An analysis of Powerball and Condition Leading to January Largest Powerball in History

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Abstract
During the JAVA Analytics Camp, several students were interested in January 13 2016 Powerball News. After conducting Powerball research and analysis, a JAVA Powerball team was formed to apply JAVA programming on simulating the Probability of a January13 2016 Powerball Scenario. Before October 2015, 59 numbers are in the first drum, and 35 are in the second drum. 69 and 26 numbers are after Oct. 2015. What's the impact of this rule change on the Jan.13 Powerball Scenario? This rule change will lower the chance of hitting the Jackpot and increase the chance of rolling over the un-invested Jackpot prize to next round. Use combination statistics to calculate each matching probability: calculate total space, and probability of matching the white ball and red ball. The team has successfully built the Powerball Probability Model through JAVA programming. We discovered several statistical patterns and conducted six major Hypotheses. Statistics and Probability can help us understand Jan.13 2016 Powerball Jackpot scenario and its formation over 19 rolling over period. Team won't suggest purchasing any Powerball ticket if the Jackpot size is still under $490M.

Keywords
Statistics, Probability, SPSS, JAVA, Expected Values

1. Project Introduction
In early January this year, people were talking about Powerball. Our project leader was curious about what the Powerball is. After getting information from his father, our leader also searched the website and found the following information: The January 13, 2016 U.S. Powerball drawing created the largest jackpot in world history. People lined up to buy Powerball on Wednesday. Record sales drove up the largest jackpot in United States history to over $1.5 billion. Eventually, it had an annuity value of $1,586,400,000. (The next largest, a Mega Millions jackpot, was just over $656,000,000). Powerball has 3 Big Winners, in California, Florida and Tennessee. The world's biggest lottery jackpot of $1.5 billion will be a three-way split of $528 million each, winning Powerball tickets were with the numbers 4-8-19-27-34 and the Powerball number, 10. In addition to the winning jackpot tickets, lottery officials said eight tickets that won $2 million were sold in seven states, and 73 that netted $1 million were sold in 23 states. As of 2016, all states with lotteries plus the District of Columbia, Puerto Rico and the U.S. Virgin Islands offer Powerball [1].

1.1 Project Research and Literature Review
The research literature in this area, however, often highlights the more problematic aspects. A paper [2] conducted a thorough review of the available research lotteries and concludes that the "poor are still the leading patron of the lottery and even the people who were made to feel poor by lotteries. The legalization of gambling has seen a significant increase of young people gambling, particularly in lotteries, and the best predictor of their lottery gambling is their parents' lottery participation." Another study [3] indicated that more people have gambling problems in states with more types of gambling or where gambling has been legal for longer. With this information

in hand-, our project leader decided to form a STEM Project team in early Feb., and he has invited two members to join this project with two team mentors: (1) Statistics Mentor, and (2) JAVA Mentor. The team immediately conducted the following research. Every Wednesday and Saturday night at 10:59 p.m. Eastern Time, we draw five white balls out of a drum with 69 balls and one red ball out of a drum with 26 red balls. With a one-in-292-million chance of winning the top prize, the odds were never in your favor [4]. The average Powerball player had a greater chance of being struck by lightning (one-in-1.9-million according to the National Oceanic and Atmospheric Administration). The team also conducted research on the Powerball Probability of each matching scenario as shown in Table 1. The team was interested in what probability formula can be used to determine the Probability and Expected values listed in Table 1.

Table 1 Expected Powerball Payout

POWERBALL EXPECTED PAYOUT

NUMBERS MATCHED	PRIZE	PRIZE - COST	LIKELIHOOD	PROBABILITY	(PRIZE - COST) X PROBABILITY
5 white and red	$450,000,000	$449,999,998	1 in 292,201,338	0.0000000034	$1.54
5 white	$1,000,000	$999,998	1 in 11,688,053.52	0.0000000856	$0.09
4 white and red	$50,000	$49,998	1 in 913,129.18	0.0000010951	$0.05
4 white	$100	$98	1 in 36,525.17	0.0000273784	$0.00
3 white and red	$100	$98	1 in 14,494.11	0.0000689935	$0.01
3 white	$7	$5	1 in 579.76	0.0017248517	$0.01
2 white and red	$7	$5	1 in 701.33	0.0014258623	$0.01
1 white and red	$4	$2	1 in 91.98	0.0108719287	$0.02
Red	$4	$2	1 in 38.32	0.0260960334	$0.05
Nothing	$0	-$2	1 in 1.04	0.9597837679	-$1.92

EXPECTED VALUE: -$0.14

1.2 Old Powerball vs. New Powerball

Powerball has changed the drawing rules in Oct. 2015. Powerball asked players to choose from two fields of numbers: 59 in the first field, and 35 in the second before Oct. 2015. That all changed after October 2015, when players would have to choose from 69 numbers in the first field and 26 numbers in the second. What's the impact of this change? Is it more worthy to buy Powerball before vs. after Oct. 2015? The team has done the quick research and found the following information between two Powerball methods. In Table 2, the ratio calculated is the chance of winning that particular matching case in old method vs. the new method. **If the Ratio is > 100%, the new method will have a lower winning probability.** The data showed that, with the Powerball drawing model changed after Oct. 2015, the probability of winning bigger prizes all went down, particularly for 5+0 case. However, winning the smaller prizes went up with the new Powerball drawing method. This change will lower the chance of hitting the Jackpot and will increase the chance of rolling over the un-invested Jackpot prize to next round. Will it be good news or a bad news for our consumers? Bad! The chance of winning the Jackpot is much smaller. Good! The Jackpot amount will be likely getting accumulated and becoming a GIANT Jackpot, never in Lotto History. Most people would want to win a bigger jackpot to get more money. This is a higher risk, and a higher return model. With this thinking, there is no wonder why, Jan.13, 2016 set the history of Jackpot dollars over $1.5B.

Table 2 Ratio of Matching Probability

	59/35	69/26	Ratio
5+1	1.75E+08	2.92E+08	167%
5+0	5.15E+05	1.17E+07	2272%
4+1	6.49E+05	9.13E+05	141%
4+0	1.91E+04	3.65E+04	191%
3+1	1.27E+04	1.50E+04	118%
3+0	3.74E+02	5.98E+02	160%
2+1	7.93E+02	7.73E+02	97%
1+1	1.40E+02	1.12E+02	80%

1.3 Hypotheses

After compiling this research information, team -went through a brainstorming session and -came out with the following hypotheses for this STEM Project: What will happen if we will place the same number of balls in both White Drum and Red Drum? Can we just use one Drum (No Replacement) to draw 5 Regular Balls and 1 Mega Ball? Can we make matching probability more uniform to let more people win -bigger prizes? When should we put the money in?

2. Basic Statistics and Probability for Powerball Matching Scenarios

Before we moved on our Project, we asked our Statistics Mentor regarding the Powerball Probability listed in Table 2. Our mentor showed us how to use the Combination Statistics (not Permutation) to calculate each matching capability [5].

For example, 5 White and Red Probability:
• Total Space= C (69, 5) * C (26 ,1)= 292,201,338
• 5 White and Red Event= C (5, 5) * C (1, 1)= 1
• Therefore, 5 White and Red Probability = 1 in 292,202,338 listed in Table 2.

Team also practiced 4 White and No Red Probability:
• Total Space= C (69, 5) * C (26 ,1)= 292,201,338
• 4 White and No Red Event= [C (5, 4) * C (64, 1)]* C (25, 1)= 8,000
• Therefore, 5 White and Red Probability = 8,000 in 292,202,338= 1 in 36,525.17 listed in Table 2.

The jackpot on Jan.13, 2016 Wednesday was not just the largest in Powerball history, New York State lottery officials said, but also the largest of any lottery game in the United States. The jackpot started at $40 million on Nov. 7 and rolled over 19 times, with no one matching all six numbers.

2.1 How could that happen on rolling over 19 times?

The chance of hitting the Jackpot of each random trial is 1 in 292,202,338 (or 0.0000000034). Let's simulate the Jackpot Probability for each drawing event. Team has conducted the probability simulation assuming how many tickets purchased at six levels: (1) 10 millions, (2) 50 millions, (3) 100 millions, (4) 500 millions, (5) 1 billion, and (6) 1.5 billion. Typical tickets sold in the regular season are normally at levels (2), and (3). When Jackpot pool is getting bigger, the ticket level will rock up to levels (4) and (5). Jan.13 case was probably at Level 5 or even Level 6, at the history of Powerball since Jackpot was in history record high. Though, at Level 5 of 1 billion, the no-hitting Jackpot probability is down to 3.3%. And at Level 6 of 1.5 billion, the probability will be even down to below 1%. Team has calculated the No Jackpot probability at six levels in Table 3.

Table 3 Probability of non-Jackpot

Tickets Sold	No Jackpot
10,000,000	0.967
50,000,000	0.844
100,000,000	0.712
500,000,000	0.183
1,000,000,000	0.033
1,500,000,000	0.006

How would that happen of rolling over 19 times of not hitting Jackpot! We further calculated the probability of rolling over 19 time of no Jackpot in Table 4.

Table 4 Probability of non-Jackpot for 19 Times

Tickets Sold	No Jackpot	19 No Jackpot
10,000,000	0.967	0.5241
50,000,000	0.844	0.0396
100,000,000	0.712	0.0016
500,000,000	0.183	0.0000
1,000,000,000	0.033	0.0000
1,500,000,000	0.006	0.0000

If the average amount of tickets sold during this 19-event span are at level 3 of 100 million of tickets sold, the probability of having 19 consecutive No Jackpot is 0.0016 (less than 1 in 600 drawing events, every six years). The new Powerball rules were applied from Oct. 2015 and were in place for about 3 months until Jan. 13, 2016. During these 3 months, around 25 Powerball events were drawn. In about 25 draws, 19 did not hitting the Jackpot. The chance of not hitting the Jackpot was very high. There is no wonder that the Jan.13 2016 Powerball event would be the largest Jackpot, not just in that year, would be the largest draw every 6 years. If we have missed this one, we may need to wait another 6 years or longer. A 6 year span is even longer than a 4-year Olympics Game. Now, Powerball has attracted more attention and more tickets were sold after Jan.13, 2016. Therefore, it's less likely to roll over 19 times like Jan. 13 2016. Though, we may hear another Powerball Storm coming soon.

3. Developing a JAVA Program

To further simulate the Powerball statistics and probability, the team wanted to create a similar table as listed in Figure 2. Instead of using an Excel File, the team decided to apply their JAVA Programming to conduct this STEM Project. We asked our JAVA mentor to help us build the JAVA Program to simulate the Powerball Probability. Our JAVA program can allow the team to adjust the drawing rules flexibly to simulate different Powerball scenarios.

In JAVA Programming, we have set the four input variables (x, w, y, n).

- x is the number of white balls available in the first drum (x= 69 in current Powerball)
- w is the number of white balls drawn from the first drum (w= 5 in current Powerball)
- y is the number of red balls available in the second drum (y= 26 in current Powerball)
- n is the number of red balls drawn in the second drum (n= 1 in current Powerball)

3.1 Develop First Powerball JAVA Program

After we developed our first JAVA program, team ran the JAVA script on the following two cases: Old Powerball Method vs. New Powerball Method to verify the JAVA programming accuracy.
Then, team has developed the first JAVA program to duplicate the current Powerball (59, 5, 35, and 1). As shown in Table 5, the JAVA program has successfully duplicated the current Powerball probability.

Table 5 Matching Probability Comparison between New and Old Powerball

69/26	59/35
5+1=Probability of 2.922	5+1=Probability of 1.752
5+0=Probability of 1.169	5+0=Probability of 5153632.647
4+1=Probability of 913129.181	4+1=Probability of 648975.963
4+0=Probability of 36525.167	4+0=Probability of 19087.528

3+1=Probability of 14961.666	3+1=Probability of 12715.784
3+0=Probability of 598.467	3+0 Probability of 373.994
2+1=Probability of 772.611	2+1=Probability of 792.867
1+1=Probability of 111.986	1+1=Probability of 140.235

What will happen if we will place the same number of balls in both White Drum and Red Drum? In our JAVA program, we can set X=Y and to calculate at which X level, the probability to win the Jackpot is the same as current Powerball. Based on the Statistics:

- Total Space= C (X, 5) * C (X ,1)= 292,201,338 (current Powerball situation)
- This will be a very complicated calculation to find the best X level to achieve the same Powerball Mega situation.
- We used our JAVA program and come out with X= Y=59 immediately as shown in Table 6 to match the 5 (White) + 1 (Red) probability ~ 2.92E8.

Table 6 Matching Probability for 59/59 Case

59/59
5+1=Probability of 2.954
5+0=Probability of 5092703
4+1=Probability of1093988.052
4+0=Probability of 18861.863
3+1=Probability of21435.180
3+0=Probability of369.572
2+1=Probability of1336.546
1+1=Probability of 236.396

We also compare the other matching probability in Figure 1 by comparing 69/26 with 59/59. However, the 59/59 drawing model can be good to study the Powerball Statistics. Also, we have observed the zig-zag pattern from the 59/59 scenario in Figure 9. We can further compare the 4+0 vs. 3+1 between two scenarios:

- **For current 69/26 Scenario to match 4+0 Prize:**
  - The total space= C (69, 5) * C (26, 1)= 292,201,338
  - The probability of matching 4 White Balls = C (5,4)*C (64,1)= 5*64= 320
  - The probability of matching no Red Ball= C (25, 1)= 25
  - The probability of matching 4+0= (**320*25**)/292,201,338 = 8,000/292,201,338= 1 in 36,525
- **For current 69/26 Scenario to match 3+1 Prize:**
  - The total space= C (69, 5) * C (26, 1)= 292,201,338
  - The probability of matching 3 White Balls = C (5,3)* C (64, 2)= 10*2,016= 20,160
  - The probability of matching 1 Red Ball= C (1, 1)= 1
  - The probability of matching 3+1= (**20,160*1**)/292,201,338 = 1 in 14,494
- **For current 59/59 Scenario to match 4+0 Prize**:
  - The total space= C (59, 5) * C (59, 1)= 295,376,774
  - The probability of matching 4 White Balls = C (5,4)*C (54,1)= 5*54= 270
  - The probability of matching no Red Ball= C (58, 1)= 58
  - The probability of matching 4+0= (**270*58**)/292,201,338 = 15,660/295,376,774= 1 in 18,861
- **For current 59/59 Scenario to match 3+1 Prize:**
  - The total space= C (59, 5) * C (59, 1)= 295,376,774
  - The probability of matching 3 White Balls = C (5,3)* C (54, 2)= 10*1,431= 14,310
  - The probability of matching 1 Red Ball= C (1, 1)= 1
  - The probability of matching 3+1= (**14,310*1**)/295,376,774 = 1 in 21,435
- The above analysis can explain why we have observed the zig-zag pattern on 59/59 scenario:

- The 4+0 probability is relatively higher than 3+1 probability because the event of getting non-Mega Red number is much higher since we have 58 red balls which can be picked as non-Mega Red ball
- Also, at 59/59 scenario, the event of getting two incorrect white balls is lower since we only have 54 incorrect white balls available to pick up two.
- Therefore, the 4+0 probability is relatively higher than 3+1 probability on 59/59 scenario. This Zig-Zag pattern is much stronger for the 59/59 case. This may be the main reason that Powerball selected two numbers very different from each other.

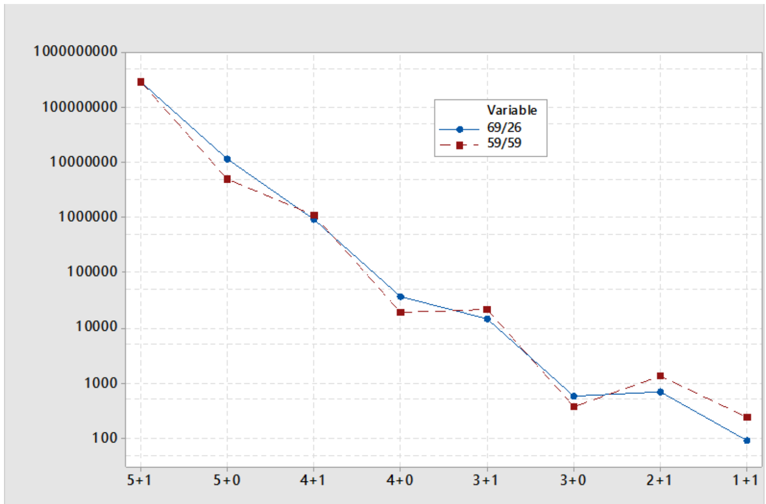

Figure 1 Zig-Zag Matching Pattern

Can we just use one Drum to draw 5 Regular Balls and 1 Mega Ball?

- If we can set the same number X=Y in two drums, can we just use one Drum to draw the Powerball?
- What's the main difference of using one drum (one color) vs. two drums? If we use only one drum, after we have picked the 5 regular balls, we will pick the Mega ball from the remaining balls (No Replacement) available. Therefore, the Mega number will be different from the first 5 numbers.
- We consulted with our Statistics Mentor and he told us this is the main difference between the Binomial Distribution with Replacement vs. Hypergeometric Distribution with No Replacement.
  - If we use only one Drum, the first five balls won't be returned back to the Drum before we will pick up the Mega ball, so called No Replacement
  - What's the probability difference with this No Replacement situation?
- In order to simulate this No Replacement situation, we have modified our original JAVA program by setting Y=X-5. X is the original number of balls available, and Y is the number of balls available after the first five balls have already been picked. We can set Y=X-5 to simulate this one Drum with No Replacement scenario.

Then, team was curious to see which matching probability will be impacted by this No Replacement situation. First question, will the matching probability higher or lower w/wo replacement? The Powerball uses two drums to draw the 5 white balls and 1 red Mega ball with Replacement. Our first intuition is Powerball must be smart to make it more profitable by possibly duplicating the Mega number as same as one of the white balls picked already. Team was sure but curious how much different between these two methods. Team has conducted the following seven comparisons between w/Replacement and wo/Replacement:
Replacement vs. No Replacement
59/59 vs. 59/54
55/55 vs. 55/50
50/50 vs. 50/45
45/45 vs. 45/40
40/40 vs. 40/35
35/35 vs. 35/30
30/30 vs. 30/25

We combined all the JAVA result in the following Table 7.

Table 7 Matching Probability of One Drum Scenario

X	Y	5+1	5+0	4+1	4+0
69	26	2.9E+08	1.2E+07	9.1E+05	3.7E+04
60	60	3.3E+08	5.6E+06	1.2E+06	2.0E+04
55	55	1.9E+08	3.5E+06	7.7E+05	1.4E+04
59	59	3.0E+08	5.1E+06	1.1E+06	1.9E+04
59	54	2.7E+08	5.1E+06	1.0E+06	1.9E+04
55	50	1.7E+08	3.5E+06	7.0E+05	1.4E+04
50	50	1.1E+08	2.2E+06	4.7E+05	9.6E+03
50	45	9.5E+07	2.2E+06	4.2E+05	9.6E+03
45	45	5.5E+07	1.2E+06	2.7E+05	6.2E+03
45	40	4.9E+07	1.3E+06	2.4E+05	6.3E+03
40	40	2.6E+07	6.7E+05	1.5E+05	3.9E+03
40	35	2.3E+07	6.8E+05	1.3E+05	3.9E+03
35	35	1.1E+07	3.3E+05	7.6E+04	2.2E+03
35	30	9.7E+06	3.4E+05	6.5E+04	2.2E+03
30	30	4.3E+06	1.5E+05	3.4E+04	1.2E+03
30	25	3.6E+06	1.5E+05	2.9E+04	1.2E+03

Then team has conducted the probability Ratio of Probability (No Replacement)/Probability (Replacement) at each scenario in Table 8.

Table 8 Ratio of probability between No Replacement and Replacement

X	Y	5+1	4+1
59	59	1.09	1.09
59	54	1.09	1.09
55	55	1.10	1.10
55	50	1.10	1.10
50	50	1.11	1.11
50	45	1.11	1.11
45	45	1.13	1.13
45	40	1.13	1.13
40	40	1.14	1.14
40	35	1.14	1.14
35	35	1.17	1.17
35	30	1.17	1.17
30	30	1.20	1.20
30	25	1.20	1.20

For the first scenario (simulated equivalent Powerball drawing 59/59), the ratio calculation has indicated that the consumers may have 9% more chance to win the top prizes if we will not duplicate the Mega Red number with the previous five regular White numbers. It's not surprising why Powerball is using two colors to avoid the "No Replacement" scenario which may lose 9% profit to the Powerball Organization at each event. The ratio is higher when the total number of balls decreases. This ratio trend is consistent with the Basic Statistics: Binomial Probability Distribution (Replacement) vs. Hypergeometric Probability Distribution (No Replacement) [6]. When the drum pool ball population size is infinity, the Hypergeometric Distribution will approach the Binomial Distribution. The difference between Replacement and No Replacement is at minimum.

3.2 Conduct our Third Hypothesis

Can we make matching probability more uniform to let more people win more Bigger Prizes? How can we increase the winning probability of Bigger Prizes relatively but not increasing the winning probability of Smaller Prizes relatively? Why do we care? The Powerball may attract more buyers when the Jackpot amount is still small in the earlier rolling over periods. In Table 9, we calculated the ratio of winning 5+1 Jackpot vs. No.4 Prize 4+0. If the ratio is higher, the Probability is less uniform. Interestingly, the new 69/26 method has observed the lower ratio than the previous 59/35 method and the X=Y=59 method. The new Powerball method did make the Bigger Prizes' probability more uniform. This result may reflect our previous Zig-Zag analysis similarly. The other trend is that if we can reduce the pool size (for X=Y case), we can make the Bigger Prizes' probability more uniform. We can change the Prize Model accordingly to come up with a similar expected value.

Table 9 Ratio of Matching Probability (more uniform)

X	Y	5+1	4+0	Ratio
69	26	2.9E+08	3.7E+04	7995
59	35	3.0E+08	1.9E+04	15263
60	60	3.3E+08	2.0E+04	16225
59	59	3.0E+08	1.9E+04	15660
59	54	2.7E+08	1.9E+04	14310
55	55	1.9E+08	1.4E+04	13500
55	50	1.7E+08	1.4E+04	12250
50	50	1.1E+08	9.6E+03	11025
50	45	9.5E+07	9.6E+03	9900
45	45	5.5E+07	6.2E+03	8800
45	40	4.9E+07	6.3E+03	7800
40	40	2.6E+07	3.9E+03	6825
40	35	2.3E+07	3.9E+03	5950
35	35	1.1E+07	2.2E+03	5100
35	30	9.7E+06	2.2E+03	4350
30	30	4.3E+06	1.2E+03	3625
30	25	3.6E+06	1.2E+03	3000

4. Expected Values (Return of Investment ROI)

After team has explored the JAVA programming on the probability of various drawing scenarios, team was curious about the outcome of the expected values listed in Table 2. Team has duplicated the similar table in Table 10 by using the same Jackpot amount at 450,000,000. This number is just an arbitrary number. The expected value is 2.76 for old 59/35 method if we use the same Prize-Cost model and Jackpot at 450,000,000. 2.76 expected value means that the average gain per ticket is $2.76. Wow, the return is more than 100% (ticket value s $2). It won't make any sense about the expected value. I further search the Prize of the old method and the Prize was different on the old method and the Jackpot amount won't be that high at 450,000,000 level. Therefore, it's less meaningless to compare 59/35 vs. 69/26 on the expected values.

Instead, we want to compare 69/26 vs. 59/59 on the expected values. The expected value is higher at -0.08 with 59/59 method vs. -0.14 with 69/26 method. The new proposed 59/59 method will increase the return on 5+0 matching case since the chance of hitting the 5+0 case is more than 2X with the new 59/59 method. Will the Powerball business allow this Prize Model? Of course not!

Table 10 Expected Value of each Matching Case

	Drawing Probability			Prize-Cost	Expected Value		
	59/35	69/26	59/59		59/35	69/26	59/59
5+1	5.7E-09	3.4E-09	3.4E-09	449,999,998	2.57	1.54	1.53
5+0	1.9E-06	8.5E-08	2.0E-07	999,998	1.94	0.09	0.20
4+1	1.5E-06	1.1E-06	9.5E-07	49,998	0.08	0.05	0.05
4+0	5.2E-05	2.7E-05	5.3E-05	98	0.01	0.00	0.01
3+1	7.9E-05	6.7E-05	4.7E-05	98	0.01	0.01	0.00
3+0	2.7E-03	1.7E-03	2.7E-03	5	0.01	0.01	0.01
2+1	1.3E-03	1.3E-03	7.5E-04	5	0.01	0.01	0.00
1+1	7.1E-03	8.9E-03	4.2E-03	2	0.01	0.02	0.01
0+1	2.6E-02	2.6E-02	2.6E-02	2	0.05	0.05	0.05
Nothing	9.6E-01	9.6E-01	9.7E-01	-2	-1.93	-1.92	-1.93
					2.76	**-0.14**	**-0.08**

If we are running the Powerball Business, how will we adjust the Prize-Cost model in order to achieve the same Expected Value as 69/26 model? Team has adjusted the Prize at "5+0" matching level from $1,000,000 - $2= $999,998 to $650,000-$2= $649,998 to matching the same expected value at -0.14 (shown in Table 11). Team was excited about learning how to running a business through Probability Model.

Table 11 Match Expected Values by Adjusting Prize-Cost Ratio

	69/26	Prize-Cost	69/26		59/59	Prize-Cost	59/59
5+1	3.4E-09	449,999,998	1.54	5+1	3.4E-09	449,999,998	1.53
5+0	8.5E-08	999,998	0.09	5+0	2.0E-07	649,998	0.13
4+1	1.1E-06	49,998	0.05	4+1	9.5E-07	49,998	0.05
4+0	2.7E-05	98	0.00	4+0	5.3E-05	98	0.01
3+1	6.7E-05	98	0.01	3+1	4.7E-05	98	0.00
3+0	1.7E-03	5	0.01	3+0	2.7E-03	5	0.01
2+1	1.3E-03	5	0.01	2+1	7.5E-04	5	0.00
1+1	8.9E-03	2	0.02	1+1	4.2E-03	2	0.01
0+1	2.6E-02	2	0.05	0+1	2.6E-02	2	0.05
Nothing	9.6E-01	-2	-1.92	Nothing	9.7E-01	-2	-1.93
			-0.14				**-0.14**

Though, after we shared our report with our parents, they came out with one very Simple Question, when should they purchase Powerball Tickets depending on the Jackpot Size? You know they are our parents and we need them to support our family. Let's group the team and come out with this Expected Value vs. Jackpot prediction model shown in Table 12.

Table 12 Break Even Jackpot Amount

Jackpot Amount	Expected Value
400,000,000	-0.31
450,000,000	-0.14
490,000,000	0.00
500,000,000	0.03
525,000,000	0.12
550,000,000	0.20

Daddy, it's at 500 Million, more exactly at 490 Million. Don't purchase any Powerball Ticket if the Jackpot amount is still below 490 Million. Son, how about over 490 Million? Should we purchase 1 ticket, 2 tickets, or even sell our house? We went to consult with our Statistics Mentor. How do we know how many tickets would hit the Jackpot Numbers when more tickets were sold. For example, there are three winners on Jan. 13 2016 Powerball. This will become a very complicated probability scenario since we won't be able to estimate how many tickets will be sold prior the new Powerball drawing event. This may be a very interesting project if we can have more historical sales distribution of the Powerball. Though, the Powerball new method just happened since Oct. 2015, not much sales data available since, after November, the Powerball went through 19 Rolling Over until Jan.13. At this moment, team has no good model to answer this subject well. We will wait another year and collect more sales data and build a more powerful model to predict the correlation between Jackpot Amount and Expected Values.

Due to resource limitation and final exams, team would need to take a stop here. It's a little sad since team momentum was getting higher after conducting each Statistical Analysis. Though, every project must end somewhere and team decided to have a good ending here.

5. Future Work Opportunities

The team has built a very basic JAVA model to simulate the Powerball Probability. The team could have done it better on the following future opportunities: Consider the Prize Model to adjust the expected value and the probability uniformity across bigger prizes. Search the historical tickets-sold amount distribution to more accurately simulate the no-Jackpot probability. Analyze the Roll-Over pattern on the tickets sold amount to more accurately predict the Jackpot Amount distributions. Build a model of two Mega Balls to create an even bigger Jackpot. Compare Powerball to other Lotto like Mega Millions or Super Lotto. The team will continue this STEM Project.

6. Summary and Conclusion

The team has successfully built the Powerball Probability Model through JAVA programming. The team has discovered several statistical patterns and conducted three major Hypotheses. Team has compared the matching probability between the Powerball Business Model before and after October 2015. Based on the Statistics and Probability, the team can understand Jan.13 2016 Powerball Jackpot probability and its formation over 19 rolling over period. Also, team has analyzed the break-even Return of Investment based on the expected values. The JAVA simulation can explain the matching probability and Jan.13 2016 event well. There are still some unsolved subjects like how to simulate the matching probability of more than one Jackpot winners when the Jackpot is beyond $490 million. It has been a great experience to apply Statistics and JAVA knowledge in one STEM Project.

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Biography

Mason Chen is a certified IASSC Black Belt. He has also certified IBM SPSS Statistics Certificate, IBM Modeler Data Analysis and Data Mining Certificates. Mason Chen is familiar with Lego Robotics/EV3, Six Sigma DMAIC, DMADOV, Lean Production, Minitab, SPSS Statistics, SPSS Modeler CRISP Data Mining, Applied Statistics, JAVA Programming, and ASQ Quality Engineering. He is the founder of Mason Chen Consulting which organization helps develop young kids on Big Data Analytics and STEM Projects.

Zonghuan (Jason) Li has certified SPSS statistics, SPSS Modeler data analyst and SPSS modeler data mining. Jason is familiar with Six Sigma DMAIC, SPSS Statistics, SPSS modeler CRISP Data Mining, and AP Statistics. Recently, he is learning "Computational Biology" which integrates Biology, Chemistry, Physics, Mathematics, Statistics, and Computer Science fields. At school, Jason is involved in Renaissance Leadership and many clubs. He is also on the JV basketball team.