Team Evaluation and Relocation Assessment
Tampa Bay Rays

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Abstract

This report details the current financial state of the Tampa Bay Rays with respect to outflow for team payroll and inflow for revenues collected based on specific factors. The analysis completed in this report aims to identify changes the Rays can execute to improve their team performance given salary constraints, increase attendance, and to ultimately determine whether a relocation from the Tampa-St. Petersburg area will benefit revenues generated in the long-term.

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1. Introduction

As a team, the Tampa Bay Rays failed to achieve their yearly goal to qualify for the Major League Baseball (MLB) Playoffs in 2024. As an organization, the Rays valuation of $1.25 billion ranks 27th and generated revenues of $301 million ranks 28th in the league (Forbes, 2024). Additionally, on October 10, 2024, Hurricane Milton shredded their home roof at Tropicana Field, causing extensive damage both inside and outside of the stadium. The damage repairs have been assessed at $55.7 million (Topkin and Wright, 2024), forcing the Rays to quickly find a solution for the 2025 season. This resulted in a deal with the New York Yankees to play home games at their spring training facility in Tampa, George M. Steinbrenner Field (Blum and Stark, 2024).

The initial purpose of this report was to assess, analyze, and improve the Rays team competitive performance and financial state via a collaboration of proven strategies. Due to the circumstances caused by Hurricane Milton, the report was expanded to assess the effectiveness of previous team relocations and to use predictive modeling to analyze which potential location could be the best fit based on relevant descriptive factors. A relocation assessment was also considered due to the stalemate the Rays and Pinellas County, Florida currently have regarding $750+ million in county bonds requested to start the new stadium development plan in Tampa by 2028.

2. Literature Review

This report used the following resources to evaluate the Rays team performance and organizational profitability compared to the rest of the MLB. The complete list of citations is listed in the References section.

Chen, K. et al. (2023). "Pay to Play: An Analysis of Payroll and Performance in the MLB and NBA"

In a blog published in the Harvard Sports Analysis Collective, the authors evaluated how team payroll impacts wins. In their analysis, the authors defined "Relative Salary" for an MLB team and utilized the Herfindahl–Hirschman index (HHI) to measure payroll concentration among players. "Relative Salary" is discussed in section *2.1: Payroll Analysis* while the HHI process and team results are detailed in section *2.2: Payroll Concentration.*

Miller, T. (2015). "Sports Analytics and Data Science: Winning the Game with Methods and Models"

In Chapter 8, Miller defines consumer's market segmentation and how target marketing actions can increase organizational revenues. In Chapter 9, Miller uses a cost-volume-profit analysis to assess particular aspects of MLB game-day revenues from ticket, concessions, and merchandise sales. This analysis provided a basis to increase profits through various paths discussed in section *4.2: Ticketing and Promotional Strategies*. In appendix A.1, Miller details the use of Constrained Optimization methods to understand the logic supporting team decisions. The best-case/worst-case approach was used in section *4.1: Player Performance Evaluation*.

Mornat, G. and Garg, T. (2022). "Valuation Drivers of Major League Baseball Franchises: Revenue Streams, Cost Structure, and M&A Rationales."

The authors' break down specific MLB profitability metrics, including drivers of game-day attendance. Factors including: day of the week, current performance of the home team, and quality of the venue are discussed in section *4.2: Ticketing and Promotional Strategies*.

Bruggink, T. and Schiz, D. (2008). "Location Model in the National Football League: Predicting Optimal Expansion and Relocation Sites."

In their article published in *The Sport Journal, t*he authors introduce and test descriptive factors of a metropolitan area which may influence the selection of target cities for an NFL relocation or expansion via a conditional probability logit model. These factors are repeated and discussed in section *4.3: Relocation Modeling*.

2.1 Payroll Analysis

To optimize the Rays player payroll in a method which provides the maximum return, we must first explore the relationship between payroll and success in terms of wins. Since there is no salary floor or salary cap in baseball, there are substantial differences in MLB payrolls (Chen et al., 2023). To calculate team payroll, we extracted each player's 2024 salary from guaranteed contracts, summing for a total amount per team (Spotrac, 2024). The Rays team payroll for 2024 was $58,538,712. The average 2024 team payroll was $162,395,545.30 with a substantial variance of almost $273 million from the lowest (Miami Marlins) to highest team payroll (Los Angeles Dodgers). In "Pay to Play", the authors start the salary analysis by creating a variable called "Relative Salary" which is a team's player payroll in one year divided by the league

average payroll, then multiplied by 100 to normalize scores. The Rays "Relative Salary" score for the 2024 season was calculated as 36.05. By comparing "Relative Salary" to win percentage, the authors' found a correlation of 38% between money spent for player payroll and the overall win percentage of MLB teams. Based on results of a linear regression, a team with a "Relative Salary" score of 100 (where team payroll equals league average payroll) would be expected to have a win percentage of .500 or 81 wins.

Since the Rays failed to qualify for the 2024 MLB playoffs with an 80-82 record, our goal will be to optimize our payroll to generate a win total of at least 90 wins next season to ensure we qualify. This does not mean that we expect the Rays to increase team payroll by over $100 million next season, but rather determine equitable roster changes which do not drastically increase player payroll. Section *4.1: Player Performance Evaluation* compares player performance metrics based on position and offers fiscally-appropriate roster changes via trade or free agency.

2.2 Payroll Concentration

In "Pay to Play," the authors used an adaptation of the Herfindahl–Hirschman Index (HHI) to measure the payroll concentration to best answer the question of how money is

$$\text{HHI} = (\text{(salary of player 1)} / \text{(team payroll)})^2 + (\text{(salary of player 2)} / \text{(team payroll)})^2 + \ldots + (\text{(salary of player n)} / \text{(team payroll)})^2,$$

Figure 1: HHI Adaptation to MLB

distributed among a team's players (Chen, 2023). The formula for the index is defined above in figure 1, which will be reused in this analysis. The authors also found it beneficial to view the

measure of a team's payroll concentration in conjunction with winning percentage and overall payroll. This analysis this analysis can be seen in figure 2 below for the 2024 season.

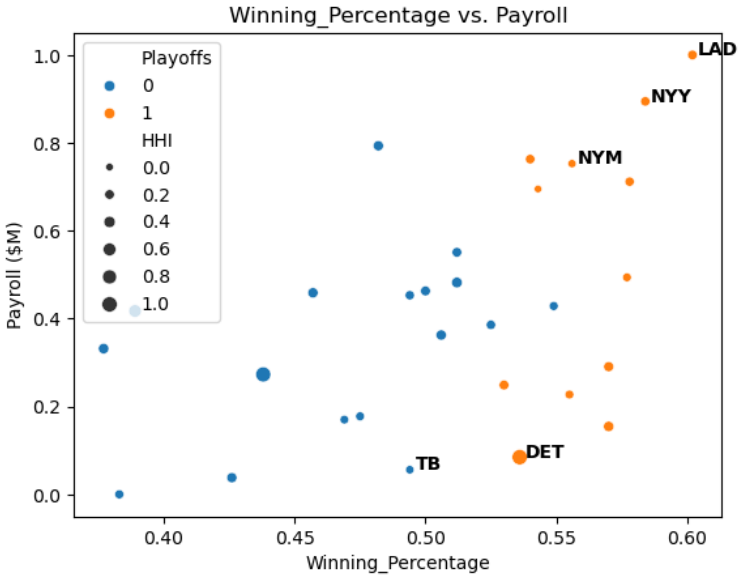


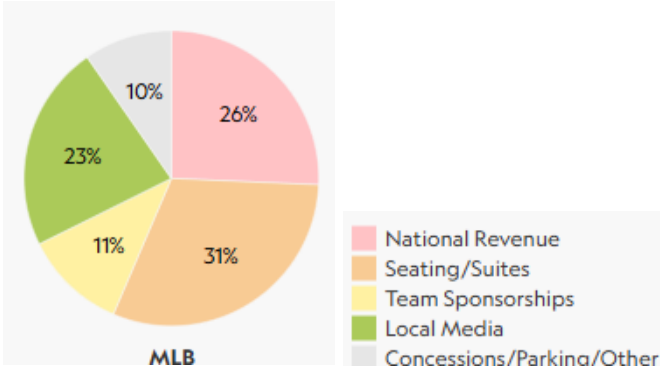
Figure 2: MLB Payroll vs Winning Percentage

Interestingly almost all the playoff teams in 2024 were evaluated on the lower end of HHI, which indicates a more balanced payroll. There is one outlier in the Detroit Tigers, who have the least balanced payroll and still qualified for the playoffs. The Rays were evaluated to have a balanced payroll; however, their overall spending is still below all playoff teams. Some of the most successful teams in the 2024 playoffs including the Dodgers, Yankees and Mets are each among the highest spenders while maintaining balance in their payroll.

2.3 MLB Team Valuation

Valuating an MLB franchise is not a trivial task; however, several factors are consistently identified in literature as valuation drivers including city/market size, stadium usage, team

brand, and revenue generated. As stated earlier, the Rays valuation of $1.25 billion ranks among the lowest in the league. Therefore, two goals of this analysis are to evaluate holistically how the Rays can increase revenue and to characterize a potential benefit of relocating out of St Petersburg. The overall revenue breakdown for the MLB in 2022 was as follows (Badenhausen, 2024):



Note: "National Revenue" is defined as league-sponsored media, sponsorships, merchandise, and shared ticket revenue sales.

Figure 3: MLB Revenue Breakdown

Ticketing is the largest driver of team revenue at 31%, whereas local media and broadcasting rights account for 23% of a team's overall revenue. While the Rays have reached a temporary deal to broadcast the 2025 season with their current regional sports network Bally Sports (owned by Diamond Sports Group), the MLB has expressed concerns about Diamond Sports Group falling back into insolvency. As such, the Rays should look into partnering with a streaming service as game broadcasts are transitioning to streaming platforms as opposed to traditional cable outlets (Mornat and Garg, 2022). However, this creates a challenging modeling task as we are in the infancy of streaming platforms owning the rights to MLB games.

In "Valuation Drivers of MLB Franchises", the authors modeling shows two negative factors impacting the Rays: 1. A fixed dome significantly destroys shareholder value, 2. A drop in average attendance will significantly reduce the valuation of the team (Mornat and Garg, 2022).

Since Tampa's climate is prone to afternoon rain storms, a domed stadium is unfortunately a must-have in the current location and Steinbrenner Field does not have a dome. Current attendance factors impacting the Rays are discussed in section *4.2: Ticketing and Promotional Strategies*.

3.. Data Collection

3.1 Data Collection Timeframe

We collected both print and online data sources from October to December 2024.

3.2 Data Preparation/Cleaning

This analysis utilized Spotrac as a data source for team payroll and player salary information. This required a copy and paste of player salary information into an excel format before uploading into a Python environment. This data required some cleaning since it was unstructured, so we wrote functions to return a pandas dataframe with columns of: Player, Team, Position, Salary. A subset of this data can be seen below in figure 4, showing the 5 highest paid Rays players in our dataset. The full Rays list can be found in the Appendix, table A. Data augmentation techniques were employed to summarize this data by team and position.

	Name	Team	Position	Salary ($M)
174	Brandon Lowe	TB	2B	8.75
189	Yandy Diaz	TB	1B	8.00
249	Jeffrey Springs	TB	SP	5.25
292	Pete Fairbanks	TB	RP	3.67
295	Shane McClanahan	TB	SP/SP1	3.60

Figure 4: Tampa Bay Rays top 5 highest paid players

Next, we gathered the winning percentage data from Teamrankings.com and merged this dataset with the salary dataframe to determine team win percentage by payroll. (Teamrankings.com, 2024)

For game attendance data, we extracted 2022-2024 game-by-game attendance from Baseball-Reference.com and filtered by home games. The Rays promotional schedule for kids (aged 14 or under) and all ages was gathered from various sources and manually added to the game attendance file. The average attendance based on promotional status was calculated in figure 7 below and discussed in section *4.2: Ticketing and Promotional Strategies*.

To determine potential strategies to increase revenue, we gathered ticketing and revenue metrics from Forbes.com most recent list of MLB Team Valuations. These metrics included estimates of net revenue, gate receipts, ticket pricing and revenue per fan for the years 2018-2023. We excluded the 2020 season because the MLB had no attendance due to the Covid-19 pandemic. Because our intention is to model the likelihood that a particular city is a good choice for an MLB team to call home, we scraped a variety of relevant descriptive features (Bruggink and Schiz, 2008) from various sources as listed in table 1. When extracting TV ratings for cities, the value for Montreal is not available since Canada does not use Nielsen ratings, so we imputed their value based on the mean of the other city values. For modeling, each of these features was normalized from [0:1] to ensure there was no unintended weighting of the features due to their variation in magnitudes.

Table 1: Relocation City Descriptive Features

Feature	Definition	Source	Impact
Wealth	Per-capita income rank of city, 2022.	U.S. Bureau of Economic Analysis (2022)	Potential Revenue Generated per Fan
Size	Population, 2023	Statista.com (2023)	Potential Attendance
TV Market Rank	TV Market Rank, 2024	TVjobs.com (2024)	Media and Broadcasting Revenue
Fortune 1000 Exposure	Number of Fortune 1000 companies within city	Fortune.com (2024)	Potential Sponsorships
Market Competition	Distance to nearest MLB park	Google Maps (2024)	Professional Competition

4. Methodology and Results

4.1 Player Performance Evaluation

To evaluate player performance for the 2024 regular season, we start with selecting metrics which are accessible, transparent, and repeatable (Miller, 2015). Using Fangraphs custom statistical reporting, we selected 12 hitting metrics: plate appearances, home runs, runs scored, runs batted in, stolen bases, batting average, walk percentage, strikeout percentage, batting average for balls in play (BABIP), on-base plus slugging percentage (OPS), weighted on-base average, and weighted runs above average (wRAA). For pitcher performance, we selected 9 pitching metrics: wins, losses, games started (for starting pitchers), saves (for relief pitchers), innings pitched, strikeouts per 9 innings, walks per 9 innings, batting average against for balls in play (BABIP), and earned run average (ERA). Each player on the Rays roster was evaluated against others in their position throughout the league with a minimum of 150 plate appearances or 30 innings pitched. The hitter and pitcher metrics are listed in the Appendix tables C and D, respectively.

Next, we tallied all Rays player salaries for 2024 and merged that dataset with the player performance metrics by position (snippet in table E of the Appendix, full dataset in Python

package attached). To determine which Rays players underperformed given their salary, a player required a negative performance in wRAA or a high ERA and a minimum of 10 players with higher wRAA or lower ERA who are also earning a lower salary. Rays underperformers given their salary include: Ben Rortvedt, Taylor Walls, José Caballero, Christopher Morel, Jose Siri, Jonny DeLuca, and Tyler Alexander.

To optimize the Rays roster to generate additional wins while keeping consistent with team payroll, we referenced the best-case/worst-case constrained optimization method in Miller's "Sports Analytics and Data Science." In this decision analysis, the process of exploring extreme outcomes is detailed as best-case and worst-case, and a third expected outcome is predicted between the two extremes (Miller, 2015). Player acquisitions were considered only when the player is the last year of arbitration or a free agent for the 2025 season (Spotrac, 2024).

The two offensive positions with the least productivity were shortstop and outfield. Since former shortstop, Wander Franco, was placed on the MLB's restricted list in July 2024, his 11-year, $182 million contract signed in 2022 becomes nullified and frees up $16,545,455 against the luxury tax cap per year through 2033. To find suitable replacement players for shortstops Taylor Walls and José Caballero, players with similar salary totals and much higher wRAA values were considered. Zach Neto (9.58 wRAA) and Tyler Fitzgerald (12.78 wRAA) are two candidates who fit the criteria with Spotrac estimating their 2025 salary at $800,000. Below are their best-case, worst-case, and projected outcomes from Fangraphs.com.

Table 2: Best-case, worst-case scenarios for shortstop acquisitions

Name		PA	HR	Runs Scored	RBI	Stolen Bases	Batting Avg	Walk%	Strikeout%	BABIP	OPS	wOBA	wRAA
Zach Neto	Best-Case	602	23	70	77	30	0.249	6.5	23.3	0.295	0.761	0.330	9.58
	Worst-Case	329	9	38	34	5	0.225	6.1	23.4	0.272	0.685	0.302	-4.40
	2025 Projections	600	21	73	68	26	0.245	6.6	22.9	0.289	0.734	0.319	4.10
Tyler Fitzgerald	Best-Case	341	15	53	34	17	0.280	6.5	31.7	0.380	0.831	0.357	12.8
	Worst-Case	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	2025 Projections	600	19	67	63	22	0.228	6.3	30.7	0.304	0.676	0.294	-7.8

Zach Neto is projected to have another productive season in 2025 with a 4.10 wRAA. Worst-case situation is not available for Tyler Fitzgerald as he has not accrued two seasons of major league data. It is also important to note, Fangraphs projects a heavy regression for Tyler Fitzgerald from 12.78 wRAA to -7.8 wRAA in 2025.

Candidates to replace outfielders Jose Siri and Jonny DeLuca were considered with the same criteria as the shortstop replacements. A former Rays player, Luke Raley (10.59 wRAA), and Wilyer Abreu (9.15 wRAA) are two candidates who fit the criteria with Spotrac estimating their 2025 salary at $800,000. Their best-case, worst-case, and projected outcomes from Fangraphs.com are below:

Table 3: Best-case, worst-case scenarios for outfield acquisitions

Name		PA	HR	Runs Scored	RBI	Stolen Bases	Batting Avg	Walk%	Strikeout%	BABIP	OPS	wOBA	wRAA
Luke Raley	Best-Case	455	22	58	58	11	0.238	5.9	29.7	0.305	0.783	0.339	10.59
	Worst-Case	72	2	5	4	0	0.182	2.8	34.7	0.256	0.538	0.302	-4.70
	2025 Projections	600	24	69	73	14	0.230	6.8	30.7	0.299	0.719	0.314	1.80
Wilyer Abreu	Best-Case	447	15	59	58	8	0.253	8.9	28.0	0.326	0.781	0.336	9.15
	Worst-Case	85	2	10	14	3	0.316	10.6	27.1	0.431	0.862	0.375	4.00
	2025 Projections	600	20	73	69	12	0.257	10.9	27.0	0.306	0.745	0.325	7.20

Luke Raley is projected to regress from his 10.59 wRAA to 1.8 next season. Also, it is important to note that Luke Raley primarily plays against right-handed pitchers only as his batting average vs left-handed pitchers is below 0.200. Wilyer Abreu is projected to have another productive

season with a 7.20 wRAA. Also, Wilyer Abreu's worst-case scenario is based on a small sample size of only 85 plate appearances.

To find a suitable replacement for pitcher, Tyler Alexander, relief pitchers with similar salary totals and lower ERA were considered. Candidates include José Ureña (3.80 ERA) and John King (2.85 ERA) who Spotrac estimates to make $1,750,000 and $1,450,000 respectively in 2025. Their best-case, worst-case, and projected outcomes from Fangraphs.com are in Table 9:

Table 4: Best-case, worst-case scenarios for Relief Pitcher acquisitions

Name		Wins	Losses	SV	Innings Pitched	Strikeouts per 9 IP	Walks per 9 IP	BABIP	ERA
Jose Urena	Best-Case	5	8	1	109.0	5.8	3.2	0.273	3.80
	Worst-Case	0	7	0	44.2	5.8	4.4	0.268	6.45
	2025 Projections	3	3	0	65.0	7.1	2.8	0.299	4.15
John King	Best-Case	3	3	0	60.0	5.7	2.1	0.279	2.85
	Worst-Case	1	4	0	51.1	5.3	2.5	0.326	4.03
	2025 Projections	3	3	1	65.0	6.1	2.6	0.310	3.75

José Ureña is the riskier option of the two candidates as his career ERA is nearly one run higher at 4.76 than his 2024 performance at 3.80. John King is projected to have another strong season with an ERA under 4.00.

4.2 Ticketing and Promotional Strategies

In 2024, the league-wide average attendance per game was 29,373 fans, however the Rays average attendance per game was only 16,515 fans, ranked 28th in the league (Baseball-Reference.com, 2024). This is due to two accessibility factors: 1. Tropicana Field is located in St. Petersburg, which is 22 miles away from center city Tampa taking up to 50 minutes driving time during peak traffic times, 2. Mass transit is scarce with the train scheduled every 45 minutes and buses taking up to 2 hours from Tampa as projected by Google Maps. The low attendance marks

occurred despite the Rays adopting several ticketing strategies in 2024, including: flexible season membership based on pricing tiers, partial season plans for weekend or weekday games only, and Friday, Saturday, or Sunday day-specific plans including 1-2 weekday games per month (MLB.com, 2024).

Several key factors impacting attendance can be noted when calculating the average home game attendance by opponent (figure 5), day of the week (figure 6), and promotional

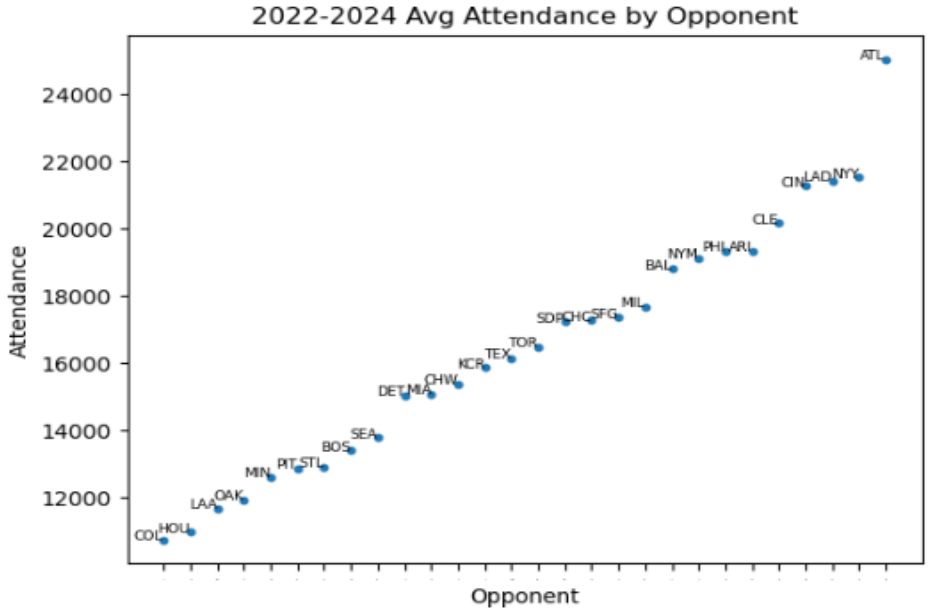


Figure 5: 2022-2024 Attendance by Opponent

status (figure 7) below. First, opponents with winning records typically draw a larger home attendance, with the Houston Astros being an outlier. Second, weekend games draw the highest attendance while early work-week games on Monday and Tuesday draw the lowest attendance. Third, games with a promotion draw on average 5,529 more fans (nearly one-third of average attendance) when compared to games without a promotion. The highest attendance drawn with a promotion was 32,142 fans (7,117 fans over standard capacity) when offering the Devil Rays socks in 2023 aimed for kids. The lowest attendance drawn with a promotion was 11,162

fans when offering the Stovepipe Hat in 2022 also aimed for kids. It is noteworthy that tickets have sold out for each Opening Day with the schedule magnet promotion at 25,025 fans. A snippet of the most successful promotions is listed in table B of the Appendix, while the full dataset is attached within the Python package.

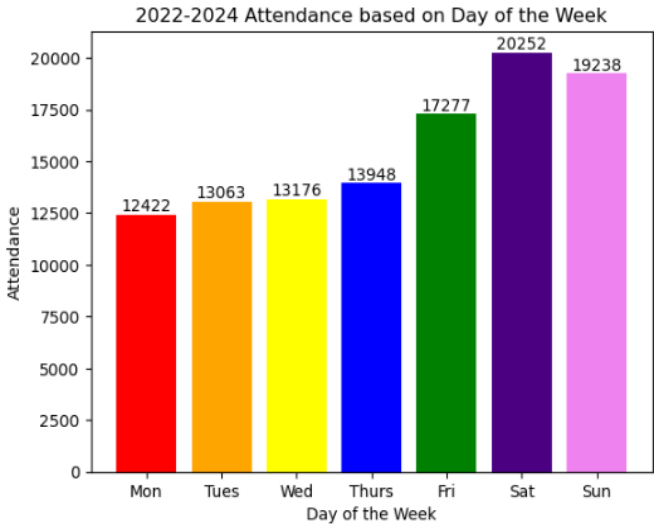


Figure 6: 2022-2024 Attendance by Day

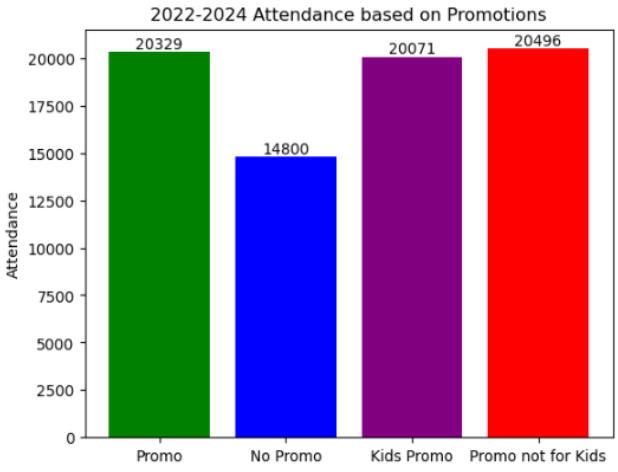


Figure 7: Promotional Attendance

Based on 2022-2024 attendance factors above, the Rays can employ a dynamic pricing strategy which adjusts ticket prices to capitalize on revenue opportunities. For example, the Rays could raise ticket prices for home games vs opponents with winning records post All-Star Break, such as the: Atlanta Braves, New York Yankees, and Los Angeles Dodgers - which would generate more ticketing, merchandise, and concessions revenue. In contrast, the Rays could lower ticket prices for teams with losing records: Colorado Rockies, Los Angeles Angels, and the former Oakland A's to attract a larger, price-sensitive audience. The Rays could also adjust the promotional schedule to offer promotions where low attendance games are projected based on opponent or day of the week.

To evaluate the application of a dynamic pricing strategy, we created a linear regression prediction model to predict estimated revenues if the average ticket price increased from $27.87 in 2024 to $29 or $31.

Table 5: Estimated revenues (in $) based on increasing average ticket price

	Average Ticket Price	Predicted Net Revenue	Predicted Gate Receipts	Predicted Revenue per Fan
	29	313,945,426.82	50,412,319.25	45.01
	31	334,222,647.34	57,882,187.16	46.94
P-values	N/A	0.070	0.156	0.006

Table 5 (above) shows the results of predicted revenues based on increased average ticket prices. The model predicted estimated net revenue at a p-value of 0.070 which is statistically significant at the 3% level, but not at the standard 5% level. The model predicted gate receipts at a p-value of 0.156, which is not statistically significant at a 5% level. The model predicted revenue per fan at a p-value of 0.006, which is statistically significant at a 5% level. The p-values show that raising the average ticket price may have a significant impact to predicted revenues, but not gate receipts due to other factors such as attendance not included in the prediction. While predicted net revenue, gate receipts, and revenue per fan have increased in each scenario, it is important to note that an effective dynamic pricing strategy can have drawbacks including: customers may perceive they're being taken advantage of during prime matchups, finding a delicate balance of price increases and customer willingness to pay the new price, and the risk of losing customers (Harrison and Bukstein, 2017).

The outlook for the 2025 season looks bleak with Steinbrenner Field having a capacity of only 11,000 fans (Blum and Stark, 2024). However, the Rays can employ a ticketing strategy used by the New York Mets in 2019, the “Ballpark Pass” subscription. The “Ballpark Pass” provides a standing-room only ticket to all home games for $40 per month (Allentuck and Draper, 2019) which contributed to home attendance increasing by nearly 2,400 fans per game. Despite this subscription model being the lowest priced option, the Rays would see an increase in attendance and as a result an increase in revenue from parking, concessions, and merchandise sold.

4.3 Relocation Modeling

Mentioned in table 1 of section 3.2, there were a total of 5 descriptive features used in evaluating the likelihood of a particular city to host an MLB team. These were collected for a total of 25 cities, 11 of which currently host an MLB team. A random forest classification model utilized the 5 features to predict a binary label - whether this city should host an MLB team. The model also returns two confidence value associated to its binary classification: one value representing its confidence in its predicted class, and another representing its confidence in the other class. These confidences sum to 100% for a two-class model. For example, if the model was 55% confident of class 0 prediction - the city should not host an MLB team, then the model is 45% confident in class 1 prediction - the city should host an MLB team. To ensure a balanced training dataset, we trained the model on the 5 descriptive features for 11 locations that currently host an MLB team, as well as 9 locations that do not currently host a team. The cities that do not host an MLB team were selectively chosen as cities that host other major league organizations across the major sports (such as Las Vegas).

Next, when testing our model on potential cities for relocation, we are evaluating how closely it represents a "baseline city;" i.e., how closely it mirrors the class of data representing cities that currently host a team from the training database. For this analysis, we evaluated 6 cities as the test dataset: Charlotte, Nashville, Raleigh, Orlando, Montreal, and Tampa. We chose the first 5 cities as they are leading contenders in recent talks of MLB expansion, and included Tampa to compare its evaluation to potential replacements.

Table 6: Relocation Modeling Results

Relocation City	Prediction	
	Class	Confidence (%)
Charlotte	1	69.0
Tampa*	1	61.0
Orlando	1	51.0
Montreal	0	51.0
Nashville	0	71.0
Raleigh	0	73.0
**Only City that currently has a team in testing dataset*		

Table 6 tabulates the results of running our model on our 5 test cities. Charlotte is evaluated as the city that the model is most confident should host a team, which includes Tampa. It is also worth noting that this model does not account for the repairs needed at Tropicana Field, the county loans required to build a new stadium, or the low attendance marks. Taking these factors into consideration and that Charlotte already has a baseball stadium for their AAA team with a capacity of 10,200 fans, further indicates a relocation should be considered. The predictions for Orlando and Montreal, though different classes, were only 51% confidence, suggesting these cities do not closely represent the "baseline city" defined by the distribution of data from model training. The predictions for Nashville and Raleigh show these cities should not host an MLB team.

To further evaluate the model, we generated feature importances through a mean decrease in impurity calculation. This metric determines a feature's importance in the overall forest of decision trees by summing the number of times the feature was used to split a node and weighted by the number of data points the feature splits. The feature importance can be

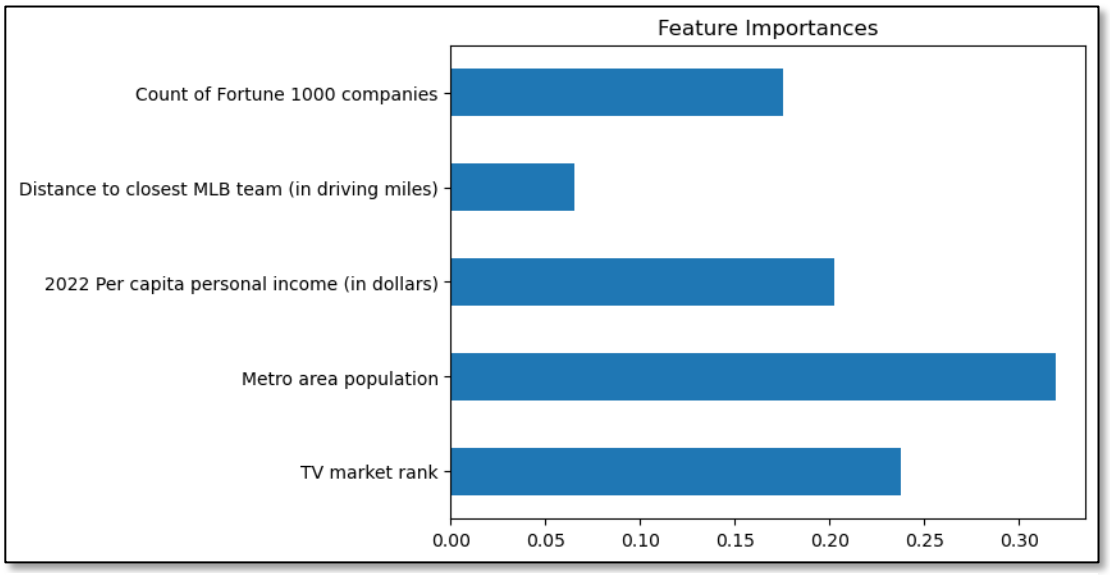


Figure 8: Relocation Modeling Feature Importance

seen above in figure 8. This shows us that Metropolitan area population is the most important of our 5 features, followed by TV market rank.

This model indicates that Charlotte is not only the preferred option to Tampa when considering the 5 features defined in section 3.2, but it is also a better option than other relocation options being considered.

5. Expectations from Previous Relocations

5.1 Performance from Other Team Relocations

The last major relocation in the MLB occurred in 2004 when the Montreal Expos relocated and changed their name to the Washington Nationals. This was due to three factors: poor team performance - making the playoffs only once in their franchise history since 1969,

poor attendance - failing to reach 1 million fans attending home games in 9 different seasons, and ownership requesting a new stadium when money was still owed on the existing stadium (Rushdi, 2009). Since moving to Washington, D.C., the Nationals have reached the playoffs 5 times (including 1 World Series victory), had 8 seasons with a win percentage over .500, and have drawn on average 2.2+ million fans to home games (Baseball-Reference.com, 2024). These results show that an MLB relocation can achieve greater success for the team and the organization.

More recently, the Oakland A's have committed to building a new stadium and relocating to Las Vegas, Nevada. This relocation was not necessarily due to team performance, but rather due to several failed attempts to replace their stadium with a more modern stadium in the Bay area and the potential of major revenue gains from a similar relocation of the Oakland Raiders to Las Vegas in the NFL. While the Raiders have not accomplished team success since moving to Las Vegas in 2020, their attendance has increased by an average of 7,945 fans per home game (Statista.com, 2024). Both Oakland and Las Vegas were included in training the relocation model to identify variances between the cities prompting the move.

5.2 Revenue Changes from Other Team Relocations

The Washington Nationals have shown their organizational revenue increase from an average of $72.5 million from 2001-2004 when they were the Montreal Expos to an average of $255.9 million since the move – excluding 2020 due to the pandemic. In the same time period, the team's valuation has increased from an average of $122 million to an average of $1.06 billion (Statista.com, 2024). As discussed in the previous section, the revenue and team valuation increases can be attributed in part to team success and increased attendance from

their new market, but also to building a new stadium, acquiring new sponsorships, and restructuring media rights contracts since their move.

The Las Vegas Raiders have also shown an increase in organizational revenue from an average of $236.3 million from 2002-2019 to an average of $690.3 million since the move – excluding 2020 due to the pandemic. In the same time period, the team's valuation has increased from an average of $1.16 billion to $5.35 billion, becoming the 6th highest valuation in the NFL in 2024 (Statista.com, 2024). Similar to the Nationals, the Raiders financial success can be attributed to building a new stadium, increasing sponsorship revenue, and increasing ticket revenue based on higher attendance in their new market.

6. Conclusions

Relevant data is available via public sources to verify and test the recommendations detailed in this analysis. This report details several methods to improve team wins with new acquisitions, to increase revenue and team valuation through utilizing proven ticketing and promotional strategies such as dynamic pricing and "Ballpark Pass", and to consider relocation to Charlotte based on new market factors and previous relocation successes. If relocation is considered as an option, it is noteworthy that current fans are 49% likely to support the team post-relocation while only 37% are unlikely to support the team (Shah, 2023). Finally, the recommendations in this report are not guaranteed to be successful, but have shown positive results in previous scenarios.

7. Limitations/Future Recommendations

With respect to the relocation model implementation of our Random Forest Classifier, we are limited in the size of the training dataset. We accept the risk of overfitting and the errors associated with performing inference on unseen data. The reason for the limited data availability is that the features to our models are 'expert defined' features of labeled data to be used in our supervised learning methods. Therefore, the manual process of preparing the data requires a significant time commitment that scales with each new data point we wish to include. We decided on the size of the datasets to prove the architecture of the model and features we have defined have some predictive value, but we do not assess our feature vector as a complete representation of the data. Also, in our relocation model we performed mean imputation to fill in missing data for Montreal's TV market rank. The reason for this imputation was to assess the other features predictive ability; however, TV market rank is the second most important feature in our model and if the true value is a large deviation from our mean, we could see different results. In addition, our models are focused on Random Forest implementations in Python's sci-kit learn library; however, future modeling could be prepared using different techniques.

A major limitation to this analysis includes the lack of publicly available data for concessions, parking, and merchandise revenue. Other limitations include: the cost to rebrand Steinbrenner Field, the cost to expand Truist Field in Charlotte, MLB or government contributions to help recovery costs for Tropicana Field damage, the inability to extract previous years guaranteed contracts from Spotrac, and metropolitan area information not yet available

for 2023-2024. In addition, it is too early to trust with confidence in Fangraphs player performance predictions for next season.

Future adaptations of team assessments should include a train and test dataset to use in a prediction model for next year's player performance metrics and to execute a regression analysis on the model to verify accuracy. Also, future assessments should include metropolitan area data for all 30 MLB team host cities as a "baseline city" comparison. Finally, adding adjustments for local cost of living and individual state taxes would benefit the player payroll analysis.

Appendix

Table A: Rays Player Salaries and Positions

	Name	Team	Position	Salary ($M)
174	Brandon Lowe	TB	2B	8.75
189	Yandy Diaz	TB	1B	8.00
249	Jeffrey Springs	TB	SP	5.25
292	Pete Fairbanks	TB	RP	3.67
295	Shane McClanahan	TB	SP/SP1	3.60
354	Wander Franco	TB	SS	2.45
358	Colin Poche	TB	RP/SU7	2.38
359	Dylan Carlson	TB	LF	2.35
391	Tyler Alexander	TB	RP	1.95
396	Drew Rasmussen	TB	RP	1.86
398	Zack Littell	TB	SP	1.85
531	Christopher Morel	TB	DH	0.77
576	Jose Siri	TB	CF	0.76
582	Taylor Walls	TB	SS	0.76
590	Jacob Waguespack	TB	SP	0.76
592	Josh Lowe	TB	RF/3B	0.76
593	Ben Rortvedt	TB	C	0.76
620	José Caballero	TB	SS	0.75
675	Garrett Cleavinger	TB	RP	0.75
695	Richard Palacios	TB	DH	0.75
714	Ryan Pepiot	TB	SP	0.74
728	Shane Baz	TB	SP	0.74
733	Taj Bradley	TB	SP	0.74
739	Jonathan Aranda	TB	1B	0.74
747	Jonny DeLuca	TB	OF	0.74
868	Edwin Uceta	TB	RP	0.74
891	Hunter Bigge	TB	RP	0.74
947	Junior Caminero	TB	3B	0.74
958	Kevin Kelly	TB	RP	0.74
973	Logan Driscoll	TB	C	0.74
982	Manuel Rodriguez	TB	RP/SU7	0.74
987	Mason Montgomery	TB	SP	0.74
1026	Richard Lovelady	TB	RP	0.74

Table B: Snippet of Home Attendance based on Promotion, 2022-2024

Day	Opp	W	L	Attendance	Promotion	Kids
Sunday	NYY	28	7	32142	Devil Rays Socks	x
Saturday	NYY	27	7	27078	NaN	NaN
Friday	ATL	57	34	25025	NaN	NaN
Sunday	NYY	74	58	25025	NaN	NaN
Saturday	ATL	57	35	25025	NaN	NaN
Saturday	NYY	27	19	25025	Devil Rays Throwback Jersey	NaN
Friday	BAL	1	0	25025	Opening Day - Schedule Magnet	NaN
Thursday	TOR	0	1	25025	Opening Day - Rays Schedule Magnet	NaN
Sunday	NYY	28	19	25025	Sweatshirt Drawstring Bags	x
Saturday	CLE	71	48	25025	Shane McClanahan Bobblehead	NaN
Saturday	BAL	61	41	25025	NaN	NaN
Sunday	ATL	58	35	25025	25th Anniversary Item	NaN
Thursday	DET	1	0	25025	Opening Day - Schedule Magnet	NaN
Friday	NYY	27	6	25007	NaN	NaN
Saturday	BAL	58	58	23898	NaN	NaN
Saturday	CIN	53	52	23464	Trading Card Day	NaN
Saturday	LAD	38	16	23443	NaN	NaN
Sunday	BAL	61	42	23440	Pencil Pouch	x
Thursday	NYY	46	47	23438	NaN	NaN
Sunday	TEX	48	20	23069	Raymond Squishy	x
Saturday	NYY	79	52	22943	25th Anniversary Item	NaN
Saturday	CLE	54	47	22756	Brett Phillips Basketball Jersey, Devil Rays T...	NaN
Sunday	CHW	19	3	22702	Brandon Lowe Dawg Tags	x

Table C: 2024 Rays Hitter metrics (sorted by wRAA)

Name	PA	HR	R	RBI	SB	AVG	BB%	K%	BABIP	OPS	wOBA	wRAA
Isaac Paredes	429	16	41	55	0	0.245179	0.121212	0.158508	0.259786	0.791905	0.346716	12.615614
Yandy Díaz	621	14	55	65	0	0.280639	0.080515	0.152979	0.314410	0.755239	0.330533	10.173440
Brandon Lowe	425	21	56	58	5	0.244156	0.077647	0.263529	0.287402	0.783316	0.334698	8.387121
Amed Rosario	275	2	22	26	9	0.306818	0.025455	0.174545	0.367442	0.747576	0.324363	3.139530
Randy Arozarena	409	15	45	37	16	0.211429	0.110024	0.246944	0.248945	0.712134	0.314866	1.542783
Junior Caminero	177	6	15	18	2	0.248485	0.062147	0.214689	0.289256	0.723677	0.309387	-0.112835
Richie Palacios	316	5	46	21	19	0.223485	0.142405	0.212025	0.279793	0.664214	0.302825	-1.870505
Josh Lowe	387	10	37	34	25	0.240793	0.082687	0.317829	0.337838	0.693260	0.298743	-3.562217
Harold Ramírez	169	1	21	13	5	0.268293	0.017751	0.195266	0.328244	0.588902	0.259580	-6.882602
Ben Rortvedt	328	3	27	31	1	0.227586	0.103659	0.268293	0.316583	0.620521	0.283090	-7.151466
Christopher Morel	190	3	13	9	1	0.190751	0.073684	0.294737	0.260870	0.546912	0.242892	-10.289782
Jonny DeLuca	362	6	29	31	16	0.216867	0.066298	0.212707	0.265060	0.609103	0.268877	-12.033648
José Caballero	483	9	53	44	44	0.226757	0.055901	0.275362	0.301325	0.630272	0.277109	-12.855954
Taylor Walls	252	1	27	14	16	0.183486	0.123016	0.265873	0.254902	0.529452	0.245189	-13.181579
Jose Siri	448	18	50	47	14	0.186567	0.069196	0.379464	0.261468	0.620176	0.270781	-14.205964

Table D: 2024 Rays Pitcher metrics (sorted by ERA)

Name	W	L	GS	IP	K/9	BB/9	HR/9	BABIP	ERA
Shane Baz	4	3	14	79.100000	7.827732	3.063025	1.021008	0.228571	3.063025
Jeffrey Springs	2	2	7	33.000000	10.090909	3.000000	1.363636	0.329545	3.272727
Ryan Pepiot	8	8	26	130.000000	9.830769	3.323077	1.176923	0.261538	3.600000
Zack Littell	8	10	29	156.100000	8.117271	1.784648	1.266525	0.310722	3.626866
Zach Eflin	5	7	19	110.000000	7.118182	1.063636	1.145455	0.294461	4.090909
Taj Bradley	8	11	25	138.000000	10.043478	3.065217	1.434783	0.284091	4.108696
Tyler Alexander	1	2	9	45.200000	7.489052	2.167883	1.576642	0.255814	4.138686
Aaron Civale	2	6	17	87.000000	8.689656	2.793104	1.655173	0.311741	5.068966

Table E: Snippet of Player Performance Metrics by Position including Salaries

Name_x	Team_x	PA	HR	R	RBI	SB	AVG	BB%	K%	BABIP	OPS	wOBA	wRAA	Salary
Kris Bryant	COL	155	2	9	15	0	0.218045	0.083871	0.309677	0.321429	0.623333	0.287028	-2.888185	$28,000,000.00
Bryce Harper	PHI	631	30	85	87	7	0.285455	0.120444	0.218700	0.330729	0.898470	0.380217	35.569989	$27,538,462.00
Freddie Freeman	LAD	638	22	81	89	9	0.282288	0.122257	0.156740	0.306075	0.853758	0.365357	28.333984	$27,000,000.00
Paul Goldschmidt	STL	654	22	70	65	11	0.245409	0.071865	0.264526	0.307882	0.715562	0.309823	-0.187654	$26,000,000.00
Matt Olson	ATL	685	29	78	98	0	0.246667	0.103650	0.248175	0.293103	0.789513	0.339450	16.137982	$22,000,000.00
Pete Alonso	NYM	695	34	91	88	3	0.240132	0.100719	0.247482	0.275862	0.788378	0.339853	16.598852	$20,500,000.00
Salvador Perez	KCR	652	27	58	104	0	0.271186	0.067485	0.197853	0.302273	0.786193	0.335024	13.037772	$20,000,000.00
Vladimir Guerrero Jr.	TOR	697	30	98	103	2	0.323052	0.103300	0.137733	0.342105	0.939814	0.397890	49.204889	$19,900,000.00
Anthony Rizzo	NYY	375	8	38	35	0	0.228487	0.072000	0.173333	0.259398	0.636645	0.284789	-7.663185	$17,000,000.00
Josh Bell	- - -	603	19	62	71	0	0.249071	0.084577	0.199005	0.286070	0.724602	0.316761	3.281083	$16,500,000.00
Jeimer Candelario	CIN	463	20	47	56	4	0.224824	0.058315	0.246220	0.256757	0.707189	0.303528	-2.478389	$15,000,000.00
Justin Turner	- - -	539	11	59	55	0	0.258696	0.109462	0.176252	0.299169	0.736969	0.326553	7.116571	$13,500,000.00
Rhys Hoskins	MIL	517	26	59	82	3	0.213808	0.102515	0.288201	0.250000	0.721621	0.313432	1.353615	$12,000,000.00
Mark Canha	- - -	462	7	46	42	7	0.241730	0.110390	0.207792	0.298305	0.690212	0.309831	-0.133324	$11,500,000.00
Christian Walker	ARI	552	26	72	84	2	0.250522	0.099638	0.240942	0.286585	0.802786	0.343448	14.780744	$10,900,000.00
Luis Arraez	- - -	672	4	83	46	9	0.313972	0.035714	0.043155	0.323967	0.738733	0.322787	6.819861	$10,600,000.00
Yandy Diaz	TBR	621	14	55	65	0	0.280639	0.080515	0.152979	0.314410	0.755239	0.330533	10.173440	$8,000,000.00
Jake Cronenworth	SDP	656	17	72	83	5	0.240901	0.092988	0.179878	0.274157	0.713568	0.314885	2.484750	$7,285,714.00

References

Badenhausen, Kurt. (2024) "How Do Sports Teams, Leagues and Owners Make Money? A Breakdown." Sportico.com. https://www.sportico.com/feature/how-sports-teams-leagues-make-money-1234766931/

Baseball-Reference.com. (2024). “Major League Miscellaneous Year-by-Year Averages and Totals.” https://www.baseball-reference.com/leagues/majors/misc.shtml

Baseball-Reference.com. (2024). “Tampa Bay Rays Schedule.” https://www.baseball-reference.com/teams/TBR/2024-schedule-scores.shtml

Baseball-Reference.com. (2024). “Washington Nationals Team History & Encyclopedia.” https://www.baseball-reference.com/teams/WSN/

Blum, S. and Stark, J. (2024). “Rays to play 2025 home games at Steinbrenner Field in Tampa after hurricane damage to Trop.” NYTimes.com. https://www.nytimes.com/athletic/5922676/2024/11/14/tampa-bay-rays-steinbrenner-field-yankees/

Chen, Kobe et al. (2023). “Pay to Play: An Analysis of Payroll and Performance in the MLB and NBA. Harvard Sports Analysis Collective.” https://harvardsportsanalysis.org/2023/02/pay-to-play-an-analysis-of-payroll-and-performance-in-the-mlb-and-nba/

Fangraphs.com (2024). “Baseball Statistics and Analysis - Major League Leaders – 2024 Batting.” https://www.fangraphs.com/leaders/major-league?pos=all&lg=all&type=8&season=2024&season1=2024&ind=0&stats=bat&postseason=&v_cr=202301&team=0&month=0&qual=0

Fangraphs.com (2024) – “Baseball Statistics and Analysis - Major League Leaders – 2024 Pitching.” https://www.fangraphs.com/leaders/major-league?pos=all&lg=all&type=8&season=2024&season1=2024&ind=0&stats=pit&postseason=&v_cr=202301&team=0&qual=0&month=0

Fortune.com. (2024). “Fortune 500 & 1000 Search.” https://fortune.com/ranking/fortune500/search/

Harrison, C. and Bukstein, S. (2017). “Sports Business Analytics: Using Data to Increase Revenue and Improve Operational Efficiency.” Chapter 2: Analytics and Ticketing Innovations at the Orlando Magic

Miller, T. (2015). “Sports Analytics and Data Science: Winning the Game with Methods and Models.” Chapter 8: Growing Revenues. Chapter 9: Managing Finances.

MLB.com – Rays Press Releases. (2024) “Tampa Bay Rays, Hines celebrate approval of new

ballpark, Historic Gas Plant District Development." https://www.mlb.com/rays/press-release/press-release-tampa-bay-rays-hines-celebrate-approval-of-new-ballpark-historic-gas-plant-district-development?t=rays-press-releases

Mornat, Gabriel & Garg, Tishya. (2022). "Valuation Drivers of Major League Baseball Franchises: Revenue Streams, Cost Structure, and M&A Rationales." https://www.researchgate.net/profile/Gabriel-Mornat/publication/361912169_Valuation_Drivers_of_Major_League_Baseball_Franchises_Revenue_Streams_Cost_Structure_and_MA_Rationales/links/62db36f5aa5823729ed92f5c/Valuation-Drivers-of-Major-League-Baseball-Franchises-Revenue-Streams-Cost-Structure-and-M-A-Rationales.pdf?

Ozanian, Mike and Justin Teitelbaum. (2024). Baseball's Most Valuable Teams. Forbes.com. https://www.forbes.com/lists/mlb-valuations/

Rushdi, F. (2009). "How Jeffrey Loria Destroyed the Montreal Expos/Washington Nationals." https://bleacherreport.com/articles/118868-how-jeffrey-loria-destroyed-the-montreal-exposnationals

Shah, K. (2023). "Home Base to Home Run – The Impact of MLB Team Relocation on Fan Engagement." https://business.yougov.com/content/47985-home-base-to-home-run-the-impact-of-mlb-team-relocation-on-fan-engagement

Spotrac.com (2024). "Sports Contracts, Salaries, Caps, Bonuses, and Transactions." https://www.spotrac.com/

Statista.com. (2023). "Population of the largest metropolitan areas in the United States in 2023." https://www.statista.com/statistics/183600/population-of-metropolitan-areas-in-the-us/

Statista.com. (2022). "Resident population of Canada in 2022, by metropolitan area." https://www.statista.com/statistics/183600/population-of-metropolitan-areas-in-the-us/

Statista.com. (2024). "Revenue of the Tampa Bay Rays (MLB) from 2001 to 2024." https://www.statista.com/statistics/196686/revenue-of-the-tampa-bay-rays-since-2006/

Statista.com. (2024). "Total regular season home attendance of the Las Vegas Raiders in the NFL from 2006 to 2023." https://www.statista.com/statistics/250076/average-home-attendance-of-the-oakland-raiders/

Statista.com. (2024). "Las Vegas Raiders revenue from 2001 to 2023." https://www.statista.com/statistics/195286/revenue-of-the-oakland-raiders-since-2006/

TVjobs.com. (2024). "Nielsen Media 2023-2024 Local Market Estimates." https://www.tvjobs.com/cgi-bin/markets/market2.cgi

TeamRankings.com. (2024). "MLB Team Win % - All Games." https://www.teamrankings.com/mlb/stat/win-pct-all-games.

Topkin, M. and Wright, C. (2024). “City report: Trop can be fixed for Rays’ 2026 season for $56 million.” https://www.tampabay.com/sports/2024/11/12/tropicana-field-damage-assessment-st-petersburg-city-council-hennessy-construction/

U.S. Bureau of Economic Analysis, Bea.gov. (2022). “Personal Income by County, Metro, and Other Areas.” https://www.bea.gov/data/income-saving/personal-income-county-metro-and-other-areas