How Efficient Baserunning Impacts Scoring

By: Henry Bednar

Executive Summary

This comprehensive analysis employed advanced machine learning techniques to develop predictive baserunning models for two critical offensive performance metrics: Run Scoring Percentage (RSP) and Runs Per Game (RPG). Through rigorous feature engineering, complete coefficient analysis, and model validation processes, it successfully identified the key performance drivers with statistical precision.

Key Findings:

- Achieved robust predictive models with R^2 values of 0.586 for RSP and 0.534 for RPG
- Identified 8 statistically significant predictors for RSP and 9 statistically significant predictors for RPG ($p < 0.05$)
- Quantified impact measurements including -5.093 coefficient for speed (RSP) and -2.738 for speed (RPG)
- Discovered counter-intuitive insights such as negative coefficients for stolen base opportunities
- Established temporal stability with year coefficients proving statistically irrelevant ($p > 0.05$ for both models)

Research Methodology & Enhanced Analytical Framework

Advanced Analytical Approach

This study employed a comprehensive machine learning pipeline enhanced with complete coefficient extraction and statistical significance testing. The enhanced framework incorporated:

- **Complete Coefficient Analysis**: Linear regression coefficient extraction with standard errors, p-values, and 95% confidence intervals for all features
- **Statistical Significance Framework**: Systematic p-value analysis identifying reliable predictors from total features

- **Multi-Algorithm Ensemble**: Stacked ensemble achieving 1.59% improvement for RSP (though individual models outperformed for RPG)
- **Rigorous Cross-Validation**: 5-fold cross-validation ensuring consistent performance across data configurations
- **Advanced Feature Selection**: Boruta algorithmic selection (RSP: 35 features, RPG: 32 features)

Data Scope & Model Performance

The analysis encompasses Baseball Savant and Baseball Reference data from 270 team-seasons across nine complete seasons (2016-2024):

- **RSP Model Performance**: $R^2 = 0.586$, Adjusted $R^2 = 0.508$, F-statistic = 7.52 (35 features, 181 DF)
- **RPG Model Performance**: $R^2 = 0.534$, Adjusted $R^2 = 0.452$, F-statistic = 6.54 (32 features, 183 DF)
- **Temporal Validation**: Both models show stable relationships across all nine seasons

Coefficient Analysis - Run Scoring Percentage (RSP)

Model Equation

- RSP = -40.335 + 0.133×(On_2nd_Single_Scored) + 0.009×(On_1st_When_Double)
- - 5.093×(Average_Time_Home_to_First) - 0.005×(Stolen_Base_Opportunities)
- + 0.131×(On_1st_Double_Scored) + ... (29 more terms)

Tier 1: Statistically Significant Predictors ($p < 0.05$)

On_2nd_Single_Scored

- Coefficient: +0.133 | p-value: 0.014* | 95% CI: [0.027, 0.239]
- Each 1% increase in scoring from 2nd base on singles adds 0.133 percentage points to overall team scoring efficiency—the ultimate clutch metric

Stolen_Base_Opportunities

- Coefficient: -0.005 | p-value: < 0.001*** | 95% CI: [-0.007, -0.003]
- Counter-intuitive finding: Excessive stealing opportunities may indicate offensive struggles—teams that create many steal chances but don't convert them into runs through hitting

Bases_Taken

- Coefficient: +0.016 | p-value: 0.008** | 95% CI: [0.004, 0.028]
- Aggressive baserunning philosophy—each additional base taken per opportunity adds 0.016 percentage points to scoring efficiency

On_2nd_Single_Reached_3rd

- Coefficient: +0.100 | p-value: 0.035* | 95% CI: [0.007, 0.192]
- Critical RISP advancement—moving from 2nd to 3rd on singles positions runners in prime scoring position

Number_of_Players

- Coefficient: -0.088 | p-value: 0.012* | 95% CI: [-0.157, -0.019]
- Roster instability indicator—teams using more players typically struggle with offensive consistency and chemistry

CS_Only_Runner_On

- Coefficient: -0.146 | p-value: 0.014* | 95% CI: [-0.261, -0.030]
- Pure baserunning mistakes when the runner is the only one on base—highly costly situational errors

Outs_On_Base_2nd

- Coefficient: -0.075 | p-value: 0.022* | 95% CI: [-0.139, -0.011]
- Rally-killing mistakes at second base—each additional out costs 0.075 percentage points in scoring efficiency

SB_2B_Advances_vs_Average

- Coefficient: +0.072 | p-value: 0.036* | 95% CI: [0.005, 0.139]
- Above-average advancement quality on stolen bases—not just stealing, but stealing effectively

Tier 2: High-Impact Non-Significant Contributors

On_1st_When_Double

- Coefficient: +0.009 | p-value: 0.918 | Importance: 0.547
- Baseball IQ metric with highest importance—ensuring that runners are on 1st when doubles occur maximizes scoring potential

Average_Time_Home_to_First

- Coefficient: -5.093 | p-value: 0.132 | Importance: 0.485

- Speed foundation with massive coefficient—each 0.1 second improvement could add ~0.5 percentage points to scoring

On_1st_Double_Scored

- Coefficient: +0.131 | p-value: 0.138 | Importance: 0.453
- Aggressive advancement from 1st to home on doubles—substantial potential impact when executed

Coefficient Analysis - Runs Per Game (RPG)

Model Equation

- RPG = 95.077 - 0.0004×(Stolen_Base_Opportunities) - 2.738×(Average_Time_Home_to_First)
- + 0.010×(On_1st_When_Double) + 0.003×(Bases_Taken)
- + 0.280×(Lead_Distance_Pitcher_Windup_to_Release) + ... (27 more terms)

Tier 1: Statistically Significant Predictors ($p < 0.05$)

Average_Time_Home_to_First

- Coefficient: -2.738 | p-value: 0.001** | 95% CI: [-4.398, -1.077]
- Speed foundation for run production—each 0.1 second improvement adds ~0.27 runs per game over a full season

On_2nd_Single_Scored

- Coefficient: +0.030 | p-value: 0.009** | 95% CI: [0.008, 0.052]
- RISP conversion drives run volume—each percentage point improvement adds 0.030 runs per game

Lead_Distance_Pitcher_Windup_to_Release

- Coefficient: +0.280 | p-value: 0.015* | 95% CI: [0.055, 0.504]
- Technical baserunning skill—optimal lead distances create multiple scoring opportunities per game

Outs_On_Base_2nd

- Coefficient: -0.021 | p-value: 0.024* | 95% CI: [-0.039, -0.003]
- Rally-killing mistakes at second base with measurable per-game cost

On_2nd_When_Single

- Coefficient: -0.025 | p-value: 0.023* | 95% CI: [-0.046, -0.004]
- Counter-intuitive negative—may indicate forcing advancement rather than smart situational baserunning

CS_Only_Runner_On

- Coefficient: -0.040 | p-value: 0.021* | 95% CI: [-0.074, -0.006]
- Baserunning mistakes with quantified run cost when no other runners are present

Number_of_Players

- Coefficient: -0.036 | p-value: < 0.001*** | 95% CI: [-0.053, -0.019]
- Roster instability strongly indicates offensive struggles—highly significant across both models

Average_Sprint_Speed

- Coefficient: -0.297 | p-value: 0.029* | 95% CI: [-0.563, -0.030]
- Quality over pure speed—suggests that context-dependent application matters more than raw athleticism

On_2nd_Single_Reached_3rd

- Coefficient: +0.025 | p-value: 0.027* | 95% CI: [0.003, 0.048]
- Consistent contributor to aggressive advancement from scoring position

Tier 2: High-Impact Non-Significant Contributors

Stolen_Base_Opportunities

- Coefficient: -0.0004 | p-value: 0.096 | Importance: 0.667
- Too many stealing opportunities may indicate an inability to drive runners in

On_1st_When_Double

- Coefficient: +0.010 | p-value: 0.599 | Importance: 0.343
- Baseball IQ metric with practical but statistically variable impact

Bases_Taken

- Coefficient: +0.003 | p-value: 0.102 | Importance: 0.287
- Aggressive baserunning philosophy with borderline statistical significance

Cross-Model Strategic Insights

Statistically Validated Universal Success Factors

Scoring from 2nd on Singles

- RSP Impact: +0.133 coefficient (p = 0.014*) - clutch efficiency validated
- RPG Impact: +0.030 coefficient (p = 0.009**) - volume production confirmed
- Strategic Value: Ultimate clutch metric validated across both efficiency and volume systems

Baserunning Discipline (Multiple "Getting Out" Metrics)

- Both Models: Consistent negative coefficients with statistical significance
- RSP Impact: Outs at 2nd (-0.075, p = 0.022*), CS only runner (-0.146, p = 0.014*)
- RPG Impact: Outs at 2nd (-0.021, p = 0.024*), CS only runner (-0.040, p = 0.021*)

Roster Management Discipline

- RSP Impact: Number of players used (-0.088, p = 0.012*)
- RPG Impact: Number of players used (-0.036, p < 0.001***)
- Strategic Value: Roster stability correlates strongly with offensive success

Counter-Intuitive Statistical Discoveries

Stolen Base Opportunities Paradox

- Both Models: Negative coefficients (-0.005 RSP, -0.0004 RPG)
- Statistical Significance: RSP highly significant (p < 0.001***), RPG marginal (p = 0.096)
- Strategic Implication: Excessive stealing opportunities likely indicate inability to drive runners in throughl hitting

Speed Application Complexity

- Average Time Home to First: Large negative coefficients (speed improvement beneficial)
- Average Sprint Speed: Negative RPG coefficient (-0.297, p = 0.029*) suggests context matters more than raw speed
- Strategic Value: Intelligent speed application trumps pure athleticism

Temporal Stability Analysis

Year Effect Statistical Analysis

RSP Model Year Impact

- Coefficient: +0.049 | p-value: 0.644 | Improvement: 0.25% RMSE
- Interpretation: Statistically irrelevant temporal trend

RPG Model Year Impact

- Coefficient: -0.035 | p-value: 0.180 | Improvement: -0.79% RMSE
- Interpretation: Year actually reduces model performance—ignore temporal adjustments

Strategic Implication: Fundamental baserunning and situational skills transcend rule changes and analytical evolution.

Statistical Significance Hierarchy

Highly Significant Predictors ($p < 0.01$)

RSP Model:

- Stolen Base Opportunities: -0.005 coefficient (p < 0.001***)
- Bases Taken: +0.016 coefficient (p = 0.008**)

RPG Model:

- Average Time Home to First: -2.738 coefficient (p = 0.001**)
- On_2nd_Single_Scored: +0.030 coefficient (p = 0.009**)
- Number of Players Used: -0.036 coefficient (p < 0.001***)

Summary of Statistical Findings

RSP Model:

- Total features analyzed: 35
- Statistically significant features (p < 0.05): 8 out of 35
- Highest coefficient impact: Average_Time_Home_to_First (-5.093, non-significant)
- Most reliable predictor: Stolen_Base_Opportunities (p < 0.001)

RPG Model:

- Total features analyzed: 32
- Statistically significant features (p < 0.05): 9 out of 32
- Highest coefficient impact: Average_Time_Home_to_First (-2.738, p = 0.001)
- Most reliable predictor: Number_of_Players (p < 0.001)

Key Strategic Takeaways

1. **Clutch Advancement**: Moving runners from 2nd to 3rd and scoring from 2nd on singles are universally valuable across both efficiency and volume metrics

2. **Discipline Over Aggression**: Avoiding outs on the basepaths, especially at 2nd base and when caught stealing as the only runner, provides measurable value

3. **Speed Context Matters**: Raw speed is less important than intelligent application—optimal leads and situational awareness trump pure athleticism

4. **Roster Stability**: Teams using fewer players throughout the season demonstrate better offensive consistency and baserunning execution

5. **Quality Over Quantity**: Excessive stolen base opportunities may indicate offensive deficiencies rather than aggressive baserunning prowess