Cal Poly Women's Basketball 2013-2014 Shot Selection Analysis

By Noah Zwarg with assistance from Dr. Matt Carlton

Page 2	Goal of the project and thought process behind the analysis
Page 3	Interpretation of a shooting chart
Page 4	Team shooting chart and recommendations
Pages 5-14	Individual player shooting charts and recommendations
Page 15	Forecast for next season
Page 16	Possible PPP improvement resulting in more wins
Page 17	Possible improvements of analysis and limitations
Pages 18-22	Methods and R code to find expected points per possession (PPP) and simulation
Page 22	References

Goal and Thought Process

I read an article that had a quote on NBA shot selection strategy, "That strategy was born out of data analysis which concluded that making one-third of your 3-point shots is essentially equal to making half your 2-point shots". This is true, but only if you don't account for second chance points. Let's say a team can shoot 30 three point shots and make 10 or shoot 30 two point shots and make 15 (So making 1/3 vs. 1/2). Both would score 30 points of the initial shots, but if the team gets the rebound 1/5 of the time on a missed shot, shooting three pointers would result in getting the ball on a rebound 20 * (1/5) = 4 times. While shooting two pointers would result in getting the ball back 15 * (1/5) = 3 times. So shooting three pointers would give you one extra possession and, if a team averages 1 point per possession, this would result in a 1/30 higher points per possession. This might seem miniscule and unimportant, but a 60 possession game would result in scoring 2 more points on average, which would make a huge difference in the outcome of a game because so many games are decided by only a few points. There can also be spots different distances from the basket that have a higher chance of getting the offensive rebound, making certain shots better than others because of the higher probability of scoring second chance points.

This is why I want to find the expected points per possession (PPP) for a certain shot and not just the initial amount of points scored. This will be the initial points off a shot plus the second chance points that the team is expected to score (average). After calculating the PPP, I will compare different types of player's shots to the team average PPP in order to find out what shots players should theoretically take and not take. This will provide answers to questions like what shots should each player shoot and what shots do players shoot better or worse than others? The goal of my project is to provide answers to these types of questions by way of a shooting chart created for each player and the team as a whole. These charts will provide the coaches with useful information on players' shooting ability from different distances from the basket that will help the team score know how to score more efficiently. It will give useful insight for each player to see what shots they shoot well in order to take more of those shots or to work hard in the offseason on the shots they did not shoot particularly well from during the season.

Interpretation of a Shooting Chart

I categorized each type of shot a player can take by two parameters, distance from the basket and whether the shot was contested. The player can shoot from close, medium, long, or from three-point range and can be either guarded or open, resulting in 8 different possible shots. Each player will have a PPP for 8 different types of shots and also a corresponding overall average. Shots in orange or red are above team average and shots in green or blue are below team average. Shots in blue have an upper bound of .84 (how many points the team would average if they get zero second chance points). So any shots with a PPP at or below .84 points are colored blue. Shots in green have a lower bound of .85 (.01 points above the upper bound for blue) and an upper bound of 1.01 (.01 points below total team average). So shots with a PPP between (.85, 1.01) are colored green. Orange Shots have a lower bound of 1.02 (total team average) and an upper bound of 1.17 (how many points the team would average if they never turned the ball over). So shots with a PPP between (1.02, 1.17) are colored orange. Shots above orange are colored red (so any PPP at or above 1.18).

Each players shooting chart will have the team's average PPP in the top left corner, just under that is the average points for only the players' initial shot, and just under that is the average PPP for that player. The initial points per shot, which are proceeded by the PPP for the 8 different possible types of shots, are contained in the chart to the right with the totals for a certain distance farther to the right, color coordinated to the conditions above. I also followed each shooting chart with an interpretation of the shooting chart with a recommendation on how to score more efficiently based on its contents. I also preceded each shooting chart with a shooting summary for each player that was used to calculate the shooting chart; these shooting summaries represents every shot that the player took during the regular reason (with the possibility of recording error on my part).

For the team PPP shooting charts, I treated each type of shot as how the team shot that shot as a whole while also taking a weighted average of the player's free throw percentages that got fouled on that specific shot. So, I did not just use the team average free throw percentage for every distance of shot because the players that get fouled closer could have lower free throw percentages while the players that get fouled farther can have higher free throw percentages. Taking a weighted average instead of the overall free throw percentage gives a better estimate of the true PPP of a certain shot by accounting for the possibility of players with different free throw ability getting fouled different distances from the hoop.

Team Shooting Chart

Note: For the number of fouls for all shooting charts I first describe how many fouls were drawn that were not and 1's (standard fouls). Then, right after that I describe how many and 1's were drawn. So the total number of fouls drawn for a specific shot can be calculated by adding these two numbers. An example is the team on guarded close shots got fouled a total of 123 times, 95 were standard fouls and 28 were and 1's.

		Open	Guarded
	Close (0-5 Feet)	164/202 Field Goals 81%	236/530 Field Goals 45%, Fouled 95 Times, 28 and 1's
	Mid (5-15 feet)	38/87 Field Goals 44%	136/417 Field Goals 33%, Fouled 42 Times, 9 and 1's
	Long (15-20.75 feet)	63/160 Field Goals 39%	13/56 Field Goals 23%, Fouled 3 Times
	Three (20.75 feet plus)	147/384 Field Goals 38%	35/131 Field Goals 27%, Fouled 8 Times, 3 and 1's

Note: For the numbers on the right side of the chart the first number is points for the initial shot then the second number is the PPP. So for close guarded close shots the team averages .98 points for the initial shot and 1.17 points for the entire possession.

Regular Season Team Statistics		Open	Guarded	Total
Average Points For First Shot = .98	Close (0-5 Feet)	**1.62 , 1.70**	**.98 , 1.17**	**1.14 , 1.30**
Average Points Per Possession = 1.02				
First Shot, Points Per Possession for Format	Mid (5-15 feet)	**.87 , 1.08**	**.74 , .87**	**.76 , .99**
Red is Best at or greater than 1.18				
Orange is 2nd Best between 1.02 and 1.17	Long (15-20.75 feet)	**.79 , .99**	**.52 , .76**	**.71 , .93**
Green is 3rd Best between .85 and 1.01				
Blue is 4th Best at or lower than .84	Three (20.75 feet plus)	**1.15 , 1.34**	**.91 , 1.12**	**1.08 , 1.28**

Recommendations: As a whole, the team shoots well from close and from three. Even guarded close two pointers and guarded three pointers have a higher PPP then open mid and long two pointers. So as a team shooting a contested three is a better shot than an open mid-range shot. So the more three pointers and close two pointers the team shoots the more efficiently the team will end up scoring.

Individual Players Shooting Charts

Shooting Chart for Number 2 Jonae Ervin

Regular Season Games		Open	Guarded
	Close (0-5 Feet)	15/16 Field Goals 94%	29/61 Field Goals 48%, Fouled 10 Times, 5 and 1's
	Mid (5-15 feet)	15/29 Field Goals 52%	34/113 Field Goals 30%, Fouled 20 Times, 5 and 1's
	Long (15-20.75 feet)	5/24 Field Goals 21%	1/3 Field Goals 33%, Fouled 0 Times
	Three(20.75 feet plus)	12/26 Field Goals 46%	0/3 Field Goals 0%, Fouled 0 Times

Regular Season Team Average PPP = 1.02		Open	Guarded	Total
Average Points For First Shot = .95	Close (0-5 Feet)	1.88 , 1.90	1.10 , 1.28	1.24 , 1.39
Average Points Per Possession = 1.15				
First Shot, Points Per Possession for Format	Mid (5-15 feet)	1.03 , 1.21	.78 , 1.01	.83 , 1.04
Red is Best at or greater than 1.18				
Orange is 2nd Best between 1.02 and 1.17	Long (15-20.75 feet)	.42 , .68	.67 , .89	.44 , .70
Green is 3rd Best between .85 and 1.01				
Blue is 4th Best at or lower than .84	Three (20.75 feet plus)	1.38 , 1.55	0 , .31	1.24 , 1.42

Recommendations: Jonae Ervin shoots well when she is open, besides long two pointers, and when she is close. I noticed she would sometimes have an open three and take one dribble in and take a long two. She has a cold spot on long open twos and a hot spot on open threes! She should forget about the long two and gladly take the open three. She should actually look to take more open three pointers because her points expected is way above team average from that spot on the floor.

Shooting Chart for Number 3 Sarah Lipton

Regular Season Games		Open	Guarded
	Close (0-5 Feet)	3/4 Field Goals 75%	3/5 Field Goals 60%, Fouled 0 Times
	Mid (5-15 feet)	0/1 Field Goals 0%	0/1 Field Goals 0%, Fouled 1 Time
	Long (15-20.75 feet)	6/11 Field Goals 55%	0/3 Field Goals 0%, Fouled 0 Times
	Three(20.75 feet plus)	11/37 Field Goals 30%	0/11 Field Goals 0%, Fouled 0 Times

Regular Season Team Average PPP = 1.02		Open	Guarded	Total
Average Points For First Shot = .79	Close (0-5 Feet)	1.50 , 1.59	1.20 , 1.35	1.33 , 1.46
Average Points Per Possession = 1.01				
First Shot, Points Per Possession for Format	Mid (5-15 feet)	0 , .37	.67 , .87	.44 , .70
Red is Best at or greater than 1.18				
Orange is 2nd Best between 1.02 and 1.17	Long (15-20.75 feet)	1.09 , 1.24	0 , .33	.86 , 1.05
Green is 3rd Best between .85 and 1.01				
Blue is 4th Best at or lower than .84	Three (20.75 feet plus)	.89 , 1.11	0 , .31	.69 , .93

Recommendations: Sarah Lipton has a relatively small sample of shot attempts from mid-range (only 2 shots) so I would not pay close attention to that part of the shooting chart. But with long twos and threes she has a good amount of shot attempts and she shoots well when she is open and not so well when she is guarded. She also improved from three-point range as the season went along so she should shoot with no hesitation when she is open while looking to get someone else a shot when she is guarded.

Shooting Chart for Number 4 Maddison Allen

Regular Season Games		Open	Guarded
	Close (0-5 Feet)	7/10 Field Goals 70%	14/37 Field Goals 38%, Fouled 4 Times, 3 and 1's
	Mid (5-15 feet)	1/5 Field Goals 20%	5/14 Field Goals 36%, Fouled 0 Times
	Long (15-20.75 feet)	4/15 Field Goals 27%	0/1 Field Goals 0%, Fouled 0 Times
	Three (20.75 feet plus)	0 Field Goals	0 Field Goals

Regular Season Team Average PPP = 1.02		Open	Guarded	Total
Average Points For First Shot = .79	Close (0-5 Feet)	**1.40 , 1.50**	**.82 , 1.05**	**.94 , 1.14**
Average Points Per Possession = 1.01				
First Shot, Points Per Possession for Format	Mid (5-15 feet)	**.40 , .69**	**.71 , .95**	**.63 , .88**
Red is Best at or greater than 1.18				
Orange is 2nd Best between 1.02 and 1.17	Long (15-20.75 feet)	**.53 , .78**	**0 , .33**	**.50 , .75**
Green is 3rd Best between .85 and 1.01				
Blue is 4th Best at or lower than .84	Three (20.75 feet plus)			

Recommendations: Madison Allen shoots well when she is close to the basket. She should look to take the ball all the way to the hoop and also crash the offensive rebounds to help the team score more efficiently.

Shooting Chart for Number 5 Ariana Elegado

Regular Season Games		Open	Guarded
	Close (0-5 Feet)	19/26 Field Goals 73%	22/50 Field Goals 44%, Fouled 8 Times, 1 and 1
	Mid (5-15 feet)	12/28 Field Goals 43%	27/91 Field Goals 30%, Fouled 4 Times
	Long (15-20.75 feet)	14/25 Field Goals 56%	4/13 Field Goals 31%, Fouled 1 Time
	Three(20.75 feet plus)	53/134 Field Goals 40%	25/84 Field Goals 30%, Fouled 0 Times

Regular Season Team Average PPP = 1.02		Open	Guarded	Total
Average Points For First Shot = .97	Close (0-5 Feet)	**1.46 , 1.56**	**.97 , 1.16**	**1.12 , 1.29**
Average Points Per Possession = 1.17				
First Shot, Points Per Possession for Format	Mid (5-15 feet)	**.86 , 1.07**	**.63 , .88**	**.68 , .92**
Red is Best at or greater than 1.18				
Orange is 2nd Best between 1.02 and 1.17	Long (15-20.75 feet)	**1.12 , 1.27**	**.68 , .89**	**.96 , 1.13**
Green is 3rd Best between .85 and 1.01				
Blue is 4th Best at or lower than .84	Three (20.75 feet plus)	**1.19 , 1.37**	**.89 , 1.11**	**1.02 , 1.23**

Recommendations: Ariana Elegado shoots exceptionally well when she is open and has no blue type cold spots on her shooting chart. But she shoots below team average when she shoots guarded medium and guarded long shots (green). She should pass those shots up and look for better shot opportunities for herself or look to create opportunities for others. She should let all other shots fly because she is significantly above team average for those shots.

Shooting Chart for Number 11 Kristen Ale

Regular Season Games		Open	Guarded
	Close (0-5 Feet)	6/8 Field Goals 75%	9/32 Field Goals 28%, Fouled 25 Times, 3 and 1's
	Mid (5-15 feet)	2/5 Field Goals 40%	5/30 Field Goals 17%, Fouled 3 Times. 1 and 1
	Long (15-20.75 feet)	1/5 Field Goals 20%	0/1 Field Goals 0%, Fouled 0 Times
	Three(20.75 feet plus)	29/77 Field Goals 38%	7/24 Field Goals 29%, Fouled 7 Times, 3 and 1's

Regular Season Team Average PPP = 1.02		Open	Guarded	Total
Average Points For First Shot = 1.01	Close (0-5 Feet)	**1.50 , 1.59**	**1.03 , 1.20**	**1.09 , 1.25**
Average Points Per Possession = 1.20				
First Shot, Points Per Possession for Format	Mid (5-15 feet)	**.80 , 1.02**	**.43 , .75**	**.51 , .78**
Red is Best at or greater than 1.18				
Orange is 2nd Best between 1.02 and 1.17	Long (15-20.75 feet)	**.40 , .66**	**0 , .33**	**.33 , .61**
Green is 3rd Best between .85 and 1.01				
Blue is 4th Best at or lower than .84	Three (20.75 feet plus)	**1.13 , 1.32**	**1.27 , 1.45**	**1.17 , 1.36**

Recommendations: Kristen Ale shot a relatively low shooting percentage of 32%, yet she was tied for second on the team in average points per possession (1.20). This is due in large part to her ability to draw fouls almost at will and additionally because such a large percentage of her field goal attempts are three pointers (55%). She was also either scorching hot or freezing cold. Shooting three pointers either open or guarded, or taking the ball all the way for a layup or to draw a foul is where she thrived.

Shooting Chart for Number 14 Beth Balbierz

Regular Season Games		Open	Guarded
	Close (0-5 Feet)	4/6 Field Goals 67%	2/10 Field Goals 20%, Fouled 5 Times
	Mid (5-15 feet)	3/7 Field Goals 43%	4/11 Field Goals 36%, Fouled 5 Times
	Long (15-20.75 feet)	1/2 Field Goals 50%	0 Field Goals, Fouled 1 Time
	Three (20.75 feet plus)	30/85 Field Goals 35%	1/6 Field Goals 17%, Fouled 0 Times

Regular Season Team Average PPP = 1.02		Open	Guarded	Total
Average Points For First Shot = 1.00	Close (0-5 Feet)	**1.33 , 1.46**	**.79 , 1.00**	**.95 , 1.13**
Average Points Per Possession = 1.20				
First Shot, Points Per Possession for Format	Mid (5-15 feet)	**.86 , 1.07**	**.99 , 1.16**	**.95 , 1.13**
Red is Best at or greater than 1.18				
Orange is 2nd Best between 1.02 and 1.17	Long (15-20.75 feet)	**1.00 , 1.17**	**1.58 , 1.60**	**1.19 , 1.31**
Green is 3rd Best between .85 and 1.01				
Blue is 4th Best at or lower than .84	Three (20.75 feet plus)	**1.06 , 1.26**	**.5 , .76**	**1.00 , 1.19**

Recommendations: Beth Balbierz has a lot of orange and red on her chart and not much green or blue while also being somewhat of a three point specialist (67% of her field goal attempts are open three pointers). These are the main reasons why she was tied for second on the team in average points per possession (1.20). She should look to shoot and shoot often, especially open threes.

Shooting Chart for Number 15 Taryn Garza

Regular Season Games		Open	Guarded
	Close (0-5 Feet)	28/34 Field Goals 82%	39/76 Field Goals 51%, Fouled 12 Times, 3 and 1's
	Mid (5-15 feet)	3/8 Field Goals 38%	11/33 Field Goals 33%, Fouled 3 Times, 1 and 1
	Long (15-20.75 feet)	4/9 Field Goals 44%	0 Field Goals, Fouled 0 Times
	Three (20.75 feet plus)	0 Field Goals	0 Field Goals, Fouled 0 Times

Regular Season Team Average PPP = 1.02		Open	Guarded	Total
Average Points For First Shot = 1.03	Close (0-5 Feet)	**1.65 , 1.71**	**.98 , 1.15**	**1.17 , 1.31**
Average Points Per Possession = 1.20				
First Shot, Points Per Possession for Format	Mid (5-15 feet)	**.75 , .98**	**.67 , .90**	**.69 , .92**
Red is Best at or greater than 1.18				
Orange is 2nd Best between 1.02 and 1.17	Long (15-20.75 feet)	**.89 , 1.07**		**.89 , 1.07**
Green is 3rd Best between .85 and 1.01				
Blue is 4th Best at or lower than .84	Three (20.75 feet plus)			

Recommendations: Taryn Garza interestingly had a higher PPP from long range than from mid-range, but this can just be because she has a small sample of open medium and open long shots. She still makes her money from close, by either getting good position inside or attacking the offensive glass. She was tied for second on the team in average points per possession (1.20) and can even improve upon that number next year if she improves her free throw percentage.

Shooting Chart for Number 30 Nwamaka Ofodu

Regular Season Games		Open	Guarded
	Close (0-5 Feet)	7/12 Field Goals 58%	14/27 Field Goals 52%, Fouled 0 Times, 1 and 1
	Mid (5-15 feet)	1/3 Field Goals 33%	9/34 Field Goals 26%, Fouled 1 Time, 1 and 1
	Long (15-20.75 feet)	23/56 Field Goals 41%	0/5 Field Goals 0%, Fouled 0 Times
	Three (20.75 feet plus)	10/19 Field Goals 53%	0 Field Goals, Fouled 0 Times

Regular Season Team Average PPP = 1.02		Open	Guarded	Total
Average Points For First Shot = .90	Close (0-5 Feet)	**1.17 , 1.32**	**1.06 , 1.25**	**1.09 , 1.27**
Average Points Per Possession = 1.10				
First Shot, Points Per Possession for Format	Mid (5-15 feet)	**.67 , .91**	**.57 , .83**	**.58 , .84**
Red is Best at or greater than 1.18				
Orange is 2nd Best between 1.02 and 1.17	Long (15-20.75 feet)	**.82 , 1.02**	**0 , .33**	**.75 , .96**
Green is 3rd Best between .85 and 1.01				
Blue is 4th Best at or lower than .84	Three (20.75 feet plus)	**1.58 , 1.73**		**1.58 , 1.73**

Recommendations: Nwamaka Ofodu shoots well when she is close or taking an open three. She shoots right at team average when she is long and open, but she has a scary good 1.73 points per possession when she shots open three pointers. Looking for open threes instead of open long twos would help her score more efficiently.

Shooting Chart for Number 42 Hannah Gilbert

Regular Season Games		Open	Guarded
	Close (0-5 Feet)	11/17 Field Goals 65%	11/28 Field Goals 39%, Fouled 9 Times, 2 and 1
	Mid (5-15 feet)	1/1 Field Goals 100%	6/16 Field Goals 38%, Fouled 2 Times
	Long (15-20.75 feet)	0 Field Goals	0 Field Goals, Fouled 0 Times
	Three (20.75 feet plus)	0 Field Goals	0 Field Goals, Fouled 0 Times

Regular Season Team Average PPP = 1.02		Open	Guarded	Total
Average Points For First Shot = 1.00	Close (0-5 Feet)	**1.29 , 1.43**	**.93 , 1.12**	**1.05 , 1.22**
Average Points Per Possession = 1.18				
First Shot, Points Per Possession for Format	Mid (5-15 feet)	**2 , 2**	**.81 , 1.01**	**.87 , 1.07**
Red is Best at or greater than 1.18				
Orange is 2nd Best between 1.02 and 1.17	Long (15-20.75 feet)			
Green is 3rd Best between .85 and 1.01				
Blue is 4th Best at or lower than .84	Three (20.75 feet plus)			

Recommendations: Hannah Gilbert clearly likes to get the ball close to the basket and is above team average basically everywhere she shoots from. She should take any shot opportunity she gets.

Shooting Chart for Number 43 Molly Schlemer

Regular Season Games		Open	Guarded
	Close (0-5 Feet)	64/72 Field Goals 90%	99/197 Field Goals 50%, Fouled 21 Times, 9 and 1's
	Mid (5-15 feet)	3/7 Field Goals 43%	43/95 Field Goals 46%, Fouled 5 Times, 1 and 1
	Long (15-20.75 feet)	6/17 Field Goals 35%	3/7 Field Goals 43%, Fouled 0 Times
	Three (20.75 feet plus)	2/4 Field Goals 50%	0 Field Goals, Fouled 0 Times

Regular Season Team Average PPP = 1.02		Open	Guarded	Total
Average Points For First Shot = 1.13	Close (0-5 Feet)	**1.78 , 1.82**	**1.05 , 1.23**	**1.23 , 1.37**
Average Points Per Possession = 1.29				
First Shot, Points Per Possession for Format	Mid (5-15 feet)	**.86 , 1.07**	**.93 , 1.12**	**.92 , 1.12**
Red is Best at or greater than 1.18				
Orange is 2nd Best between 1.02 and 1.17	Long (15-20.75 feet)	**.71 , .92**	**.86 , 1.05**	**.75 , .96**
Green is 3rd Best between .85 and 1.01				
Blue is 4th Best at or lower than .84	Three (20.75 feet plus)	**1.50 , 1.66**		**1.50 , 1.66**

Recommendations: Shoot it!

Excluding Graduating Players Shooting Chart

		Open	Guarded
	Close (0-5 Feet)	59/75 Field Goals 79%	72/195 Field Goals 37%, Fouled 56 Times, 12 and 1's
	Mid (5-15 feet)	7/20 Field Goals 35%	23/84 Field Goals 27%, Fouled 12 Times, 2 and 1's
	Long (15-20.75 feet)	15/38 Field Goals 29%	5/28 Field Goals 18%, Fouled 2 Times
	Three (20.75 feet plus)	70/201 Field Goals 35%	10/44 Field Goals 23%, Fouled 8 Times, 3 and 1's

Regular Season Team Statistics		Open	Guarded	Total
Average Points For First Shot = .94	Close (0-5 Feet)	**1.55 , 1.64**	**.88 , 1.07**	**1.04 , 1.20**
Average Points Per Possession = .98				
First Shot, Points Per Possession for Format	Mid (5-15 feet)	**.70 , .94**	**.65 , .89**	**.66 , .90**
Red is Best at or greater than 1.14				
Orange is 2nd Best between .98 and 1.13	Long (15-20.75 feet)	**.79 , .99**	**.41 , .69**	**.63 , .86**
Green is 3rd Best between .81 and .97				
Blue is 4th Best at or lower than .80	Three (20.75 feet plus)	**1.04 , 1.25**	**.98 , 1.19**	**1.03 , 1.23**

This shooting chart will give a look into shooting as a team for next year by excluding the shots from the graduating players. It first assumes that players will shoot the same percentages as the previous year but they can easily improve. It also assumes that players will shoot the same ratios of shots compared to other returning player's as the year previously. The latter means that this shooting chart assumes that younger players that did not play starters minutes who might play a larger role next year will shoot the same proportion of shots as this past season. An example would be that Hannah Gilbert had a high PPP of 1.18 and will likely shoot a higher proportion of the team's shots next year. So she can bring the team expected PPP of .98 upward.

Recommendations: The team is red hot from three-point range and this seems to be a strength of the team going into next year.

PPP Improvement

To improve upon the team average of PPP of 1.02 I wanted to find what the team average PPP would be if players did not shoot any blue shots (lowest PPP). If a player does not shoot a certain shot the possession would continue, so the probability of turning the ball over would most likely go up some amount. The probability of turning the ball over when you don't shoot a shot should not be more than the team average turnover rate, but it should also not be zero. I made an interval for improved average PPP that has an upper bound PPP of the new team shooting parameters with the same TO percentage (no increase) and a lower bound with the adjusted higher team turnover rate turning it over the same average rate on the shots the team theoretically passed up as the team did an average. So by this thought process the new team average PPP would be somewhere in between the interval (1.03, 1.05) if players did not shoot any shots that were colored blue. I also did this same calculation excluding shots that were both blue and green and got an interval of (1.04, 1.09). This gives a look into how much more efficient the team could score if they passed up lower PPP shots. The following analysis gives a look into the projected winning percentages of the team in league games with the initial average team PPP and also the improvement in average team PPP. It might be unrealistic to not shoot any blue or green shots, but an effort can be made to drastically lower these shot attempts in order to find better shot opportunities.

I simulated the number of points Cal Poly scores in a game with a certain PPP and then what the league opponents scored during a game. The table below describes the projected probability that Cal Poly wins in regulation (without overtime) for a regular season game when playing a league opponent (To see how I simulated this and an explanation see pages 21 and 22).

Actual winning percentage in regulation for the season was 61.5% (8/13 league games finished in regulation the team won), so the team won more than the simulation expected in regulation. Every .01 point increase is associated with about a 2 percentage point increase in winning in regulation for a 70 possession game. So, small improvements can add up and have a big impact on the probability of winning a game.

PPP	Winning % in regulation
1.02	55.7%
1.03	57.8%
1.04	59.9%
1.05	61.8%
1.06	63.8%
1.07	65.9%
1.08	67.8%
1.09	69.8%

Possible Improvements of Analysis and Limitations

One drawback of the analysis is that I only had eight different shot types, but basketball has many more different shot variations. For future analysis I would keep track of shots individual players shoot often (like floaters or hook shots) to see how well players shoot shots that they often take. I also wished I had made a distinction between close three pointers and far three pointers. I counted a three attempt far behind the line as a guarded three. It would have been interesting to see how well players shoot far three pointers compared to three pointers close to the line. This might show a player that far threes are better shots than guarded threes close to the line (or vice versa, it would be nice to know which shot type is better for each player).

Another limitation of the analysis is that it was up to me to judge what the distance of the shot was and decide if the player was either open or guarded on a shot. It was hard to tell on certain shots what distance the shot was taken from and whether I should count the shot as guarded or open. These were both very subjective and I did the best I could at being both consistent and accurate. In addition, the amount of contest could also have an effect on the PPP. For future analysis I would categorize a shot as open, slightly contested, or highly contested. This would give some insight on how much the degree of contest affects a players shooting ability

I also did not look into how different missed shots affect the opposing team's offense. It might be true that missed shots have a negative impact on the team's ability to play transition defense, which would impact the decision on whether or not to take a certain shot. So for future analysis I would keep track of the opponents points scored on missed shots to test if this hypothesis is true.

I also assumed independence (no difference) between points scored off second chance points and distance of the shot, points scored off second chance points and which player shot, and other circumstances as well. I assumed total independence with the exception of distance of shot and the probability of getting the offensive rebound. This is not necessarily a limitation, but it is worthy of a note on how I came up with the calculations for PPP.

Methods and R Code

Expected Points Function

```
PointsExpected=function(TwoOrThree,FieldGoalsMade,FieldGoalsAttempted,
FoulsNotAndOnes,AndOnes,FreeThrowPercentage,ReboundShot,ReboundFree,ReboundTORate,
ReboundPoints,OnReboundMissAndRebound)
{
       MissAndRebound = (((FieldGoalsAttempted - FieldGoalsMade) * ReboundShot) +
       ((FoulsNotAndOnes+AndOnes) * (1-FreeThrowPercentage) * ReboundFree))/
                                          (FieldGoalsAttempted + FoulsNotAndOnes)


       FirstPoints = (((FieldGoalsMade * TwoOrThree) + ((TwoOrThree * FoulsNotAndOnes
       + AndOnes) * FreeThrowPercentage)))/
                                          (FieldGoalsAttempted + FoulsNotAndOnes)


       SecondChancePoints = (MissAndRebound * (1-ReboundTORate) * ReboundPoints) /
                                    (1-(OnReboundMissAndRebound * (1-ReboundTORate)))


       ExpectedPoints = FirstPoints + SecondChancePoints



       Points = c(FirstPoints,SecondChancePoints,ExpectedPoints)
       Points
}
```

An example of an input for the function above is Miss Mustang, who made 5 out of 10 long two pointers and shot 80% from the free throw line. She got standard fouled twice and also had one and 1. The team got the rebound on a missed long two 1/4 of the time and 1/10 of the time on a missed free throw. The team turned it over 1/6 of the time after getting an offensive rebound. The team averaged 1.1 points after getting an offensive rebound and got the ball back 1/10 of the time on a shot attempt after already getting an offensive rebound (note this is not rebound probability on a miss but total rebound probability off a shot attempt). The input for the function above to find Miss Mustang's PPP for long two pointers is

PointsExpected(2,5,10,2,1,.80,1/4,1/10,1/6,1.1,1/10) =

1.166667 .1091667 1.2758333 (PPP)

Explanation for Function Points Expected

MissAndRebound is calculating the proportion of the time the team is expected to get the ball back after they shoot it. This will be the number of times the team gets the ball back on a missed field goal, plus the number of times the team gets the ball back on a missed free throw, all divided by the number of times the player decided to shoot that specific shot. The number of times the team gets the ball back on a missed field goal is the number of field goals missed multiplied by the proportion of the time the team gets a rebound on a miss.

The number of times the team gets the ball back on a missed free throw equals the number of times the team gets an opportunity to get the rebound on a free throw (opportunities = total number of fouls because each type of foul has one possible opportunity for the team to get the offensive rebound) multiplied by the proportion of the time the player misses the free throw, multiplied by the proportion of the time the team gets the rebound on a missed free throw. The number of times a player decided to shoot equals field goals attempted plus standard fouls.

FirstPoints is calculating the points for the initial shot. This will be the number of field goals made multiplied by the points for the shot (2 or 3), plus the number of free throws shot multiplied by the free throw percentage, all divided by field goal attempts plus standard fouls.

SecondChancePoints is calculating the PPP the player gets on the second opportunity and all opportunities that can possible follow.
For this calculation we want the sum from n = 0 to infinity of
(MissandRebound) * (Don't turn it over off an offensive rebound) * (ReboundPoints) * [(the proportion of the time the team misses and gets the rebound off an offensive rebound * Don't turn it over off an offensive rebound)] ^{n}

We use an infinite geometric sum because to find the points per possession off a first offensive rebound, plus the second, third, fourth… We want the probability that we get to a certain offensive rebound (everything above besides rebound points) and the probability of getting to the first offensive rebound is everything above when n = 0, the probability of getting to the second offensive rebound will be everything above when n = 1, the third at n = 2. Then we will multiply the probability of getting to a certain offensive rebound by the points the team is expected off an offensive rebound (ReboundPoints).

We know that the sum above from n = 0 to infinity is
((MissandRebound) * (Don't turn it over off an offensive rebound) * (ReboundPoints)) /
[(1 - (the proportion of the time the team misses and gets the rebound off an offensive rebound * don't turn it over off an offensive rebound)] *because of the following theorem*

If and only if $|r| < 1$ *then* $\sum_{n=0}^{\infty} a * r^n = a/(1-r)$
a = (MissandRebound) * (Don't turn it over off an offensive rebound) * (ReboundPoints)
r = (the proportion of the time the team misses and gets the rebound off an offensive rebound) * (Don't turn it over off an offensive rebound)

Our PPP will be FirstPoints + SecondChancePoints

Average Points Expected Function

```
AveragePointsExpected =
function(ThreesMade,ThreesAttempted,FoulsOnThreesNotAndOnes,AndOnesOnThrees,
       ReboundRateOnThrees,TwosMade,TwosAttempted,FoulsOnTwosNotAndOnes,
       AndOnesOnTwos,ReboundRateOnTwos,FreeThrowPercentage,
       ReboundRateOnFreeThrows,ReboundPoints,OnReboundMissAndRebound,
       ReboundTORate,FirstTORate)
{
       NoReboundOnThreesTotal = (ThreesMade * 3) + ((3 * FoulsOnThreesNotAndOnes +
       AndOnesOnThrees) * FreeThrowPercentage)

       NoReboundOnTwosTotal = (TwosMade * 2) + ((2 * FoulsOnTwosNotAndOnes +
       AndOnesOnTwos) * FreeThrowPercentage)


       ReboundsThrees = (ThreesAttempted - ThreesMade) * ReboundRateOnThrees

       ReboundsTwos = (TwosAttempted - TwosMade) * ReboundRateOnTwos

       ReboundsFreeThrows = (1-FreeThrowPercentage) * (FoulsOnThreesNotAndOnes +
FoulsOnTwosNotAndOnes + AndOnesOnThrees + AndOnesOnTwos) * ReboundRateOnFreeThrows

       MissAndRebound = (ReboundsThrees + ReboundsTwos + ReboundsFreeThrows) /
 (ThreesAttempted + FoulsOnThreesNotAndOnes + TwosAttempted + FoulsOnTwosNotAndOnes)

       FirstPoints = (NoReboundOnThreesTotal + NoReboundOnTwosTotal) /
       (ThreesAttempted + FoulsOnThreesNotAndOnes + TwosAttempted +
FoulsOnTwosNotAndOnes)

       SecondChancePoints = (MissAndRebound * (1-ReboundTORate) * ReboundPoints) /
       (1-(OnReboundMissAndRebound * (1-ReboundTORate)))

       AveragePointsTeam = ((1-FirstTORate) * FirstPoints) + ((1-FirstTORate) *
       SecondChancePoints)

       AveragePointsPlayer = FirstPoints + SecondChancePoints

       Points = c(FirstPoints,FirstPoints * (1 - FirstTORate), AveragePointsTeam,
AveragePointsPlayer)
       Points
}
```

An example of an input would be the team as a whole for the year shot 300 threes and made 100. While getting fouled 10 times with two and 1's when shooting three pointers. The team shot 500 twos and made 200 while getting fouled 25 times with five and 1's when shooting two pointers. The team got the rebound 1/4 of the time on a miss from both three and two, 1/10 of the time on a missed free throw, and 1/10 of the time on an attempted shot after an offensive rebound. The team shot 70% from the line and turned the ball over 1/6 of the time before a shot was attempted, 1/7 of the time after they got the offensive rebound, and scored 1.1 points on average after an offensive rebound.

AveragePointsExpected(100,300,10,2,1/4,200,500,25,5,1/4,.7,1/10,1.1,1/10,1/7,1/6)

[1] 0.9112575 0.7593812 0.8893270 1.0671924 (PPP)

Explanation for Function Average Points Expected

This function is very similar to the first function, PointsExpected. One of the two differences is that I needed to split the points and rebound proportions into two point shots and three point shots. To find the FirstPoints I added points off three pointers and points off two pointers. To find MissAndRebound I found the total number of rebounds off threes, twos, and free throws and added them all together. Then I divided by the number of times the player decided to shoot (field goal attempts plus standard fouls). Then AveragePointsPlayer will be the same as expected points, FirstPoints + SecondChancePoints. But for the team average we have to factor in the chance the team turned the ball over before even getting a shot opportunity, if a player got a shot opportunity the team could not have possibly turned the ball over that possession. So we multiply AveragePointsPlayer by the probability the team does not turn the ball over initially (1- FirstTORate) to get the AveragePointsTeam.

Function for PPP Improvement Simulation

```
Sim = function(GoodGuys,BadGuys,Possesions,PointsGained)
{
      test1 = shapiro.test(GoodGuys)

      test2 = shapiro.test(BadGuys)

      GoodGuys2 = round(rnorm(1000000, mean = mean(GoodGuys) + (Possesions *
PointsGained), sd = sd(GoodGuys)))

      GoodGuys1 = round(rnorm(1000000, mean = mean(GoodGuys), sd = sd(GoodGuys)))

      BadGuys1 = round(rnorm(1000000, mean = mean(BadGuys), sd = sd(BadGuys)))

      wins1 = 0
      overtimes1 = 0
      loses1 = 0
      for (i in 1:1000000){
        if (GoodGuys2[i] > BadGuys1[i]){
        wins1 = wins1 + 1}  else if (GoodGuys2[i] == BadGuys1[i]){
        overtimes1 = overtimes1 + 1} else {
               loses1 = loses1 + 1}
        }
      wins2 = 0
      overtimes2 = 0
      loses2 = 0
      for (j in 1:1000000){
        if (GoodGuys1[j] > BadGuys1[j]){
        wins2 = wins2 + 1}  else if (GoodGuys1[j] == BadGuys1[j]){
        overtimes2 = overtimes2 + 1} else {
               loses2 = loses2 + 1}
        }

      summary = c(wins1/1000000,wins2/1000000,test1$p.value,test2$p.value)
      summary
      }
```

For this function the inputs are the summary of the points scored for a team in a game adjusted per four quarters (so if 90 points were scored including overtime that would result in 80 points per four quarters), the summary of the points scored for the team opponents in the same fashion,

the number of possessions for an average game (I used 70), and the amount of points per possession **gained**.

Explanation for Simulation-

I first tested to see if each summary of points scored followed a normal distribution by performing a Shapiro Wilk test of normality. If the summaries do not follow a normal distribution the simulation would not be valid (I found no evidence of this because I had high p-values). I then simulated games with a mean of the average points scored for a team, the mean of the average points scored by the opponents, and the mean of the average points scored for a team plus the PPP increase multiplied by the number of possessions. Then I compared each observation from GoodGuys1 and GoodGuys2 to BadGuys1 to see the proportion of the time the team won in regulation without the PPP increase and compare that to the proportion of the time the team wins in regulation with the PPP increase. This simulation is simple and in no way represents what actually occurs in a basketball game, but it will give us some idea on how much a rise in PPP increases the probability that the team would win in regulation.

References

Statistic and Data with R An Applied Approach Through Examples by Yosef Cohen and Jeremiah Y. Cohen

Probability and Statistics Fourth Edition by Morris H. DeGroot and Mark J. Schervish

JMP Pro 11

R 3.0.2