NBA Offensive Simulation with Trades: Executive Summary

Link to Web App: https://bit.ly/Andrew-Vaughn

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Project Overview:

This project is an accurate NBA simulator that individuals can use with no coding skills required. The simulation uses individual players' real-life tendencies and statistics from the 2022-23 NBA season to predict season average per-game statistics. Through the connection of multiple data frames in R, we can track individual players' simulated box score statistics. It can also track the effect of new additions or losses to the roster. The code is designed to be scaled and built upon, with ease of continued improvement being a top priority. **When simulating the Charlotte Hornets' top five players and inputting their minutes played per game, we can accurately predict all offensive box score statistics within an average value of one (some variation by statistic and player).**

This accuracy not only gives us confidence in our simulation of existing players but also allows us to edit rosters (which a user can do on the web app) and assess the impact of new additions or losses. A new player will affect the entire team, at the individual player level. For example, when you add a ball-dominant player to a team, the rest of the rotation will take fewer shots and decrease general production.

In addition to Monte-Carlo Simulation, the web application also features a player finder tool that allows a user to find specific players that fit certain criteria. The user can also choose which statistics they would like to display. Players are automatically sorted by BPM with the idea of being top candidates for a potential trade.

Skills Applied:
- **Monte-Carlo Simulation:** Monte-Carlo simulation is implemented to simulate NBA Games on a per-possession basis. We use a mix of individual player tendencies, real-life statistics, and league averages to simulate an NBA offense. Through the connection of a unique roster, players on the floor, and a specialized box score we can assess the impact of trades on **ALL** players on an NBA offense.

- **Web App Development:** Our web application is created using a mix of R and HTML, and published using an R Shiny Application. We created a custom UI and Server to host all of our functions and plots, which interact with the user through a WebSocket connection. This is a two-way connection between the client and the server.
- **Data Management and Interactivity:** One of the features of our web application is a unique player finder tool that allows a user to filter through athletes based on specific parameters. From there, it will display players that match the selected inputs, and also allow the user to display statistics of their choice. This player-finder tool is designed to find potential trade candidates for an NBA team.

Calculating Minutes for an NBA Roster:

Our simulator uses a roster that consists of individual players, allowing the user to edit that roster. The user will also be able to suggest the number of minutes that they want their "star player" (decided on the player with the highest BPM of the season) to get, and the simulator will then assign the maximum minutes to that player. The 15th player will be assigned zero minutes as an active NBA roster can only have 14 players playing in a given game. The rest of the players will play minutes proportional to their BPM, without exceeding their maximum minutes. This is done by creating a scaling multiplier between 0 and 1 (normalizing the BPM relative to the team) and then ensuring that the total number of minutes sums to 240 (the number of minutes to allocate over a full game). This is accomplished through a mix of iteration and custom calculations. The web application also allows the user to manually give minutes if they believe the automatic calculation to be unrealistic.

Simulation:

Our simulator focuses on simulating offensive statistics, with an emphasis on team management. This includes making "trades" and both automatically and manually adjusting playing time. Then simulate many games to see on average, how these adjustments affect individual offensive box score statistics. The simulation begins with a "possession" that has a random chance of ending (based on real-life NBA Percentages) with a shot attempt or a turnover.

- **Who Shoots the Ball?** If the simulator decides the possession will result in a shot attempt, the taker of the shot is determined based on percentages of each player on the floor's USG% of the sum of the floor as a whole. These percentages are then randomly sampled to determine the shot taker.
- **Where is the shot taken?** Once the shot taker is determined, real-life NBA shooting tendencies by distance are implemented and then sampled to determine the distance of the attempt. This is done at the individual player level
  - For example, Giannis Antetokounmpo will attempt a 3-10 foot shot 21.2% of the time (in the 2022-23 season)
- **Does the Shot Go In?** Once the shot taker and shot distance are determined, real-life NBA shooting percentages from each range are implemented and sampled to determine the outcome of the shot.
  - For Example, Giannis Antetokounmpo shoots 35.4% from 3-10 feet
- **Who gets assists?** If the shot is successful, using the league average assist rate (tuned for accuracy), the simulator will decide if the shot was assisted. If so, using our custom assist percentage (a player's assists, relative to their team total, as a weighted average of the players on the floor), the simulator will determine who assisted the shot.
- **What About Rebounds?** If the shot is unsuccessful, using the league average offensive rebound rate (tuned for accuracy), the simulator will decide if the missed shot was rebounded by the offense. If so, using our custom offensive rebound percentage (a player's offensive rebounds, relative to their team total, as a weighted average of the players on the floor), the simulator will determine who rebounded the shot. Note that because we are only simulating offense (at this point in time)
- **How are Turnovers Decided?** If the simulator determines that the possession does not result in a shot attempt it will instead be marked as a turnover. Given this, using our custom turnover percentage (a player's turnovers, relative to their team total, as a weighted average of the players on the floor), the simulator will determine who turned the ball over.

Scalability:

One important feature of the code that we made sure to include is the ability for it to be continuously improved upon. For example, one opportunity to scale this project would be to implement the defensive side of the game into this simulation. In the current code, we simply sample 50 percent of the possessions a game as an offensive possession for the team of interest. Adding code to simulate the other 50 percent of possessions using defensive statistics is certainly within reach. This would allow for the tracking of far more statistics such as steals and defensive rebounds, giving a more complete picture of an added/removed player impact. These implementations would make a complete game simulator and we could then track the stats of both teams.

Other Considerations & Future Work:

Many different avenues could be taken to further improve this project, and because of the previously discussed scalability, all are possible. The first idea would be to have two teams play each other. This would require multiple teams in the box score and the implementation of defensive statistics. Another key improvement would be instead of using NBA averages, you could use a specific coach and system for how often players should shoot or where they shoot from. Salary cap restrictions would be another interesting idea to implement, and instead of simply adding or removing players we could implement a trade-logic system that suggests trades and players based on their fit and contract details. The possibilities for expanding the current capabilities are limitless and very much possible.

Data Used & Acknowledgments:

The data used for this project are from a combination of Basketball Reference for individual player statistics and HoopsHype for individual player salaries. Thank you to Professor Brad Hartlaub for being an advisor for this project. Thank you for taking the time to read our executive summary, and if you have any questions, we can be reached at:

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