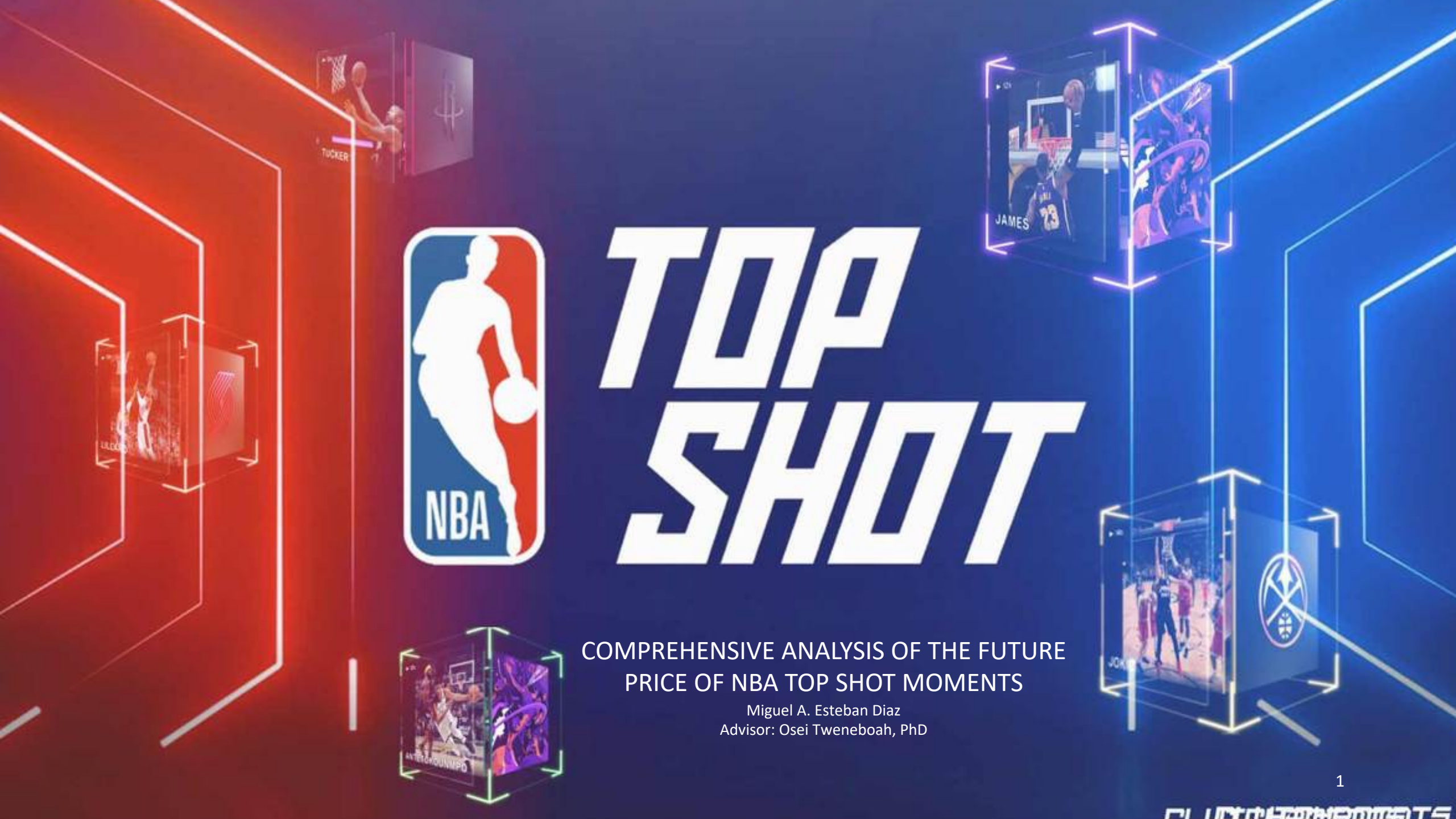


COMPREHENSIVE ANALYSIS OF THE FUTURE PRICE OF NBA TOP SHOT MOMENTS

Miguel A. Esteban Diaz
Advisor: Osei Tweneboah, PhD

Abstract

- NBA Top Shot moments are NFTs built on the FLOW blockchain and created by Dapper Labs in collaboration with the NBA.

- This project aims to:
  - ❖ Provide a statistical analysis that could yield correlations of the characteristics of a moment and its price.
  - ❖ Provide a prediction of the price of moments with the use of machine learning regression models.

- Expand the up to date analysis and research and serve as a foundation for future research, as well as provide helpful and practical information about the valuation of moments.

- Provide future possible application of this information to other similar highlight-oriented sport NFTs like NFL AllDay or UFC Strike.

Table of Contents

Introduction: What are NFTs?

- NFTs are tokens that we can use to represent ownership of unique items.
  - Only one official Owner.
  - Secured by the blockchain.

- Examples: Art, collectibles, real estate.

Introduction: NBA Top Shot

- Marketplace where users can buy/sell NFTs of NBA/WNBA highlight clips.
- Types of highlights:
  - Block
  - Dunk
  - Assist
  - Jump Shot
  - 3 point
  - Handles
  - Steal
  - Layup
- The modern version of trading cards.
- NBA Top Shot NFTs are known as “Moments”.

Introduction: Research Purpose

- Provide a statistical analysis that could yield correlations of the characteristics of a moment and its price, and a prediction of the price of moments.
- Explore a new research area.
- Serve as a foundation for future research of this project and other future highlight-oriented sports NFTs.

Introduction: Research Benefits

- Provide information to more than 1.1M registered users & other NFT owners / potential owners.
  - Discovery of relationships between features.
  - Research of a model that can predict the price of moments.

Background: Literature Review

- Scarcity of in-depth analysis of NBA Top Shot moments.
- No scholarly application.
- NBA Top Shot analysis found in GitHub and Medium.

Background: Literature Review (Cont.)

- Previous NBA Top Shot analysis found:

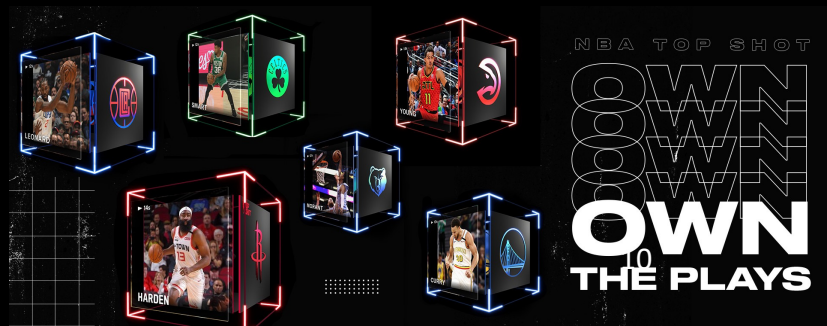
  - “NBATopShot Presentazione” by Riccardo Del Chin.

- Study if the skill of the player appearing in the moment, the rarity and mint size of moments and the results of NBA games could have a direct impact on the price of a moment.

Background: Literature Review (Cont.)

- Relevant Results found by Del Chin's Analysis:

  - Higher prices correlated with higher in game-efficiency of a player.
  - Point difference of a moment's game final score did not have a relevant impact in the price.
  - Team's position in the league's standings did not affect the moment's price of players in that team.
  - Rarity, scarcity and listings of a moment impacted the price.

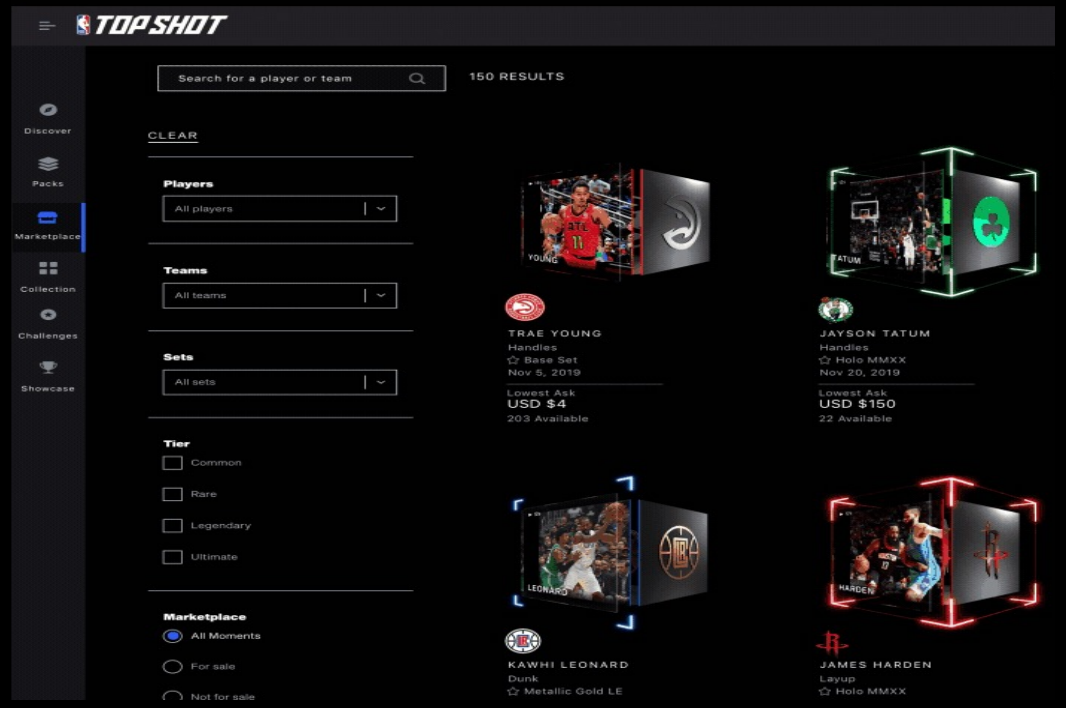


Background: Literature Review (Cont.)

- Features not included in his analysis.
  - ❖Type of Play
  - ❖Set
  - ❖Series
- Characteristics added post June 2021:
  - ❖New rarity: Fandom
  - ❖Introduction of badges.

Methodology

- Dataset obtained from the marketplace of the NBA Top Shot platform.



Methodology (Cont.)

Data Cleaning & Processing

- Data Organization
- Feature Elimination
- Extra Characters Removal
- Correct Data Types of Features
- One Hot Encode Features
- Data Train/Test Split

Methodology: Dataset Features

- Title: NBA or WNBA player appearing in the moment.
  - Example: Kevin Durant, Luka Doncic or Sue Bird

Methodology: Dataset Features (Cont.)

- Rookie Mint: Moment created during the rookie season of the player appearing in the moment.
- Rookie Year: The play that appears in the moment is from a game during the first season of a player.
- Rookie Premiere: Moments that have a play from the first career game of a player.

ROOKIE MINT BADGE

ROOKIE YEAR BADGE

ROOKIE PREMIERE BADGE

Methodology: Dataset Features (Cont.)

- Rookie Three Stars: Moments that have a Rookie Mint, Rookie Year and Rookie Premiere badge.
- Top Shot Debut: Moments that contain a player's first play created in NBA Top Shot.
- Championship Year: Moments that contains a play from the season that a team won the NBA/WNBA Championship.

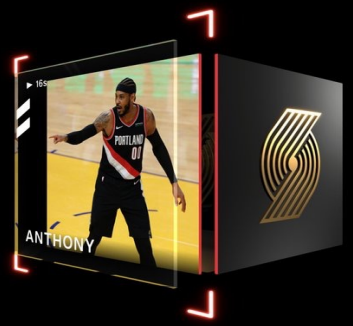
Methodology: Dataset Features (Cont.)

- Challenge Rewards: Exclusive moments that are distributed when a user is holding in an account specific moments by a date stated by NBA Top Shot.

Methodology: Dataset Features (Cont.)

- Rarity : Tier of the moment.

Common



Rare

Legendary

Fandom

- Scarcity: Mint size of the moments.

Methodology: Dataset Features (Cont.)

- Sets: Moments of the same tier that have an attribute in common, can be part of a collection.
- Series: Season when a moment was released.
- Supply: Number of listings in the marketplace for a specific moment.
- Team: Team the player appearing in the moment plays for.
- Play Type: Play that is displayed in the highlight.

Methodology: Predictive Modeling Metrics

- Mean Absolute Error (MAE)
- R-Squared
- Mean Squared Error (MSE)
- Root Mean Squared Error (RMSE)

Methodology: Predictive Modeling Models

- Multiple Linear Regression
  - Ridge Regression
  - Lasso Regression
  - Elastic Net
- Stochastic Gradient Descent Regressor
- Tree Based models
  - Decision Trees
  - Bagging
  - Random Forest
  - ADABoost
  - Gradient Boosting Regressor
- K-Neighbors Regressor
- Gaussian Process Regressor
- Partial Least Squares Regressor
- Support Vector Regressor
  - Nu Support Vector Regressor
  - Linear Support Vector Regressor
- Deep Learning models
  - Multi-Layer Perceptron Regressor
  - Recurrent Neural Networks
- Voting Regressor

Analysis & Discussion: Exploratory Data Analysis

Badge/Non Badge Features Analysis

Rookie Badges

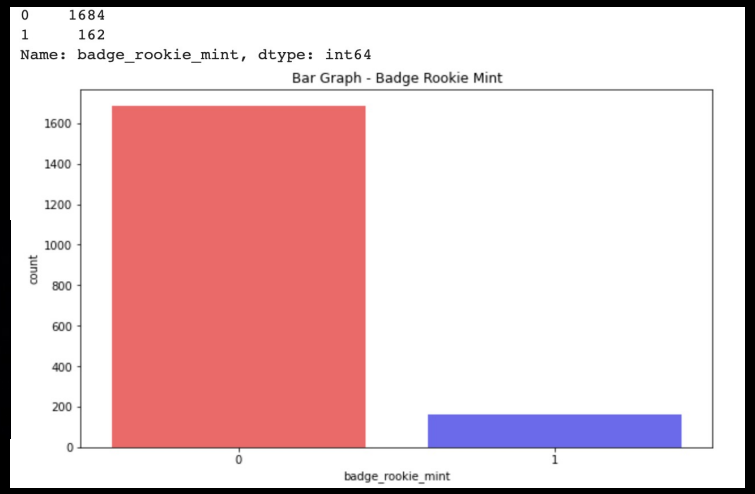


Figure 1 – Count of Moments without/with the Rookie Mint Badge

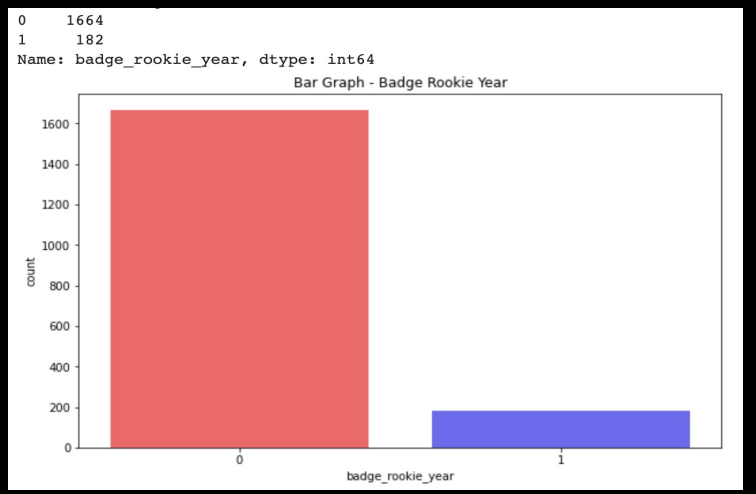


Figure 3 – Count of Moments without/with the Rookie Year Badge

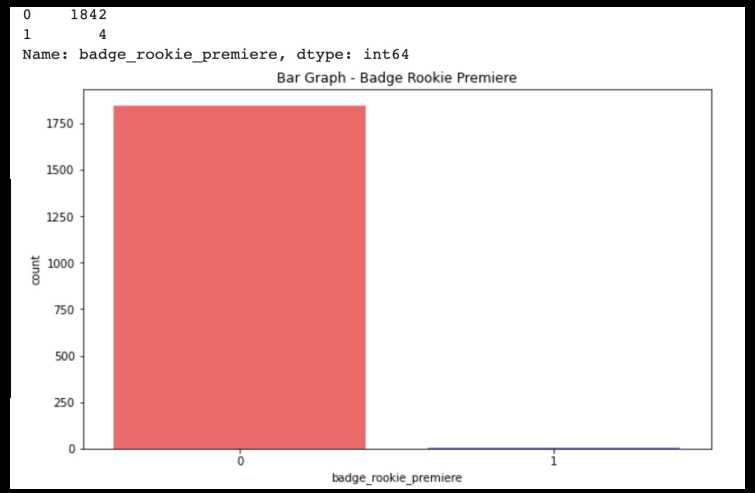


Figure 2 – Count of Moments without/with the Rookie Premiere Badge

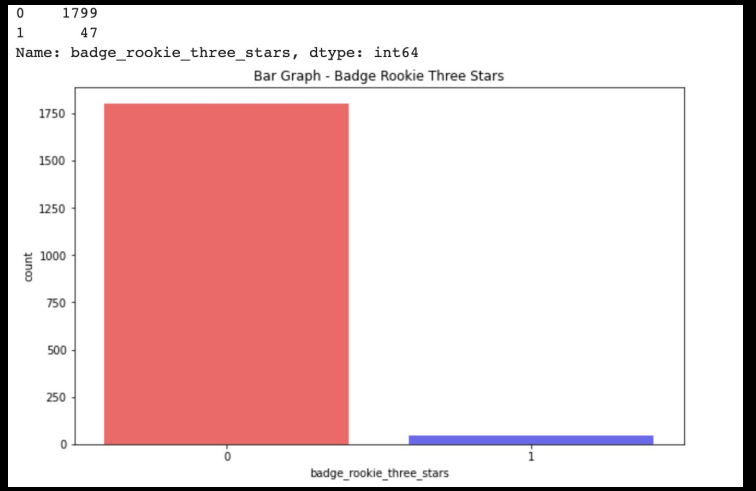


Figure 4 – Count of Moments without/with the Three-Star Rookie Badge

Analysis & Discussion: Exploratory Data Analysis (Cont.)

Badge/Non Badge Features Analysis

Rookie Badges

	Badge - Avg. Price	No-Badge - Avg. Price
Rookie Mint	$5,550.14	$2,729.19
Rookie Premiere	$574.25	$2,981.97
Rookie Year	$5,020.80	$2,753.18
Three-Star Rookie	$515.45	$3,041.05

Table 1 – Average price of Moments with/without each Rookie Badge

Analysis & Discussion: Exploratory Data Analysis (Cont.)

Badge/Non Badge Features Analysis

Challenge Rewards, Top Shot Debut and Championship Year Badges

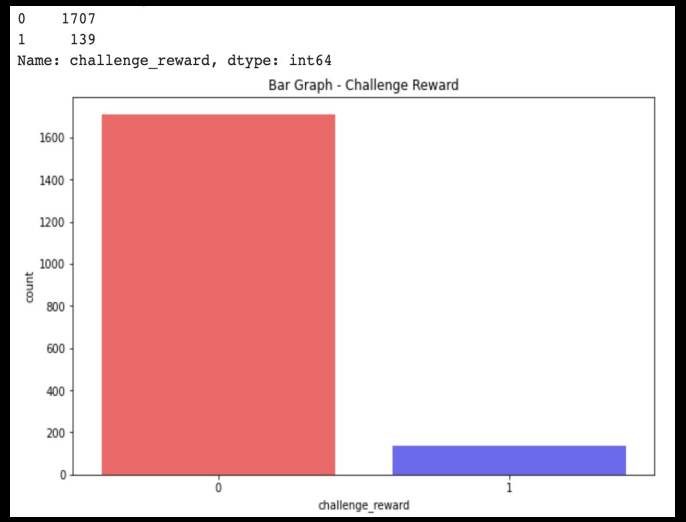


Figure 5 – Count of Moments without/with the Challenge Reward Badge

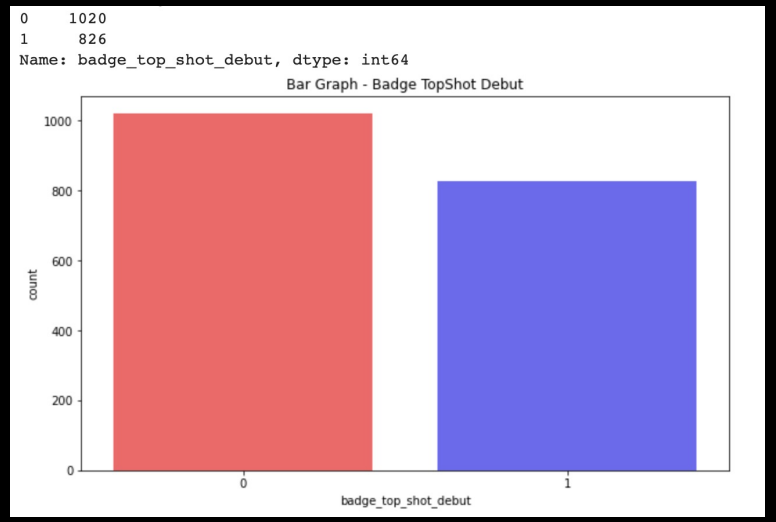


Figure 6 – Count of Moments without/with the Top Shot Debut Badge

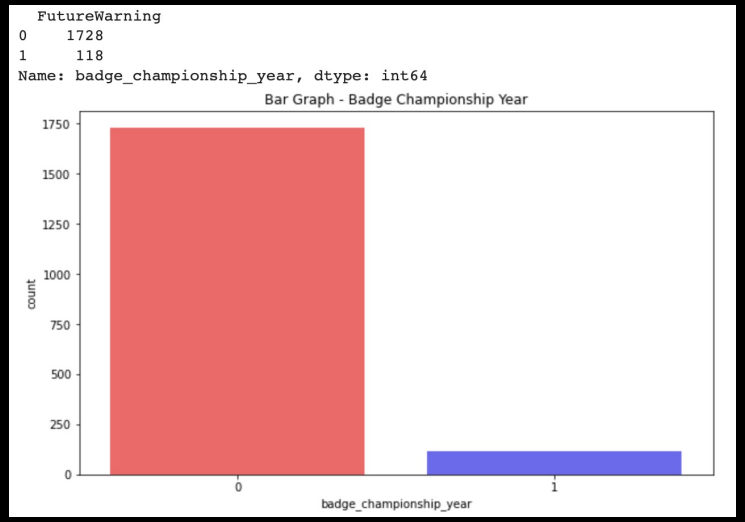


Figure 7 – Count of Moments without/with the Championship Year Badge

Analysis & Discussion: Exploratory Data Analysis (Cont.)

Badge/Non Badge Features Analysis

Challenge Rewards, Top Shot Debut and Championship Year Badges

Average price of Non-Challenge Reward and Challenge Reward moments.

	challenge_reward
0	2296.200351
1	11334.266187

Average price of Non-Top Shot Debut and Top Shot Debut moments.

	badge_top_shot_debut
0	2212.459804
1	3920.542373

Average price of Non-Championship Year and Championship Year moments.

	badge_championship_year
0	2424.736111
1	11060.449153

Analysis & Discussion: Exploratory Data Analysis (Cont.)

Rarity

```
Common       899
Rare         645
Legendary    272
Fandom        30
Name: rarity, dtype: int64
```

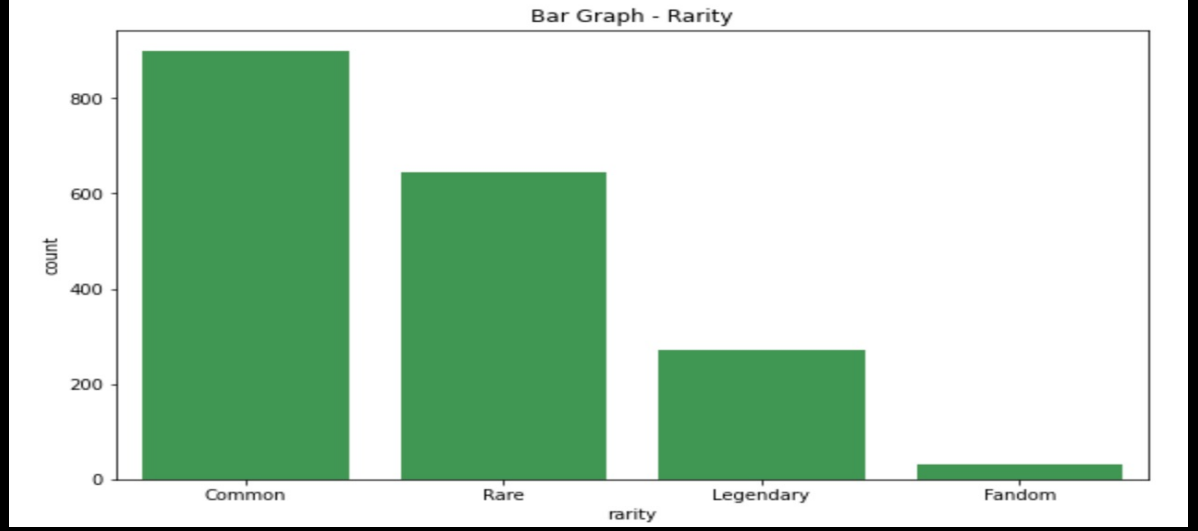


Figure 8 – Moment count per Rarity

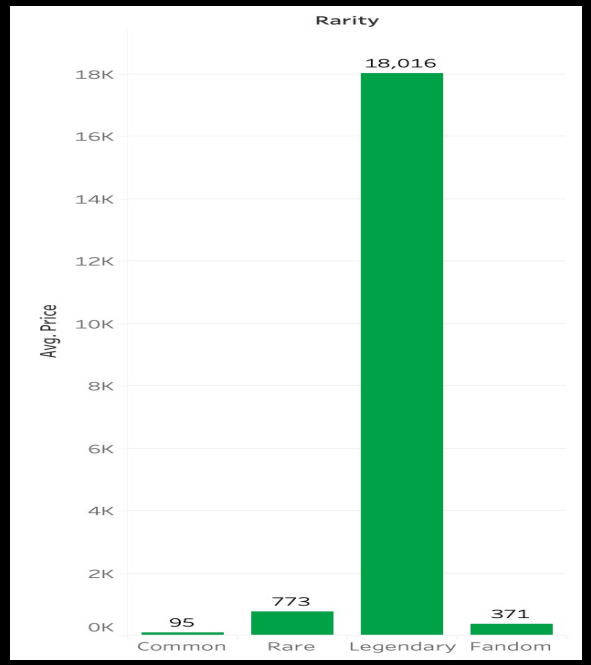


Figure 9 - Moment average price per Rarity

Analysis & Discussion: Exploratory Data Analysis (Cont.)

Title

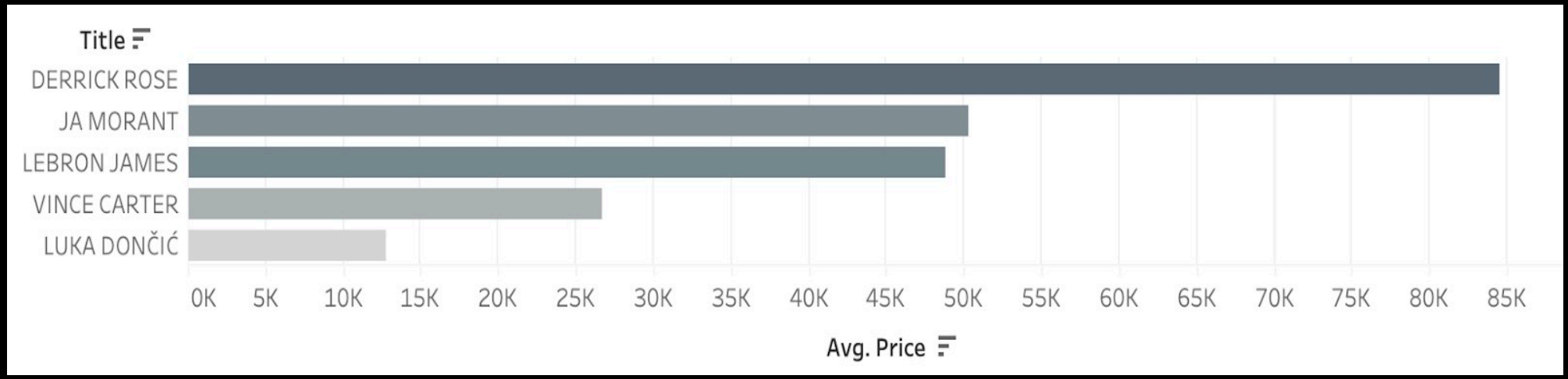


Figure 10 – Top 5 highest average price players

Analysis & Discussion: Exploratory Data Analysis (Cont.)

Series

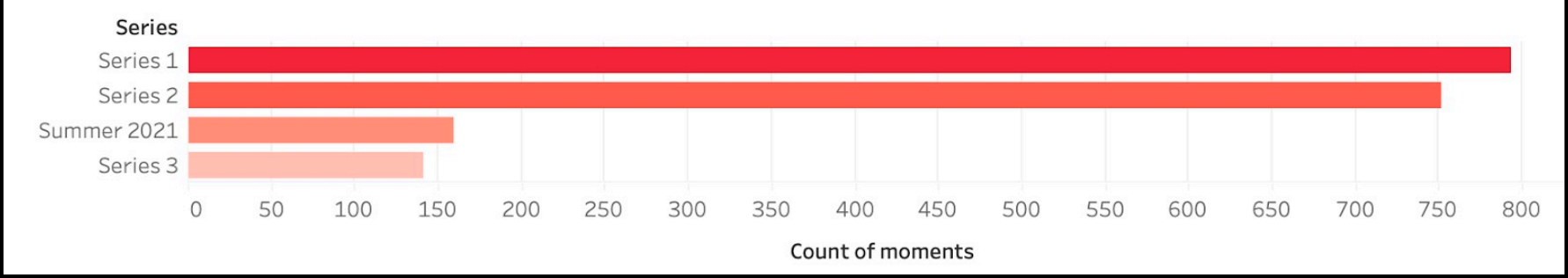


Figure 11 – Moment count per Series

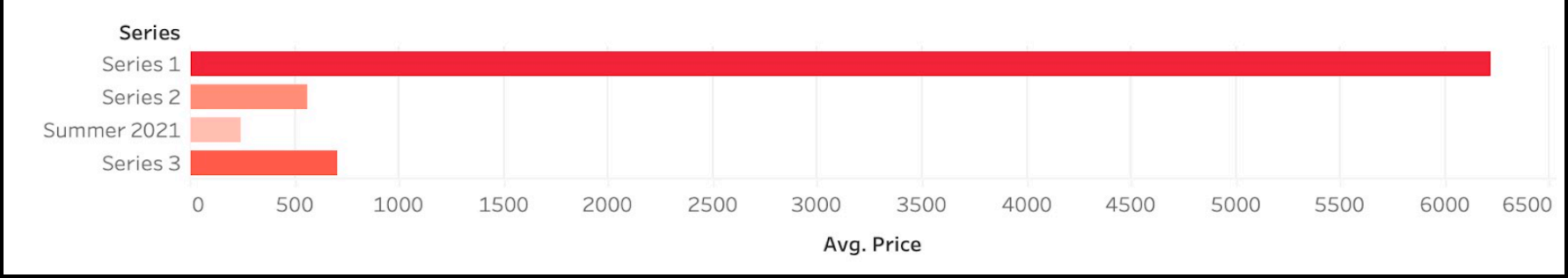


Figure 12 – Moment average price per Series

Analysis & Discussion: Exploratory Data Analysis (Cont.)

Series & Play Type

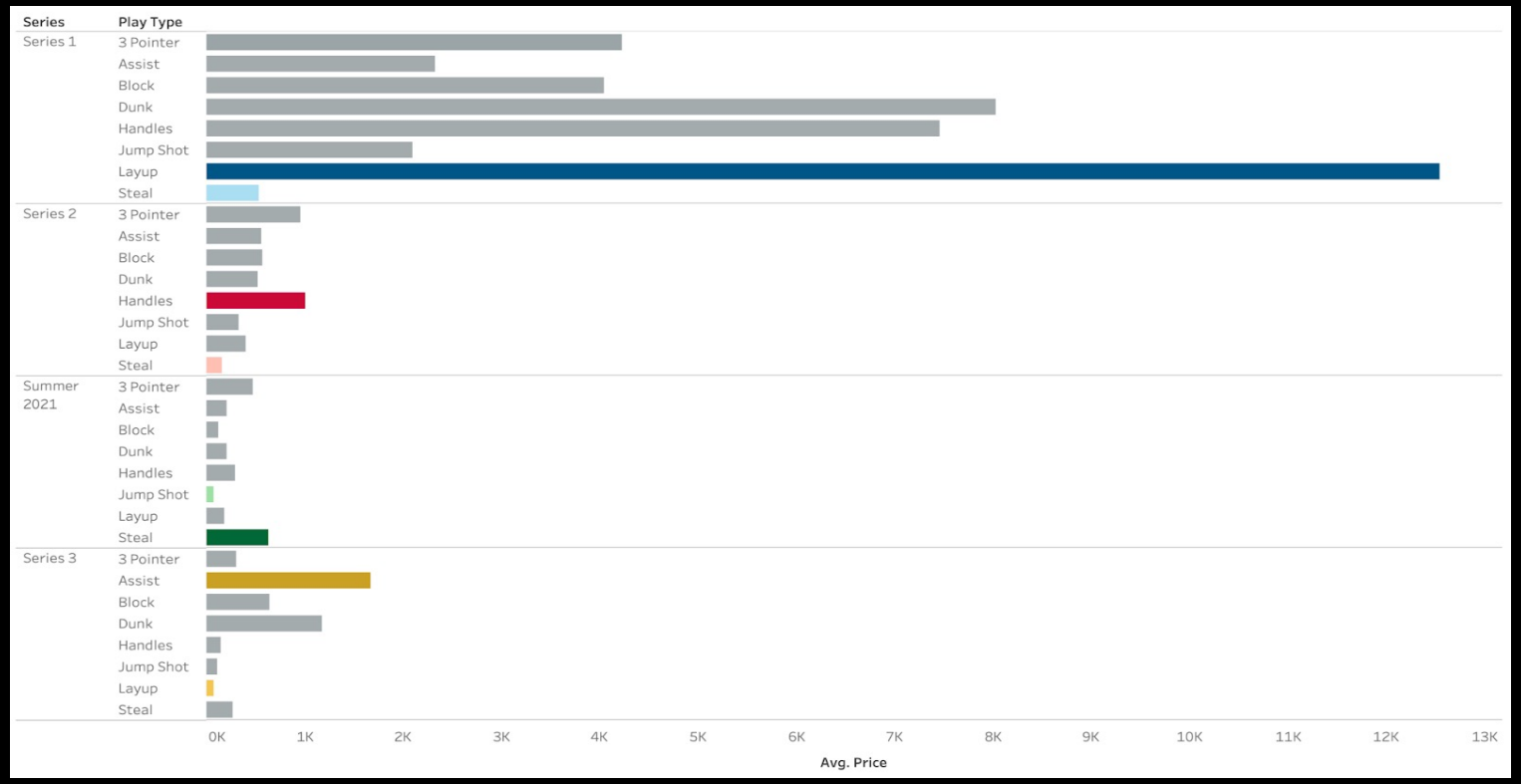


Figure 13 - Moment average price per Series and Play Type

Analysis & Discussion: Predictive Modeling Analysis

	Metrics			
Models	MAE	R-Squared	MSE	RMSE
Multiple Linear Regression	$17,187,669,336.72	-$89,909,312,409,256.00	$17,879,103,578,396,200,000,000.00	$133,712,765,203.61
Ridge Regression	$3,502.76	$0.17	$165,001,064.94	$12,845.27
Lasso Regression	$10,077.46	-$4.72	$1,137,465,000.48	$33,726.33
Elastic Net	$3,491.62	$0.14	$170,501,707.62	$13,057.63
Decision Trees	$2,781.43	-$2.34	$663,198,153.40	$25,752.63
Random Forest	$2,601.31	-$0.59	$316,032,819.41	$17,777.31
AdaBoost	$11,462.49	-$2.86	$766,771,670.67	$27,690.64
Gradient Boosting Regressor	$1,394.27	$0.18	$162,275,503.63	$12,738.74
SVR	$2,145.43	-$0.02	$202,504,850.87	$14,230.42
Nu SVR	$2,151.03	-$0.02	$202,650,748.89	$14,235.55
Linear SVR	$2,228.00	-$0.01	$200,628,639.96	$14,164.34
Bagging	$3,106.05	-$0.99	$394,755,821.90	$19,868.46
SGD Regressor	$225,584,631,764,580,000.00	-$1,047,226,085,839,020,000,000,000,000.00	$208,248,324,417,022,000,000,000,000,000,000,000.00	$456,342,332,484,093,000.00
K-Neighbors Regressor	$2,066.63	$0.12	$175,146,975.09	$13,234.31
Gaussian Process Regressor	$2,055.42	-$0.11	$220,929,062.07	$14,863.68
PLS Regression	$9,323.07	-$4.08	$1,009,578,583.94	$31,773.87
Voting Regressor	$2,687.39	$0.19	$161,580,823.74	$12,711.44
MLP Regressor	$2,895.02	$0.19	$160,471,336.27	$12,667.73
Sequential - RNN	$4,772.39	-$5.40	$1,272,552,158.70	$35,672.85

Table 2 – Machine Learning model results per performance metric

Analysis & Discussion: Predictive Modeling Analysis (Cont.)

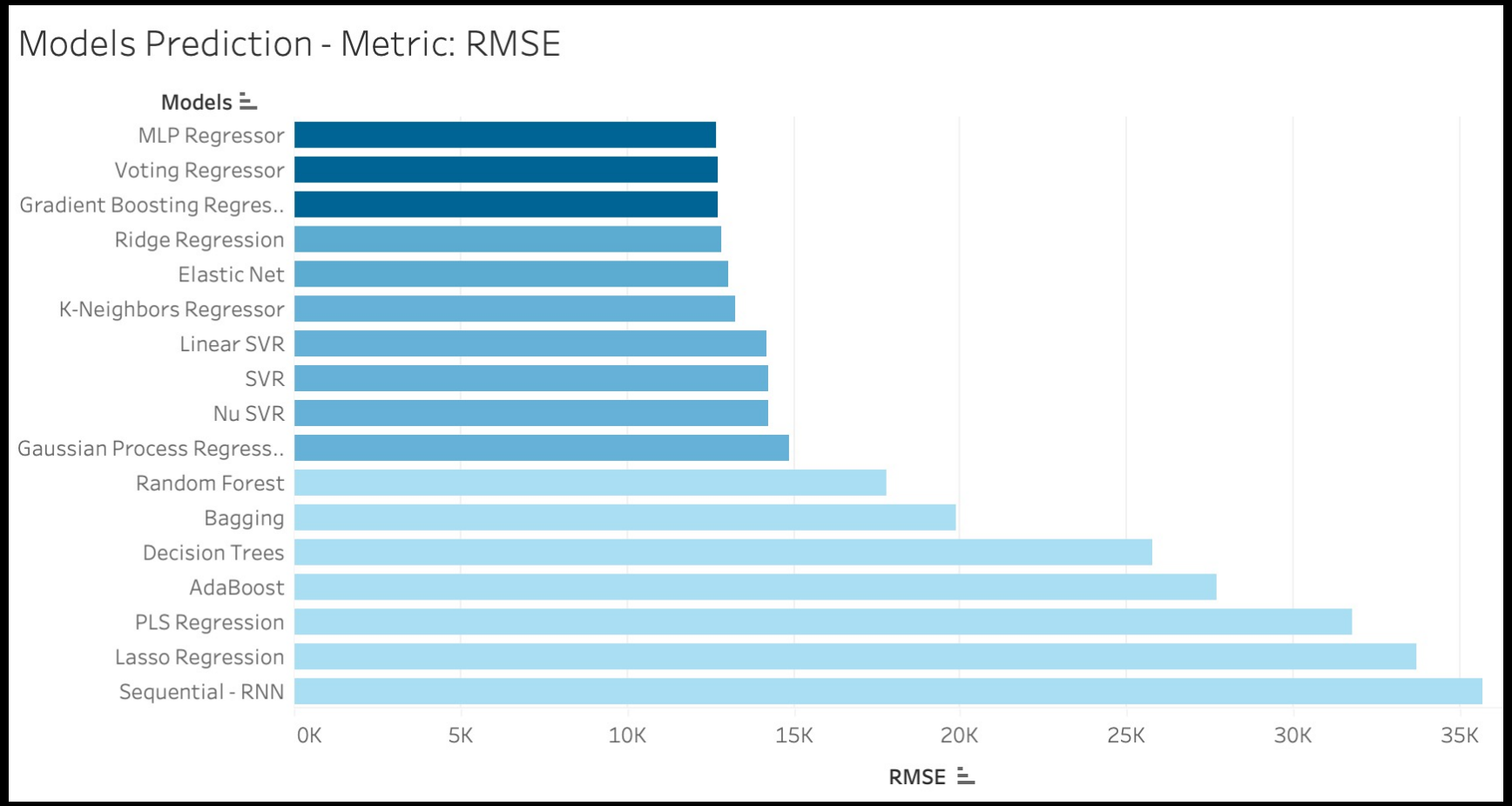


Figure 14 - Machine learning models performance using the metric RMSE

Analysis & Discussion: Predictive Modeling Analysis (Cont.)

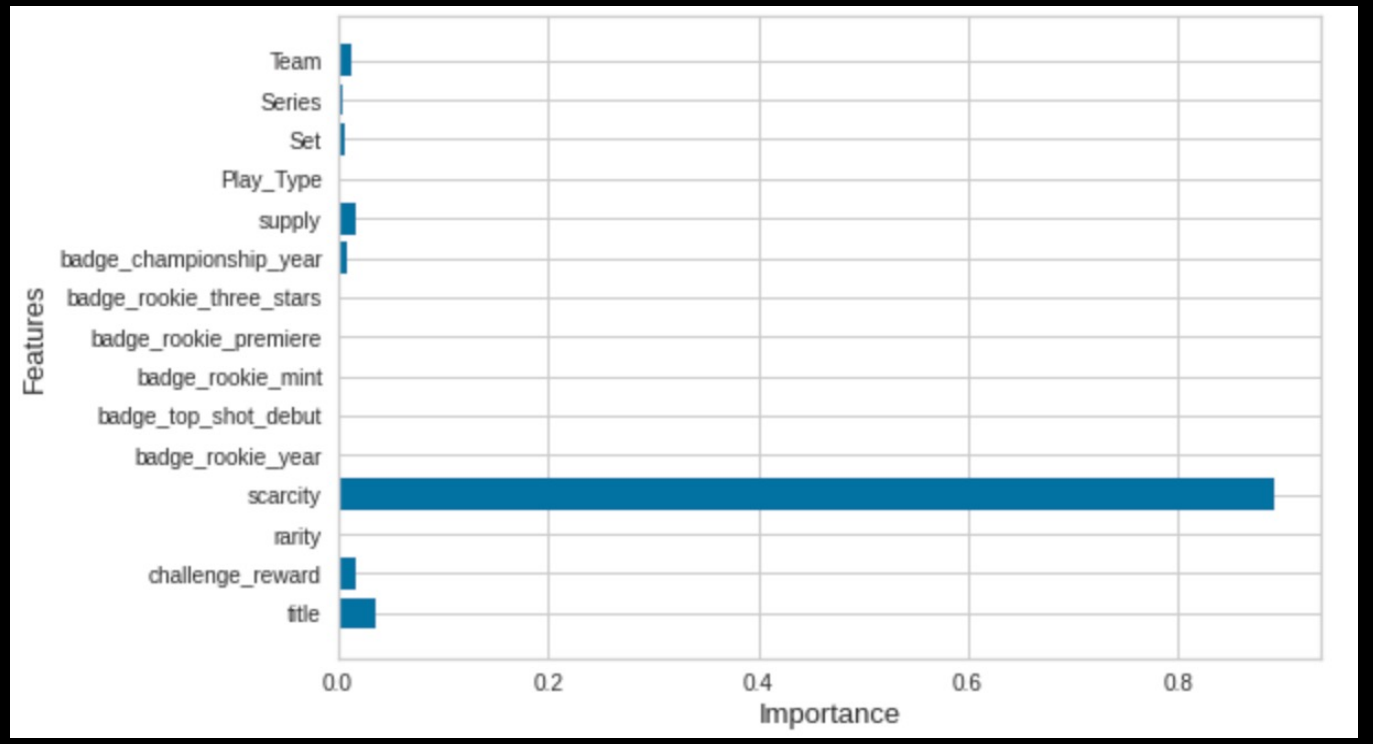


Figure 15 - Variable Importance plot of Gradient Boosting Regressor

Conclusions

- Relevant Results found in this Research

❖ Badges
- All 4 Rookie Badges scarce
  - Rookie Year & Rookie Mint more valuable on average than Rookie Premiere or Rookie Three Stars, and Non-Badge moments.
- Challenge Rewards and Championship Year Scarce, Top Shot Debut less common.
  - All 3 Badges more valuable on average than Non-Badge moments.
- Partial Supply & Demand economic relationship.

❖ Rarity
- Legendary tier is the most valuable on average.
- Fandom tier's value is between Common and Rare Tiers.

❖ Title
- Top most expensive players: Elite level or recognized by basketball community.

Conclusions (Cont.)

- Relevant Results found in this Research
  - ❖ Series
    - Series 1, oldest series, highest value.
    - Series Summer 2021, least value and only off-season series.
  - ❖ Series & Play Type
    - Steals significantly lower value than rest of Play Types in Series 1.
    - Rest of Series 1 Play Types, significantly more valuable than other Series' Play Types.

Conclusions (Cont.)

- Relevant Results found in this Research
  - ❖ Best performer: prediction - Multiple-Layer Perceptron
  - ❖ Best performer: prediction + interpretability - Gradient Boosting Regressor
    - ❖ Most important features
      1. Scarcity
      2. Title
      3. Supply
    - ❖ Least important features
      1. Rarity
      2. Rookie Mint Badge
      3. Rookie Year Badge

Future Work

Research improvements

- Eliminate unrealistic samples
- Eliminate least important features
- Apply model to specific data of interest

References

1. Songco, D. (2021, February 2). *Everything you need to know about NBA top shot*. ClutchPoints. Retrieved May 4, 2022, from https://clutchpoints.com/everything-you-need-to-know-about-nba-top-shot/
2. Contreras, I. (2022, April 21). *Sotheby's makes first crypto investment, backing nft startup using Ethereum Blockchain*. Forbes. Retrieved May 4, 2022, from https://www.forbes.com/sites/isabelcontreras/2021/10/21/sothebys-makes-first-crypto-investment-backing-nft-startup-using-ethereum-blockchain/?sh=4af0c67a3d82
3. Spangler, T. (2021, July 13). *'space jam: A new legacy': Warner Bros.. is tossing 91,000 nfts featuring characters, Lebron James up for grabs (exclusive)*. Variety. Retrieved May 4, 2022, from https://variety.com/2021/digital/news/space-jam-new-legacy-nft-lebron-james-1235016220/
4. *Digiland: NFT: Earn BNB, FTM, Polygon via nfts: Airnfts*. Best NFT Market. (n.d.). Retrieved May 4, 2022, from https://app.airnfts.com/nft/DigiLand_1637880700837
5. Phan, T. T. (2020, December 23). *What's the most valuable NBA highlight?* The Hustle. Retrieved May 4, 2022, from https://thehustle.co/nba-top-shot-most-valuable-highlight/
6. Labs, D. (n.d.). *NBA top shot*. NBA Top Shot. Retrieved May 4, 2022, from https://nbatopshot.com/
7. Press, T. A. (2021, August 8). *Kevin Durant agrees to 4-year contact extension with nets*. NBA.com. Retrieved May 4, 2022, from https://www.nba.com/news/report-kevin-durant-to-sign-extension-with-nets

References

8. Medina, M. (2020, December 2). *Opinion: Dallas Mavericks' Luka Doncic will be even better in Year 3 with upgrades on roster around him*. USA Today. Retrieved May 4, 2022, from https://www.usatoday.com/story/sports/nba/mavericks/2020/12/01/dallas-mavericks-luka-doncic-even-better-roster-upgrades/3786530001/

9. Gannett Satellite Information Network. (2022, January 7). *WNBA star Sue Bird puts off retirement, says she's returning to Seattle storm in 2022*. USA Today. Retrieved May 4, 2022, from https://www.usatoday.com/story/sports/wnba/storm/2022/01/07/sue-bird-returning-seattle-storm-2022-wnba-season/9133462002/

10. Admin. (2021, June 23). *The 5 badges in NBA top shot and what they mean*. Top Shot 101. Retrieved May 4, 2022, from https://topshot101.com/badges/

11. Shot, N. B. A. T. (2021, August 30). *Going a level deeper ... 🔢 the serial number of the moment, 🏆 the championship year badge on it, ✅ and even the purchase price all came with extra meaning.all championship year badges: Https://t.co/0bkf8qy6sl pic.twitter.com/yewdcji4r7*. Twitter. Retrieved May 4, 2022, from https://twitter.com/nbatopshot/status/1432141099351556097?lang=fa

12. Carr, A. (n.d.). *The official NBA Top Shot Challenge Guide*. RSS. Retrieved May 4, 2022, from https://blog.nbatopshot.com/posts/challenge-guide


MCCOLLUM


QUICKLEY


IRVING


BAMBA
GOT
GOT
GAME


WALL

QUESTIONS


ANTHONY
RUN IT BACK


CARTER


JAMES


IGUODALA