (ADR), Revenue per Available Room (RevPAR), and Occupancy (OCC)**

These three metrics are pivotal for evaluating hotel management effectiveness, rooted in the fundamental concepts of Supply, Demand, and Revenue. Supply is quantified by the number of room nights available annually, while Demand is gauged by the number of room nights sold within the same timeframe. Revenue is tallied as the total room sales over the year. Derived from these metrics, hotel operators strategize their business approaches based on ADR, OCC, and RevPAR. ADR represents the ratio between Revenue and Demand, OCC indicates the ratio between Demand and Supply, and RevPAR signifies the ratio between Revenue and Supply.

In this research, we aim to utilize game theory to elucidate the dominant strategy of a prominent meeting destination market, represented by New York, in its competition against other meeting market destination contenders, exemplified by San Francisco. The actions undertaken by the primary player, New York, constitute the rows of a matrix, while those of the secondary player, San Francisco, form the columns. Each entry in the matrix represents a pair of numbers signifying the payoff measured by Revenue per available room (RevPAR) for the respective players; higher RevPAR values indicate more favorable outcomes.

The two hotel entities, New York and San Francisco, engaged in the same meeting market within the U.S., would deliberate on pricing strategies (increase or decrease) for short- and long-term planning. Consequently, there are two matrices delineating pricing games: one for short-term and another for long-term plans. Each matrix comprises two rows and two columns, each denoting a pricing adjustment (increase or decrease) for New York and each column representing the corresponding adjustments for San Francisco.

In the pricing game between New York and San Francisco, the players act rationally as individuals, selecting outcomes that serve their own best interests. Each market's "Pay-off" in this study is gauged by the enhancement of their Revenue per available room (RevPAR) from inbound tourism. The game may manifest as either a zero-sum (winner/loser) or a non-zero-sum (win-win) scenario. A win-win game facilitates mutual profitability for all participants, where New York and San Francisco aim to bolster their market share and develop RevPAR through integrative outcomes. Conversely, in a zero-sum game, gains (or losses) of RevPAR by one participant are counterbalanced by others' losses (or gains), resulting in a distributive outcome where New York and San Francisco vie for shares of hotel revenue.

To mitigate seasonal variations, we applied time series methodology, incorporating four dummy variables to represent four scenarios of ADR percent change, namely: (1) NYADR increases and SFADR increases, (2) NYADR increases and SFADR decreases, (3) NYADR decreases and SFADR increases, and (4) NYADR decreases and SFADR decreases. These dummy variables were then multiplied with the corresponding RevPAR percent change for New York and San Francisco, yielding four RevPAR percent changes to signify the performance of each city in the matrix across the scenarios above (Table 1 and Table 2)

Results

**TABLE 1**  
**TWO MATRICES OF NEW YORK AND SAN FRANCISCO IN THE 20-YEAR PERIOD**  
**(2003-2023)**

New York \ San Francisco	ADR Increase	ADR Decrease
ADR Increase	-0.36 \ 0.38	21.2 \ 3.14
ADR Decrease	-3.51 \ -0.78	-0.13 \ 0.11

Source: Author’s calculation using time series in EViews

Table 2. Price elasticity of Demand (PED) and Income elasticity of Demand (YED) in New York and San Francisco during the 20-year period (2003-2023)

**TABLE 2**  
**PRICE ELASTICITY OF DEMAND (PED) AND INCOME ELASTICITY OF DEMAND (YED)**

	Price Elasticity of Demand	Income Elasticity of Demand
New York	-4.5	1.09
San Francisco	1.4	-1.44

Source: Author’s calculation using time series in EViews

The subsequent findings from the averages of the products among the dummy variables and the RevPAR of New York are as follows:

- U<sub>1i</sub> (I,I) = -0.36
- U<sub>2i</sub> (I,D) = 21.2
- U<sub>3i</sub>(D,I) = -3.51
- U<sub>4i</sub>(D,D) = -0.13

Similarly, the payoff for San Francisco is determined as follows:

- U<sub>i1</sub> (I,I) = 0.38
- U<sub>i2</sub> (I,D) = 3.14
- U<sub>i3</sub> (D,I) = -0.78
- U<sub>i4</sub> (D,D) = 0.11

Findings indicate that (1) the price elasticity of demand in New York exhibits elasticity, whereas in San Francisco, it demonstrates Giffen elasticity. (2) The income elasticity of demand in New York reflects luxury income, while in San Francisco, it indicates inferior income. (3) New York possesses a dominant strategy associated with an increase in ADR and (4) A Nash equilibrium is reached for both New York and San Francisco when ADR rises in New York and decreases in San Francisco.

The research hypotheses were supported.

**DISCUSSION**

Recent research has endeavored to address two significant gaps within the hospitality and tourism domain. One gap pertains to establishing a competition model, as evidenced by works such as those by Feeny, Hanna, and McEvoy (1996), Vail and Hultkrantz (2000), and Williams (2001). The other gap concerns the utilization of time series analysis in competitive tourist destinations, as explored in studies by Pasaca, Renzi, Pietro, & Mugion (2021), Buhalis (2000), Uysal et al. (2000), Kerim & Ucal (2020), Milhalic (2000), Kozak (2001), Ritchie and Crouch (2000), Qu, Ennew, & Sinclair (2005), Stokes (2008), Singh and Hu (2008), Song, Kim, and Yang (2010), and Lim, Min, and McAleer (2008). The present study contributes

to these contemporary debates within hospitality and tourism by integrating game theory and time series analysis for hoteliers.

The findings of this study enrich hotel literature by guiding hotel managers to incorporate game theory and time series methods into their strategic planning using the STAR approach. Consequently, it bridges the gap between Smith Travel Research (2024) and strategic practices in the hospitality industry.

### **Limitations and Recommendations for Future Research**

Despite the theoretical and practice contributions, it is essential to acknowledge a limitation of this study, namely, the overarching assumption that there will be no changes in the surrounding realities affecting international meeting flow patterns, such as wars, political conflicts, terrorism, flight accidents, or other catastrophic events. Despite this limitation, the game theory findings serve as a benchmark for shaping future meeting policies in the U.S. All major meeting markets in the U.S. stand to benefit from identifying effective strategies to contribute to the meeting industry. Incorporating game theory offers hotel managers invaluable insights for analyzing STAR data and potential applications within hotel management arenas, paving the way for future perspectives in the field.

### **REFERENCES**

- Buhalis, D. (2000). Marketing the competitive destination of the future. *Tourism Management*, 21(1), 97–116.
- Feeny, D., Hanna, S., & McEvoy, A.F. (1996). Questioning the assumptions of the “Tragedy of the Commons” model of fisheries. *Land Economics*, 72(2), 187–205.
- Hurwicz, L., & Reiter, S. (2006). *Designing Economic Mechanisms* (p.30). Cambridge.
- Kerim, K., & Ucal, M. (2020). A dynamic game theory model for tourism supply chains. *Journal of Hospitality & Tourism Research*, 45(2), 304–324.
- Keynes, J.M. (2008). *The General Theory of Employment, Interest and Money* (Chapter 19). BN Publishing. ISBN 9650060251.
- Kozak, M. (2001). Repeater’s behavior at two distinct destinations, *Annals of Tourism Research*, 28(3), 784–807.
- Levin. (2016). Retrieved from <http://levine.sscnet.ucla.edu/general/whatis.htm>
- Lim, C., Min, J., & McAleer, M. (2008). Modelling income effects on long and short haul international travel from Japan. *Tourism Management*, 29, 1099–1109.
- Milhalic, T. (2000) Environmental management of a tourist destination: A factor of tourism competitiveness. *Tourism Management*, 21(1), 65–78.
- Mossetti, R. (2006). Game theory approach on sustainable tourism. In C.A. Brebbia, & F.D. Pineda (Eds.), *Sustainable Tourism II* (pp. 337–340). Southampton, UK: WIT Press.
- Mousavi, E., Hafezalkotob, A., Makui, A., & Sayadi, M. (2021). Hotel pricing decision in a competitive market under government intervention: A game theory approach. *International Journal of Management Science and Engineering Management*, 16(2).
- Neumann, J. (2007). *Theory of Games and Economic Behavior* (60<sup>th</sup> Anniversary Commemorative Edition). Princeton University Press. ISBN: 980691130613.
- Nobel Prize Winners in Game Theory. (2014). Retrieved October 21, 2014, from <http://lcm.csa.iisc.ernet.in/gametheory/nobel.html>
- Pasca, M., Renzi, M., Pietro, L., & Mugion, R. (2021). Gamification in tourism and hospitality research in the era of digital platforms: A systematic literature review. *Journal of Service Theory and Practice*, pp. 691–737.
- Qu, R., Ennew, C., & Sinclair, T. (2005). The impact of regulation and ownership structure on market orientation in the tourism industry in China. *Tourism Management*, 26(6), 939–950.
- Ritchie, J.R.B., & Crouch, G.I. (2000). The competitive destination: A sustainability perspective. *Tourism Management*, 21(2), 1–7.

- Singh, N., & Hu, C. (2008). Understanding strategic alignment for destination marketing and the 2004 Athens Olympic Games: Implications from extracted tacit knowledge. *Tourism Management*, 29(5), 929–939.
- Smith Travel Research. (2024). Retrieved from <https://www.strglobal.com/products/star-program>
- Song, H., Kim, J., & Yang, S. (2010). Confidence intervals for tourism demand elasticity. *Annals of Tourism Research*, 37(2), 377–396.
- Stokes, R. (2008). Tourism strategy making: Insights to the events tourism domain. *Tourism Management*, 29(2), 252–262.
- Tran, X. (2015). Effects of economic factors on demand for luxury hotel rooms in the U.S. *Advances in Hospitality and Tourism Research*, 3(1), 1–17. Retrieved from [http://www.ahtrjournal.org/admin/dosyalar/9/1-manuscript.pdf#:~:text=They%20found%20that%20in%20the,\(slower\)%20than%20economic%20growth.&text=The%20study%20focuses%20on%20the,January%201998%20to%20December%202013](http://www.ahtrjournal.org/admin/dosyalar/9/1-manuscript.pdf#:~:text=They%20found%20that%20in%20the,(slower)%20than%20economic%20growth.&text=The%20study%20focuses%20on%20the,January%201998%20to%20December%202013)
- Tran, X. (2021). Economics in game theory for hotel unemployment. *Anatolia: An International Journal of Tourism and Hospitality Research*, 34(2), 210–223. <http://dx.doi.org/10.1080/13032917.2021.2005648>.
- Tran, X. (2023). Using Slutsky equation to find the hotel growth model in the destination life cycle: An empirical study in Myrtle Beach. *International Hospitality Review*. Retrieved from <https://www.emerald.com/insight/2516-8142.htm>
- Tversky, A., & Kahneman, D. (1992). Advances in prospect theory: Cumulative representation of uncertainty. *Journal of Risk and Uncertainty*, 5(4), 297–323.
- Vail, D., & Hultkrantz, L. (2000). Property rights and sustainable nature tourism: Adaptation and mal-adaptation in Dalarna (Sweden) and Maine (USA). *Ecological Economics*, 35, 223–242.