

# Modeling the NCAA basketball tournament selection process using a decision tree

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**Abstract.** Each year, 68 teams are invited to participate in the NCAA basketball tournament. Of these 68 teams, 36 are given an at-large bid by a selection committee rather than automatically qualifying. However, despite the process being public, the exact method by which teams are ranked against other teams to determine which teams are given at-large bids is not known. Many factors are known or theorized to be in use, including the RPI, top 50 wins, and strength of schedule. In this paper we attempt to provide a quantitative method to mimic the team made by the selection committee by constructing a decision tree. We then test our method on years 2012–2016, where we find that in each year all but one team selected by our method was invited to the tournament.

Keywords: NCAA, basketball, selection, decision tree

## 1. Introduction

The men’s college basketball championship tournament held by the National Collegiate Athletic Association (NCAA), henceforth referred to as *the tournament*, attracts mass media and popular attention across the country. Surprisingly, for such a popular event, the method by which teams are selected for participation in the tournament is something of a mystery. Each year 32 teams are guaranteed entry by winning their conference tournaments. However, the other 36 teams are selected by a selection committee whose job is to determine which teams are best qualified to play in the tournament. While the procedure followed by the selection committee to select the 36 teams is known, the details on exactly how the teams are ranked have not been made fully public. There has been much speculation on which factors are important to the committee, how quantitative or qualitative their assessment is, and how much of it is just the “eye test”.

In this paper we propose a decision-making method that attempts to mimic the process performed by the selection committee. Here we focus solely on the selection process, where we identify the teams that will be given entrance into the tournament, rather than also attempting to predict the seed each team will be assigned. We then present the results of our method when tested over the years 2011–2016, and show that we are able to correctly select all but one team in each of those years.

## 2. Background

There has been much public speculation on how the committee selects teams for the tournament. The process by which a committee selects teams is public (NCAA, 2016); each committee member identifies 36 teams which they believe should be given entrance, as well as marks any team which they believe should be considered for entry. Then, any team which at least all-but-two committee members select for inclusion will be added to the tournament. The remaining teams are taken from the lists for inclusion and consideration and filtered down via another series

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of ballots. Finally, those teams are ranked by each committee member, and the highest ranked teams are added to the tournament four at a time.

The uncertainty comes when attempting to determine how a committee member decides which teams are stronger than other teams. The members have copious amounts of data available, including box scores, head-to-head results, results against common opponents, conference schedules, overall and non-conference strength of schedule, road record, injury reports, coach availability, and other tracked metrics (NCAA, 2016). However, it is not known which of these pieces of information is used and how much they are weighted. For example, it was long thought that the Rating Performance Index (RPI) was a large factor in the selection process (Ezekowitz, 2013), but recent statements from committee members state that the RPI is used to determine which teams are considered, but is not a determining factor (Stephens, 2015). Other statements by committee members suggest the importance of acquiring top-50 wins (wins against a team with a top-50 RPI) and avoiding 200+ losses (losses against a team with an RPI of over 200) (Katz, 2016).

The RPI metric is used to rank teams based on each team's wins, losses, and strength of schedule (how strong their opponents were). The current formula for RPI is given as

$$RPI = (WP * 0.25) + (OWP * 0.5) + (OOWP * 0.25) \quad (1)$$

where WP is Winning Percentage, OWP is Opponents' Winning Percentage, and OOWP is Opponents' Opponents' Winning Percentage. The WP is calculated as number of wins / number of games, where a home win is counted as 0.6, a neutral win is 1, and an away win is 1.4. This weighting is due to the observed influence of game location on game outcome, where home teams tend to win significantly more than away teams. The OWP is the average of the WP for each of a team's opponents, while the OOWP is the average of each opponent's OWP.

While official statements may seek to downplay the role of RPI, the RPI values are embedded into numerous pieces of information the committee admits to using. For example, top-50 wins are counted as wins against teams with the top 50 RPI ranks, while strength of schedule measure the strength of each team using its RPI rank. Therefore, the RPI of each team is inherently included in the committee selection process.

The RPI has also been subjected to criticisms. One of the most frequent criticisms is that it relies too heavily on strength of schedule (Pomeroy, 2011). As seen in the formula for RPI, the strength of the opponents appears in both the OWP and OOWP components, which means that 75% of the RPI value is dependent on opponent strength to some degree. This can cause problems for teams in weaker conferences, since they do not play against strong opponents in their conference. Indeed, playing a weaker team is typically detrimental to a team's RPI rank regardless of the outcome of the game. Another criticism is that RPI does not take into account margin of victory. However, the RPI rankings are officially acknowledged to be used in the selection process, so we chose to include them.

In light of the weaknesses found in the RPI, several other rating systems have risen to popularity. The Basketball Power Index (BPI) was introduced in 2013 by ESPN and referred to as "a little more refined than any other existing power ranking" (Oliver, 2013). The formula for the BPI is not included in the literature, but it is said to include information such as whether a team is missing an important player during a game, how close the game was, the pace of the game, and strength of schedule (Oliver, 2013).

Another popular rating system is provided by Ken Pomeroy, who scores each team using a *pythagorean winning percentage* (Pomeroy, 2012). His ratings combine the *adjusted offensive efficiency* (*AdjO*) and *adjusted defensive efficiency* (*AdjD*) which are an estimate of the points scored (for offense) or allowed (for defense) per 100 possessions against the average defense (or offense). The formula to combine these into the pythagorean rating is

$$\text{pyth} = \frac{AdjO^{10.25}}{AdjO^{10.25} + AdjD^{10.25}} \quad (2)$$

Jeff Sagarin also publishes the popular Sagarin rankings, but his formula is also proprietary.

### 3. Methodology

The goal of this method is to predict which teams will be selected for entrance into the tournament. In order to do this, we must first choose which pieces of information pertaining to each team to use. This information will then be built into a model to determine the relative strength of the teams considered for entry in the tournament.

### 3.1. Choosing relevant information

We decided to use some expert rankings in conjunction with some performance metrics for the teams over the regular season.

The first included ranking is RPI, which is known to be a factor that the selection committee at least considers. We also chose to include other expert rankings to potentially make up for some of the weaknesses in the RPI system. The main expert rankings in popular use are the BPI, Pomeroy rankings, and the Sagarin rankings. In order to determine which ranking system

to use, we compared the RPI, BPI, Pomeroy, and Sagarin rankings for each team between the years 2012 and 2016. The plots showing the pairwise comparison between these ranking systems can be found in fig. 1, where each point on each plot represents the different rankings of a single team. We then calculated the pair-wise Spearman correlation coefficients between the RPI, BPI, Pomeroy, and Sagarin rankings (given in Table 1) and observed that the BPI, Sagarin, and Pomeroy rankings were all highly correlated. Since the correlation coefficient was so large, using all of the ranking systems would provide only

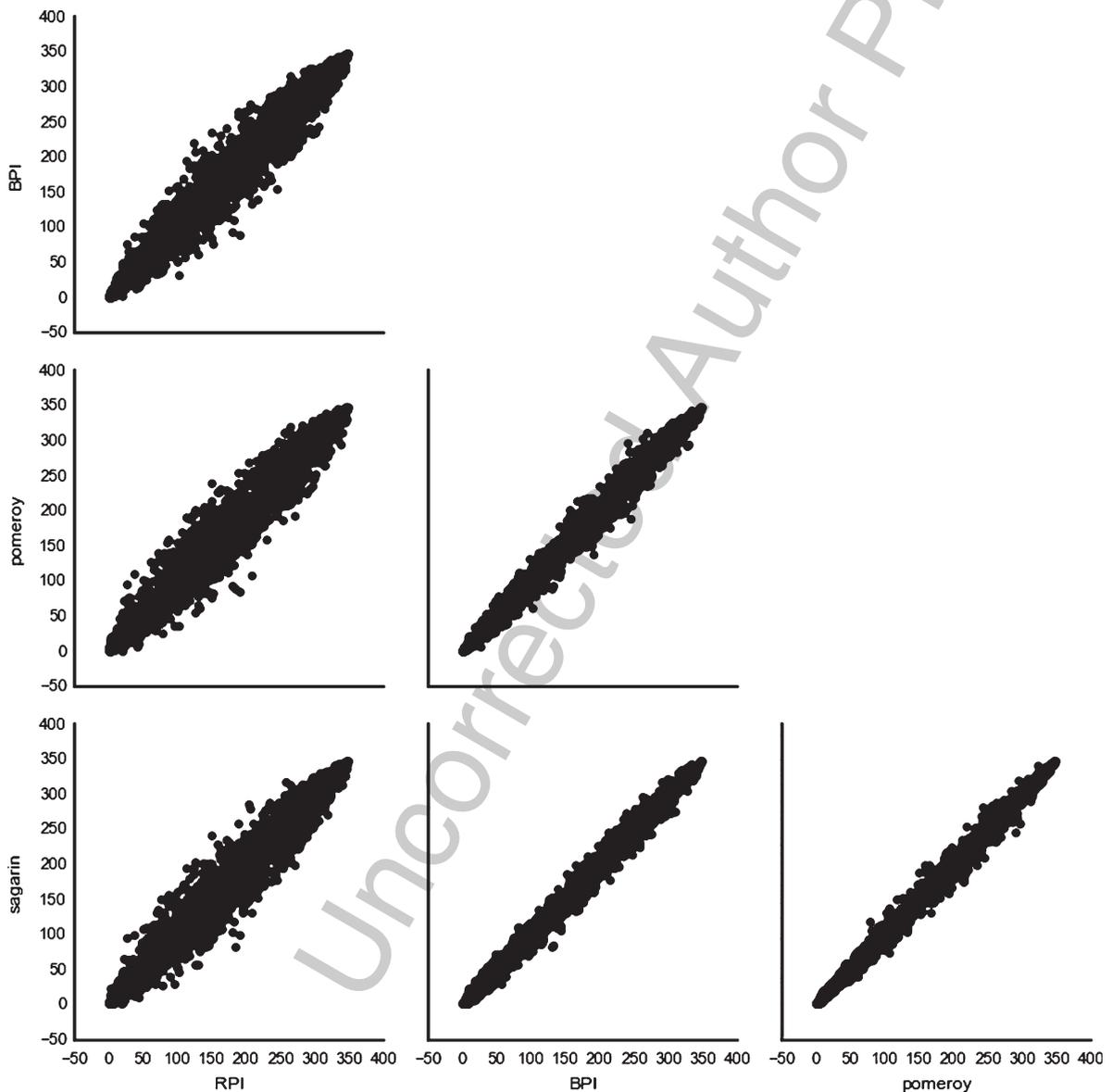


Fig. 1. Plot comparing RPI, BPI, Pomeroy, and Sagarin.

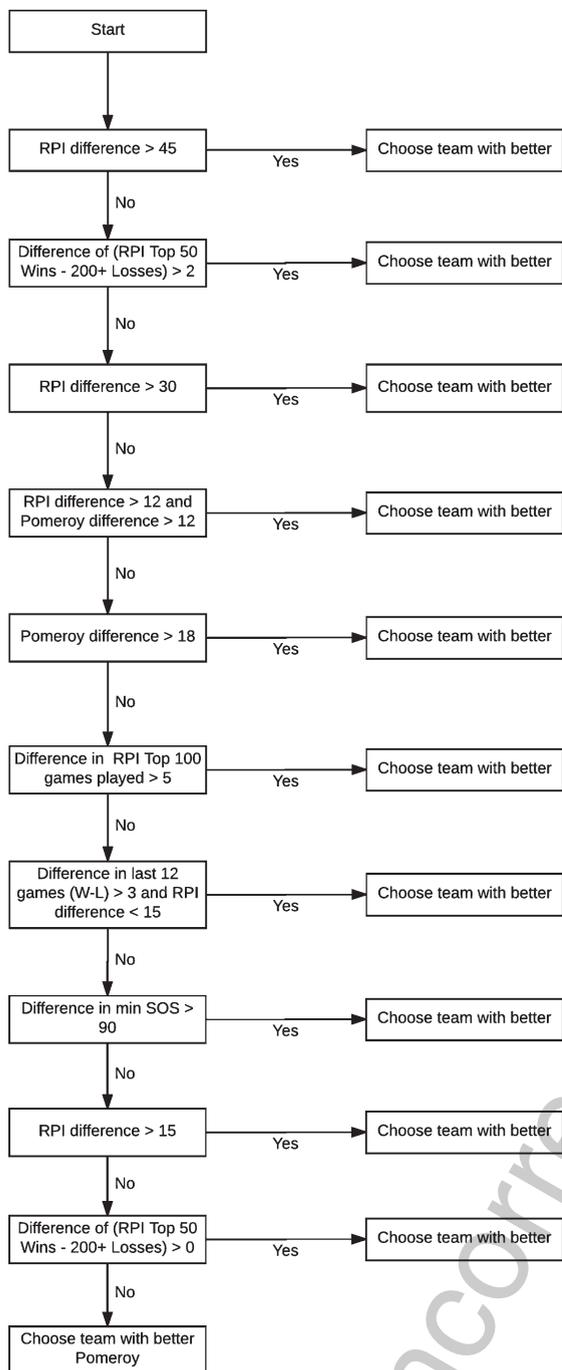


Fig. 2. Tree to determine stronger of two teams.

marginally more information than using just one; therefore, for the sake of simplicity, we opted to only use the Pomeroy rankings.

Choosing the relevant performance metrics to use was done by examining the statements made by the selection committee in the past. The metrics most fre-

quently mentioned were the number of top 50 wins (wins against the teams with the 50 highest RPI values) (Katz, 2016), the number of 200+ losses (losses against teams with an RPI rank of more than 200), and the strength of schedule of each team (NCAA, 2016).

Through experimental results, we also included the number of games played against the top 100 teams and the record of the team in their last 12 games before the tournament. The intuition behind including the last 12 games is that a team that plays well during their most recent 12 games are more likely to look strong to a selection committee than a team who plays poorly in those last games. The number 12 was chosen because the last 12 games is a statistic tracked and provided by ESPN. The inclusion of recent games and games against the top 100 teams was decided by doing some data exploration. In particular, we looked at how those two statistics were correlated with tournament entry, and determined them to be worthy inclusions. There are other more performance-oriented variables that were briefly considered such as field goal percentage, three point percentage, etc., but we opted not to include those since we were able to build a reasonably accurate decision tree without them. We were also aiming to have our process resemble the actual process of the selection committee as closely as possible, and therefore aimed to use only statistics that the committee is known to use.

### 3.2. Selecting tournament teams

Selecting the teams for the tournament was a two-step process. The first step was to evaluate the teams in a pair-wise fashion, thereby determining which team was stronger than which other teams. To do this, each team was compared to each other team in the same year, and the stronger of the two teams (according to our evaluation method) was given one victory. Then, the teams with the most pair-wise victories were chosen for the tournament.

The teams we used as candidates for tournament selection were the teams in the NCAA tournament

Table 1  
Correlation between ranking systems

	RPI	BPI	Pomeroy	Sagarin
RPI				
BPI	0.967			
Pomeroy	0.965	0.991		
Sagarin	0.968	0.994	0.994	

Table 2  
Intuition behind criteria in our ranking decision tree

Condition	Intuition
RPI difference > 45	If one team has a much better RPI, choose that team
Difference of (RPI Top 50 Wins - 200+ Losses) > 2	One top 50 win is negated by one 200+ loss. If one team has at least 2 more, pick that team
RPI difference > 30	Same RPI condition with smaller threshold
RPI difference > 12 and Pomeroy difference > 12	If one team has both a moderately better RPI and Pomeroy ranking, pick that team
Pomeroy difference > 18	If one team has a moderately better Pomeroy ranking, pick that team
Difference in RPI Top 100 games played > 5	If one team has played at least 5 more games against the top 100 teams, pick that team
Difference in last 12 games > 3 and RPI difference < 15	If both teams have a similar RPI, pick the one that has done better in the past 12 games
Difference in min SOS > 90	If one team has had a much stronger strength of schedule, pick that team
RPI difference > 15	If one team has a moderately better RPI, pick that team
Difference of (RPI Top 50 Wins - 200+ Losses) > 0	Same as the second condition, but with a lower threshold
Choose team with better Pomeroy	If a decision has not been made yet, default to the team with better Pomeroy rank

211 with a seed of ten or higher who had been granted an  
 212 at-large bid into the tournament and the one and two-  
 213 seeded teams in the National Invitation Tournament  
 214 (NIT), which is a tournament played by teams who  
 215 were not granted entrance to the NCAA tournament.  
 216 The best teams that played in the NIT should be a rea-  
 217 sonable approximation for teams that were close to  
 218 but did not get invited to the NCAA tournament. We  
 219 used these teams because we decided to focus solely  
 220 on the teams that may or may not make it into the tour-  
 221 nament, rather than including the high-performing  
 222 teams that are certain to make the tournament. These  
 223 teams are those that the media typically classified as  
 224 bubble teams, discussing their merits and deficiencies  
 225 in the weeks leadin up to Selection Sunday. Note that  
 226 high performing teams (i.e., teams who ended up be-  
 227 ing seeded No. 9 or better) compare favorably to the  
 228 teams that we focused our analysis on, and hence,  
 229 would be selected for the tournament based on our  
 230 pairwise comparison process.

231 Our evaluation method for determining which team  
 232 was the stronger of a given pair is modeled as a  
 233 decision tree. The decision tree was created by exper-  
 234 imenting with various combinations of factors that  
 235 could model the selection process. The goal was  
 236 to create a tree without relying on complex condi-  
 237 tions, since increasingly complex conditions could  
 238 result in the tree being less generalizable and appli-  
 239 cable to future years. Also, since the tree is meant  
 240 to mimic the process done by the selection commit-  
 241 tee, it seemed unlikely that the conditions should be  
 242 complex. Although the resulting pairwise compari-  
 243 son could also be applied to teams that are safely  
 244 in the tournament, we opted to narrow our focus to

245 only include those teams in contention for an at-large  
 246 bid. The full tree is shown in fig. 2, and the intu-  
 247 ition behind the different conditions can be found in  
 248 Table 2.

249 Some of the data is preprocessed before being run  
 250 through the tree. Instead of the raw strength of sched-  
 251 ule value, we use the minimum of the strength of  
 252 schedule and the non-conference strength of sched-  
 253 ule (where a lower value indicates a stronger strength  
 254 of schedule). A strong non-conference strength of  
 255 schedule indicates a team that made an effort to play  
 256 against strong teams despite being in a weak confer-  
 257 ence. However, the original strength of schedule is  
 258 also included so as not to penalize teams in strong  
 259 conferences who do not feel the need to look else-  
 260 where for strong competition. Additionally, the RPI,  
 261 strength of schedule, and Pomeroy rankings are con-  
 262 verted to ordinal values by year instead of using the  
 263 raw values. This way, we avoid inter-year variation  
 264 in the values, since each team is ranked only against  
 265 teams in the same year. Finally, the last 12 games  
 266 of each team were combined into a single number,  
 267 which was computed as the number of wins - the  
 268 number of losses in those last 12 games. For exam-  
 269 ple, A team with a 7–5 record in its last 12 games  
 270 would be assigned a score of  $7-5=2$ .

#### 271 4. Results

272 Evaluating the accuracy of the tree was done by  
 273 attempting to select the correct teams for the tourna-  
 274 ment for the years 2012–2016. The teams selected  
 275 for each year and their rank is given in Tables 3–7.

Table 3  
2012 Tournament Selections

	Predicted Selections	Predicted Non-Selections
Actual Selections	10 teams: Texas Purdue Xavier South Florida West Virginia NC State Virginia California Colorado State BYU	1 team: Iona
Actual Non-Selections	1 team: Seton Hall	8 teams

Table 4  
2013 Tournament Selections

	Predicted Selections	Predicted Non-Selections
Actual Selections	9 teams: Colorado Iowa State Minnesota California Boise State Cincinnati Saint Mary's La Salle Oklahoma	1 team: Middle Tennessee
Actual Non-Selections	1 team: Baylor	11 teams

Table 5  
2014 Tournament Selections

	Predicted Selections	Predicted Non-Selections
Actual Selections	8 teams: Tennessee Dayton Nebraska Stanford Arizona State BYU Iowa Xavier	1 team: NC State
Actual Non-Selections	1 team: Florida State	11 teams

Table 6  
2015 Tournament Selections

	Predicted Selections	Predicted Non-Selections
Actual Selections	9 teams: Texas Ohio State UCLA BYU Indiana Ole Miss Davidson Boise State Dayton	1 team: Georgia
Actual Non-Selections	1 team: Temple	9 teams

Table 7  
2016 Tournament Selections

	Predicted Selections	Predicted Non-Selections
Actual Selections	7 teams: Syracuse Vanderbilt Wichita St Michigan Tulsa Pittsburgh VCU	1 team: Temple
Actual Non-Selections	1 team: Florida	11 teams

The tables show the teams we used, the rank our method assigned to each team, and their seed in the tournament if they were granted entrance. In each of the five years, our method allowed one team into the tournament that did not actually make the tournament, but selected all the others correctly.

Some interesting observations can be made about the results. First, there was no single year where our method selected every team correctly. Whenever the method was adapted get every team right for a given year, it caused the other years to become significantly less accurate. Furthermore, some teams were entered into the tournament despite a seeming lack of foundation in the metrics used. Iona in 2012 is an example of this, with numbers that are far worse than other teams that were denied entrance to the tournament. This leads to the conclusion that the committee selection process is not an exact science - there seems to be some human factor involved that uses information outside the available numbers.

We can estimate which factors are most important to the committee by examining our decision tree. Factors used in a condition early on in the tree are more discriminatory, since they are able to operate with less prior information. In this tree, we can see that the RPI is highly distinguishing - it appears in two of the top three conditions. It is also implicitly present in the third one by virtue of the fact that top

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304 50 and 200+ teams are determined by their RPI rank.  
 305 Therefore, despite the statements for the committee  
 306 that RPI is not heavily used for selection, it seems to  
 307 be either very important or a very good indicator. The  
 308 RPI combined with the top 50 wins and 200+ losses  
 309 seem to provide a strong indicator of whether a team  
 310 will be in the tournament.

## 311 5. Conclusion

312 In this paper we presented a decision-making  
 313 method that would mimic the results of the selection  
 314 committee. We found that we could provide a close  
 315 approximation, but that the actual selection process  
 316 seems to also rely on factors that cannot be easily  
 317 explained by numbers. In particular, we tested our  
 318 method over the years 2012–2016, and found that it  
 319 selected all but one of the teams correctly each year.  
 320 However, the remaining team was sometimes ranked  
 321 far below others in our analysis.

322 One interesting avenue for future work would be  
 323 to expand the method to incorporate seeding as well  
 324 as selection. Here, we do not ascribe any value to the  
 325 ranking of teams - they are either chosen for inclusion  
 326 in the tournament or they are not. However, the real  
 327 selection committee assigns each team a seed after  
 328 the selection process is complete, so this would be  
 329 a suitable addition to this method. Another possible  
 330 area would be to incorporate more detailed informa-  
 331 tion such as injury reports, further sources of expert  
 opinion, etc. This would reduce the simplicity or the

resultant model and therefore may be undesirable, but  
 may also provide more accurate results. The largest  
 gain, however, would come from more statements by  
 the selection committee on exactly what information  
 they use and value.

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