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Mountain West Conference Strategic Scheduling

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Abstract: The Mountain West Conference is a Division I-A National Collegiate Athletic Association athletic conference. The MWC uses a tier system based on the Ratings Percentage Index (RPI) to stratify their teams in the sports of basketball, baseball, softball, volleyball, and soccer. They use this system in an attempt to maximize teams' ability to win and obtain high RPIs to ultimately make post-season tournaments. Our mission is to analyze this strategy's current performance, provide improvements and recommendations, and use forecasting to help coaches schedule in accordance with MWC strategy. We analyze the impact of individual games on a team's Ratings Percentage Index ranking, and use this information in conjunction with predicted Ratings Percentage Index rankings in order to provide a tool for coaches to use.

1. Introduction

Our client, the Mountain West Conference (MWC), was conceived on May 26, 1998, when the presidents of eight institutions decided to form a new National Collegiate Athletic Association (NCAA) Division One (D1) intercollegiate athletic conference. The conference consisted of schools that split from a 16-school West Athletic Conference. The MWC has now expanded to consist of 11 schools along with multiple affiliate members in different sports. The focus of our work is on the MWC's 11 schools competing in men's basketball.

In 2017, the NCAA realized $761 million in revenue from the men's basketball tournament, the most in its history (Rovell, 2018). The NCAA states that it is a "member-led organization dedicated to the well-being and lifelong success of college athletes." It is also a business. For each game a team plays in the men's basketball tournament, that team's conference receives approximately $1.67 million. In 2018, the MWC had two teams in the tournament and earned approximately $6.7 million in the span of two weeks, playing in four tournament games. Every D1 athletic conference sends their champion team to the tournament via automatic bids. The remaining spots in the 68-team tournament are "at-large" meaning any team can fill those spots and they are chosen by a committee. This same process works across other NCAA D1 sports to field 68 and 64 team end of season tournaments. Our motivation was to help the MWC increase team and overall conference Ratings Percentage Index (RPI). RPI is a key metric in determining which schools receive at-large bids to tournaments, to get more at-large bids and ultimately make more money. NCAA D1 men's basketball has the largest financial incentives for our client so they directed us to examine it further.

To understand our motivation for improving basketball strategic scheduling specifically, the top performing athletic conferences must be examined. The top three athletic conferences in 2018 for the men's basketball tournament were the Atlantic Coast Conference, Big 12, and South Eastern Conference. They each made $31.7 million, $31.7 million, and $26.7 million dollars respectively to compare to the MWC's $6.7 million. Monetary compensations extend beyond success in men's basketball. In 2010, intercollegiate sports events generated $2 billion in revenue and $1 billion in profit. Programs that win receive financial compensation through ticket sales, alumni donations, and TV contracts (Silverthorne, 2013). This compensation also expands to other aspects of successful institutions. Between 1983 and 1986, Georgetown University applications increased by 45 percent following a surge of basketball success in the NCAA tournament (Silverthorne, 2013). After Florida Gulf Coast University made a "Cinderella-story" run in the NCAA tournament, winning multiple games as underdogs, applications increased by an estimated 40 percent (Rogers, 2014). Similarly, after University of Louisville won the men's basketball tournament championship, they saw their largest freshman class in the school's 220 year history (Rogers, 2014). In a recent study, Douglas Chung found that when a school rises from mediocre to great in football, applications increase by 18.7 percent (Knowledge, 2013). More applications equates to more students and more students generate more money for

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the university. The financial implications of success on the field and in the NCAA tournament go far beyond the payment from the NCAA.

Outside of college basketball, conferences and teams do not receive any compensation for participation in the NCAA tournament. This raises the question, "Why would the MWC care about the selection of their teams in other sports?" Money is a huge motivating factor, and there are other inputs to the equation to consider including overall conference prestige. The more teams that are selected into end of year tournaments, the higher the draw to watch teams. The MWC is working on a new TV deal, and higher television ratings due to more respected teams playing in tournaments could lead to more money for the conference. Also, with more tournament teams, the conference may be able to improve recruiting which again raises the talent level and ability to be selected for more tournaments.

Selection committees often consider RPI in deciding who gets at-large bids into a tournament. RPI is a rating that takes into account win percentage, opponents' win percentage, and opponents of opponents' win percentage. It is weighted 0.25 to win percentage, 0.50 to opponents' win percentage, and 0.25 to opponents of opponents' win percentage. Each team is then ranked based on its RPI up to that point. These rankings are considered by selection committees to select at-large bids.

Coaches and Athletic Directors from individual schools determine who they play in non-conference games, not the MWC. However, the MWC tier system provides guidelines for coaches to follow and punishments are given to athletic departments of schools that do not follow the MWC guidance. Our client has asked us to examine the validity/success of their current guidelines. Due to consideration for our client's confidentiality, we will not release the exact guidelines. However, we can disclose it is a general rule that more successful (high tier) MWC teams are instructed to play higher RPI non-conference opponents and lower tier teams are instructed to play lower RPI ranked teams. The principle is to win more non-conference games overall, increase all teams' win percentages, and therefore boost RPI by affecting two of its categories: win percentage and opponent's win percentage.

1.1 Problem Statement

The purpose of this study is to answer the question, "How can the MWC maximize the number of teams that make it into tournament play by maximizing RPI through strategic scheduling?" Currently, the MWC uses a 3-year moving average to rank all NCAA D1 teams' RPIs in multiple sports. The MWC teams are then split into three tiers (high, middle, and low) and the conference instructs them to scheduled non-conference games according to their tier. The only information a coach has to schedule next season's opponents is the previous three years of RPI data. Coaches commonly complain that they tried to schedule in accordance to MWC guidance, but their opponents ended up higher or lower ranked in RPI than predicted (using a 3-year moving average) and therefore their schedule was out of alignment with MWC guidance. This RPI tier system fails in a few ways. The 3-year moving average has extremely high standard errors and cannot accurately predict how non-conference opponents will be ranked in the following year. The tier system does not consider the likelihood a team will win a matchup with an opposing team. The current tool given to coaches to schedule next season's games does not include the opponents predicted overall win percentage that highly affects RPI. Our client has asked us to examine their current state to provide improvements and recommendations to their strategic scheduling guidance to increase future success of the conference and get more teams at-large bids to NCAA tournaments across multiple sports.

1.2 Related Work

1.2.1 RPI

While our specific problem has never been looked at, there are certain studies that have been done that will assist us in our analysis. When scheduling games it is beneficial to have an idea of the team's skill level in order to schedule according to the appropriate difficulty. Reining and Horowitz (2018) attempt to create a simple and effective method to select and seed teams for the 68 team NCAA Basketball tournament. They use Minimax LP solutions and Quadratic Problem Solutions to find weights for different ranking systems, and find that win percentage and strength of schedule (SOS) are principal drivers in rankings. They concluded that RPI is an important factor but not the most important in seeding teams for tournaments. Therefore, we need to look at other statistics such as win percentage and SOS for the MWC. A writer under the anonymous name of Squared2020 details "How to Game the Rating Percentage Index (RPI)" (2017). He discusses how a team can go about increasing their RPI by always winning at home and scheduling tough opponents but evening it out with easy opponents. Squared2020's research is similar to what we are attempting to do; however, our problem is much larger, looking at the MWC as a whole, and we are attempting to have it implemented in the coming scheduling years.

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1.2.2 Scheduling

Shapiro, Drayer, Dwyer, and Morse (2009) conducted a study to examine direct and indirect attributes of teams that consistently finished in the top 100 RPI. Using a logistic regression, they predict whether teams would qualify for the tournament and, using logistic regression, which games had the most effect on RPI. We can use their analysis on what factors affect RPI and their resulting effects on tournament selection in order to build appropriate schedules that will maximize teams RPI. Scheduling games will require data on many different statistics that are based on past RPIs, predicted RPIs, and recruiting classes.

2. Methodology

In order to maximize RPI and answer our research question, we must deepen our understanding on the formula itself. Our first area of analysis is understanding how different factors, to include individual team winning percentage as well as overall conference winning percentage, impact the RPI of individual teams. First, we started with the basic RPI formula:

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

where $winpct$ represents an individual team's winning percentage, opp_winpct represents an individual team's opponents' average winning percentage, and opp_opp_winpct represents individual team's opponents' opponents' average winning percentage. This formula is used to compare teams by the NCAA tournament selection committee across all sports.

For example, let's calculate the RPI of the San Diego State Aztecs 2017 men's basketball team. In 2017, the Aztecs won 67.74% of games, their opponents won 52.73% of their games, and the opponents of their opponents won 52.17% of their games. Their RPI looks like

$$RPI = 0.25 * (.6774) + 0.5 * (.5273) + 0.25(.5217) \quad (2)$$

$$RPI = .5634$$

While some analysis can be done using just this equation and tampering with these three values to maximize RPI, we break down this equation further. All opponents are either in conference or out of conference. To assess how MWC teams are impacting the RPI of the other teams in their conference, we must make this distinction. The variable *p* represents the percentage of a team's games played against a conference opponent and *q* represents the percentage of a team's games that are played against non-conference opponents. The original RPI formula is now broken down into more pieces:

$$RPI = 0.25WinPct + 0.5[p(OppWP) + q(\underline{Opp}WP)] + 0.25[p(p * Opp\_Opp\_WP + q * Opp\_\underline{Opp}\_WP) + q(q * \underline{Opp}\_Opp\_WP + p * \underline{Opp}\_\underline{Opp}\_WP)] \quad (3)$$

Table 1. Legend for Equation 3

$OppWP$	win percentage of opponents in-conference
$\underline{Opp}WP$	win percentage of non-conference opponents
Opp_Opp_WP	win percentage of in-conference opponents against other in-conference opponents
$Opp\_\underline{Opp}\_WP$	win percentage of in-conference opponents against non-conference opponents
$\underline{Opp}\_Opp\_WP$	win percentage of non-conference opponents against opponents within the conference of study (MWC)
$\underline{Opp}\_\underline{Opp}\_WP$	win percentage of non-conference opponents against opponents within their own conference

Now that the formula is split into all of these parts, we can take partial derivatives and assess the impact each one has on a team's RPI. For example, to answer the question, "how much does the conference's average winning percentage influence RPI?", we derive the RPI equation with respect to $OppWP$, Opp_Opp_WP, and $\underline{Opp}\_Opp\_WP$. This method allows us to answer more specific questions when it comes to factors impacting RPI, thus scheduling, and allows conferences to set constraints, given *p* and *q*, when building their ideal schedules. Tampering with each of these variables will give conferences a more in depth look at factors helping or hurting their chances of getting teams into the NCAA tournament.

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One important thing to note is that this analysis works under the following assumption: that the *p* and *q* values are the same for all opponents across conferences and within conferences.

Another model we are working on involves predicting future RPI in order to schedule teams that meet the conference's RPI constraints. The MWC currently uses a three year average to predict RPI for the following season. We believe their current best practice can be improved upon with a more robust model. We improved prediction capability by adding weights to the three year average model to create a weighted moving average. We hypothesize that the most recent year's RPI will hold more weight than RPIs from years prior. Based on related works, we also expanded the information given to coaches to schedule non-conference opponents to also include historical data on opponent's winning percentage. This will show coaches the teams that are more likely to boost their RPI because opponents' win percentage accounts for 50% of RPI.

The combination of these two previous methods enables coaches to effectively schedule their games. Given the goals and strategies to maximize RPI and given the best predictions of how well other teams will do, coaches should have the tools they need to match MWC guidance for scheduling.

2.1 Data

We have collected historical data on RPI and RPI rank, and we have win and loss data as well, which we gathered from https://extra.ncaa.org/solutions/rpi/SitePages/Home.aspx, on multiple sports, including women's soccer, men's and women's basketball, and baseball, in order to answer our research question. We also have access to all of the MWC data through the Associate Commissioner of Championships, Mr. John Sullivan. We built spreadsheets with this information. The data gave us the ability to use four consecutive years' RPI rankings and use the first three years to predict the fourth similar to how the MWC currently uses the three previous years to predict next season before coaches begin scheduling. The MWC also provided confidential material called "team sheets" that they created. This data broke down individual team performance and how they fared against individual opponents throughout a season. It also contained information on how well a team scheduled in accordance to MWC guidance. For this reason, this part of our data remains confidential.

3. Results and Analysis

To answer the question, "how much does the conference's average winning percentage influence RPI?", we derived the RPI equation with respect to Opp_Opp_WP, $\underline{Opp}\_Opp\_WP$, and $\underline{Opp}\_\underline{Opp}\_WP$. The result showed that every in-conference team's RPI will increase by .0043 for every 1 percent increase in overall conference average win percentage (refer to Appendix A). Similarly, for every one percent increase in non-conference opponent average win percentage, every team in the conference will receive a .0032 boost to their individual RPI. This is under the assumption that all else is held constant.

Last season, the MWC only put one team in the NCAA tournament, their automatic bid the University of Nevada - Reno. Boise State, who held the nation's 50th best RPI was not selected. We collected RPI data from the last five years of the "last four in", or the last four teams selected for the NCAA tournament as at-large bids. Using this data, we computed the average historical RPI, set it as our "goal RPI" and compared it to the top three MWC teams that were not selected. Given there are 90 total conference games played each year and each of the team plays 12 non-conference opponents, there were 210 games total last season played by MWC. Using the .0043 we found earlier and taking the difference between each of these four teams' RPI to the target value (historical average), we computed how many wins each team needed from the MWC in non-conference matchups to hypothetically have made the tournament. The data is shown in Table 1.

Table 2. The Difference Between Tournament Selection

	2017 RPI	Δbetween 2017 RPI and goal RPI	Win percentage needed = Δ/.0043	Number of wins needed from conference
Boise State	0.5725	0.0078	1.82 %	4
Wyoming	0.542	0.0383	8.91 %	19
Fresno State	0.5372	0.0431	10.03 %	22

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Boise State needed four more wins from any team in the MWC in their non-conference schedules to hypothetically have made the tournament and made the MWC another $1.67 million. In other terms, out of 120 non-conference games played by Boise State's peers in the MWC, just four more wins would have made the peers win percentages higher therefore increasing Boise's average opponent's win percentage enough to get them into the NCAA tournament hypothetically.

The MWC's current practice for future scheduling of games uses a three year average RPI to assist coaches in scheduling opponents. One of our hypotheses was that a weighted average and minimization tool can beat the performance of their current best practice. Using Microsoft Excel's Solver tool, we took MWC Women's Soccer data from 2013-2015 to predict 2016 empirical data. First, we compared three year average predictions. Then, we applied weights to the individual year 2013, 2014, and 2015 and ran a solver tool to minimize the sum of difference between 2016 predictions and empirical data. The results show that using weights improved the average difference between prediction and actual values by about three RPI positions. The highest weights were applied to the most recent year RPI because 2015 teams share the most similarities to the 2016 teams compared to 2014 or 2013 teams. This simple approach changes how the MWC gives its scheduling tool to coaches and improves their ability to follow MWC guidance.

The last set of results we found related to confidential information in the team sheet's provided to us by the MWC. The findings here led to recommendations in restructuring the MWC tier system as well as further improvements to the 3-year weighted moving averages that the MWC provides to coaches. The MWC has asked us to not disclose this information as it provides a strategic advantage to the conference in future competition.

4. Future Research

We need to conduct more analysis in order to find optimal weights for predicting RPI. We will run regressions on records, recruiting, and historical RPI in order to create these weights. We then need to build this prediction function and run testing data through it in order to minimize errors. There is room to conduct a more thorough analysis of the RPI function. We need to test to identify the constraints that we should apply based on the RPI function. With the prediction function in conjunction with the analysis gathered from the RPI function, we plan on creating a model that will maximize a team's RPI by providing information to inform scheduling. This will enable coaches, athletic directors, and the MWC to build better schedules, resulting in higher RPI's, leading to more end-of-year tournament entries.

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Appendix A

How much does conference's average winning percentage impact RPI?
p=.6
q=.4

$$RPI = 0.25winpct + 0.5[p(oppicwinpct) + q(oppocwinpct)] + 0.25[p(p * oppicoppicwinpct + q * oppicoppocwinpct) + q(q * oppocoppicwinpct + p * oppocoppocwinpct)]$$

$$\frac{\partial RPI}{\partial oppicwinpct} + \frac{\partial RPI}{\partial oppicoppicwinpct} + \frac{\partial RPI}{\partial oppocoppicwinpct} = 0.5p + 0.25p^2 + 0.25q^2 = \mathbf{0.43}$$

Appendix B

Boise State 2017 RPI for men's basketball= 0.5725

"Target" RPI based on average of NCAA published "last 4 in" at-large bids= 0.5803

Δ2017 RPI and goal RPI - (.5803)-(.5725) = 0.0078

A 1% increase in win percentage in the conference increases RPI by .0043

Win percentage needed to meet "target" RPI
(.0078)/(.0043) =1.8178

There are 210 games between all teams in the conference.
(.018178)*210 = 3.817

$3.817 \approx 4$ = the number of more games the conference needed to win to reach RPI goal