Lottery Numbers Visual Analysis

(This lottery number analysis is going to be in the form of a report to the New York State Gaming Commission. The purpose is to illustrate the unfairness of the Powerball and Mega Millions lotteries and recommend increasing advertising for New York’s Pick 10 lottery.)

At the New York State Gaming Commission (NYSGC), we advocate for our citizens to responsibly play fair games. Part of a game being “fair” is that the odds of a player winning don’t change and that the game itself does not change. We at the NYSGC should encourage our lottery players to choose the Pick 10 over other games like the Mega Millions and Powerball lotteries. This could come from increased advertising for the NY Pick 10.

Visual Analysis of the Powerball

The Powerball lottery is one of the most popular lotteries played in the United States. Its basis has been matching six numbers. It has, however, changed somewhat in the time that it has been played. These changes can be seen in the addition of additional numbers that can be drawn.

A graph of a number of people

Description automatically generated

We can see from the histogram above that the number of times each number is drawn (displayed in bins of 5) are not even. Numbers from 20-25 and below have tended to appear more often than other numbers and those from 60 and above appear less often than the rest of the numbers. We can look into this and see that some time during 2013-2015 additional numbers were added to the game.

A graph of numbers and a number of years

Description automatically generated with medium confidence

The increase in numbers that can be drawn directly correlates to a decrease in the likelihood an individual wins a prize, including the jackpot. During the same time frame, Powerball added a multiplier – an additional hurdle for players to win.

A red dots on a white background

Description automatically generated

The scatterplot shown above adds together the numbers from each drawing, excluding the multiplier, to illustrate the spread of drawings. In a fair game, the sums of all drawings would for a cloud of points that generally sits around the same height/sum. We can see the addition of the multiplier marked on the scatterplot and can also see that the height of the cloud increases slightly to the right of the multiplier line when compared to the left of the line. This represents the effect of the addition of larger numbers being added to the game.

The multipliers themselves have also appeared to change since their addition to the game. We can split this scatterplot across the multipliers for the drawings and see the differences in the number of drawings with each multiplier. The point where the multiplier was added is highlighted in each subplot. The densities of the clouds of points is readily apparent with the 10 being drawn the fewest number of times in addition to not even initially existing after the multiplier’s implementation. This represents yet another change the Powerball has added to make it harder for players to win.

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Visual Analysis of the Mega Millions

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| The Mega Millions lottery game is a more serious offender when it comes to changing the rules of the game. The game itself asks players to match five drawn balls and a “Mega Ball” that is drawn separately. Mega Millions has tended to implement changes before the Powerball lottery and has done so more often. We can see a similar phenomenon with the numbers drawn for the Mega Millions that we observed in the Powerball. This spread, | A graph of numbers and a number  Description automatically generated |

however, is larger with the numbers that can be drawn now going up to 75. Further breaking down this spread over three year spans further illustrates the instability of the Mega Millions lottery. Numbers were added in the 2013-2015 timespan and then reduced

sometime later. This reduction could indicate that customers were aware of the increased difficulty winning a prize in the Mega Millions lottery, but it also cements the idea that the game has and can continue to change over time.

A graph of numbers and a number of numbers

Description automatically generated with medium confidence

Summation of the numbers drawn for the Mega Millions can lead to a similar look we took at the Powerball. While we cannot see much of a difference when Mega Millions added a multiplier, we can see a distinct shift in the height of the cloud of sums when changes are made to the values the Mega Ball can be.

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| A graph of blue dots  Description automatically generated |

Initially, the value of the Mega Ball could range from 1 to 52. In 2014 this range was lowered to 1 to 15. This also coincides with the timeframe where the sum of numbers drawn distinctly increases, indicating this is when Mega Millions increased the range of numbers that can be drawn from the five regular numbers previously mentioned. The Mega Ball was again modified to occupy a range of 1 to 25 in 2017 with a narrowing of the range of numbers that can be drawn, which can be seen in the previous histograms. The subplots below show these sums graphed with binned Mega Ball values with bins of size 8.5. The changes related to the Mega Bal are highlighted as well.

A graph of blue dots

Description automatically generated

A graph of blue dots

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The Mega Millions multiplier has also undergone changes since its implementation. Above, we can see how the use of the multiplier has changed from the addition of a number to the possible change in odds for the numbers themselves. We can clearly see this from the number of times 5 occurred as a multiplier. It was added when the Mega Ball’s range was reduced and its odds may have been reduced when the range of the Mega Ball was increased in 2017.

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| A silver lining that can be observed is that the average value of all numbers drawn for the combinations of multiplier and the number of different mega balls each multiplier has had are similar. We can see this | A graph with blue circles  Description automatically generated |

as the areas of the circles in the plot. But while these areas are similar, we can see that the 5 multiplier has seen noticeably fewer Mega Balls be drawn with it and the 2 multiplier has seen less combinations than 3 and 4, which are close to each other. This could indicate that the odds of a multiplier of 3 and 4 could be more likely since they have been drawn with a larger number of Mega Balls. This possible bias in addition to the other changes made to the game over time show that the Mega Millions may not be the best choice for New Yorkers.

Visual Analysis of New York Pick 10

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| The New York Pick 10 lottery has players match 10 numbers to the 20 drawn by the lottery. Instead of having to match every number, they only need to match half of them. The history of the fairness of the Pick 10 can be easily shown using a histogram, as done with the Powerball and Mega Millions. The distribution of numbers |  |

shows that each number is equiprobable, so players should feel comfortable picking whatever numbers they like.

A blue and orange dots

Description automatically generated

Minimum, median, and maximum numbers from the 20 numbers drawn can also be plotted together to illustrate the distribution of winning numbers. The minimum values tend to range between 1 and 20, median values tend to fill the space between 30 and 60, and maximum values tend to range from 60 to 80. Naturally, there are some noticeable points where the median reaches too high or low, minimums reaching too high, or maximums reaching too low. This is to be expected from random drawings of 20 different numbers, however.

If the NYSGC is able to highlight the fairness of the Pick 10 and contrast it with the changes made over time to the Powerball and Mega Millions lotteries, we may be able to increase sales of the Pick 10 while also encouraging fair play for citizens of New York.