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On the Performance of Lottery Winning Strategies: A Case Study of Oyo State Lottery, Nigeria

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Original Research Article

Abstract

Aims: In this study, we investigated three lottery strategies: random, low and high frequency strategies, usually employed by lottery players. For the three strategies, we considered whether the selection of numbers in Oyo State lottery occurred with equal probability, whether the lottery winning numbers occurred with equal probability, whether the performance of a strategy was associated with the amount of historical information considered and whether a game strategy outperformed others using the game's history.
Place and Duration of Study: The Oyo State Lottery, a type of lottery in Oyo State, Nigeria was used as a case study.
Methodology: The data used for this research work consisted of the year 2011 lottery winning numbers of the Daily draw type of game as collected from the Oyo State Lottery Commission. The data was used to simulate the random, low frequency and high frequency game strategies. Various statistical tests which include runs test, Chi-square goodness of fit test, one-way ANOVA test and Least Significant Difference test were carried out to test the different hypotheses defined.
Results: For H_1 (Each number is equally selected by the public), $|Z|=20.98 > Z_{1-\alpha/2} = 1.96$. For H_2 (The winning numbers occur with equal probability), $P>.05$ across the months of the year. Considering H_3 (There is no performance difference in the strategies with small amount of historical information), $P=.06$ and for H_4 (There is no performance difference in the strategies with large amount of historical information), the one-way ANOVA test gave P=.20. For H_5 (There is no difference in the performance of the three strategies), ANOVA test yielded $P=.013$. Further test revealed that low frequency and random strategies; low and high frequency strategies were different from each other at 5% significance level.
Conclusion: Players do not select lottery numbers randomly, but rather based on certain strategies. Oyo State lottery winning numbers are selected with equal probability. Thus, we can say that the process that the Oyo State Lottery Commission is using in generating winning numbers is not biased. From the simulation results, the low frequency strategy has the highest number of matches among the three strategies considered. The introduction of small and large amount of historical information component into the ANOVA tests revealed that no strategy is better than others among the three strategies considered. Using full historical information,

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however, it was discovered that the three strategies were significantly different from one another at 5%. Further tests revealed that random and low frequency, low and high frequency strategies are significantly different from each other at 5% level of significance. Thus, for this study, the low frequency strategy performed better than the other two strategies.

Keywords: Tickets, lottery strategy, winning numbers, hypothesis testing, historical information.

1 Introduction

Lottery is a game of chance and it involves the distribution of prizes among purchasers of tickets. The game of lottery has a very long history. This can be found in [1,2]. Among all the games of chance, lotteries have been and still are very popular. According to [3], the most prevalent form of lottery game is lotto, which involves random selection of numbers. Participants in this type of game randomly choose n distinct numbers from a large pool of m integers. The organizers stop the sale of tickets at a certain point and then select p winning numbers randomly from the m numbers. If any of the tickets sold match t or more of the p winning numbers, a prize is given to the holder of the matching ticket. To receive a prize, t is usually three or more [4].

Lotteries are often run by the government to raise funds for the improvement of infrastructural facilities. For example, the California lottery was created to raise supplemental funds for public schools [5]. The Big Lottery Fund in the UK is a non-departmental public body that distributes 46% of all funds raised by the national lottery for good causes. It funds a diverse range of programmes and projects in the fields of health, education, the environment and charitable purposes [6].

The profile of people playing lottery was studied in [7] and it was found that people with lower income and education level contribute greatly to the funds obtained from lottery. Also, older people buy more lottery tickets than younger people [8,9]. It was showed in [10] that an increase of 1% of a country's education index led to a decrease of about 3% of total lottery sales. Sociological approaches were adopted by [11] in explaining why the poor spend more on lottery tickets than their wealthier and better educated peers while [12] argued that lottery is associated with increasing social inequality.

The possibility of winning a huge amount of money is a great feature that attracts players despite the very low probabilities of winning. For instance, in the USA, the odds of winning the Mega Millions jackpot are 1 in 175 million and that of the Powerball jackpot is 1 in 195 million. The drive to win the jackpot or any of the other prizes has led players to devising strategies that are different from the traditional selection of numbers in a random fashion. Some of the strategies adopted include repeated play of the same number, choosing or avoiding certain numbers, for instance, numbers that belong to the same interval of tens, consecutive numbers and so on [13].

In [14], lottery purchase strategies were defined as the number of lottery tickets purchased for the same combination of lottery numbers in the same draw. The authors also gave the distribution of lottery purchase strategies for 30,366 SSQ lottery players in China in 2001. An agent-based model of the lottery market was introduced in [15]. The agents were designed on the basis of two empirical phenomena one of which is conscious selection of numbers so as to be able to answer the question of random selection of winning numbers. Six winning lottery strategies were analysed in [16] to identify their logical and mathematical fallacies. It was also shown, using Chi-square, that the Oregon State Lotto game, "Megabucks," is an unbiased game. A Bayesian

approach was presented as an alternative to the frequentist method for testing the randomness of lottery draws in [17]. The method was applied to draw history data pertaining to the first 1, 101 draws of the main U.K. National Lottery game of 24th June 2006 and the results were compared with those obtained using existing frequentist methods. The author concluded that Bayesian updating is easier to interpret and more informative than significance testing. In [18], it was reported that in the UK, 67% of people chose the same numbers each week. Of this figure, 30% chose their regular numbers after an initial random selection and 37% chose the same numbers each week based on birthday dates, house numbers, favourite numbers and so on. Panel data from the Danish State Lottery was used to track choices of individual players in [19]. The study revealed that players tend to avoid numbers that have been drawn in the previous week but tend to favor numbers that have been drawn in several consecutive weeks. It was also shown that being prone to biases is costly. This implies that players that do not select lottery numbers randomly realized lower winning prizes than they would have done if their selection had been random. A research carried out by [20] showed that there is a very significant correlation between the number of lottery winners and the number of ticket sales. Also, using the chi-square approach, there was no evidence that the selection of the lottery balls was not random.

In this study, we investigated three common lottery strategies: random, low and high frequency strategies, usually employed by lottery players. The Oyo State Lottery, a type of lottery in Oyo State, Nigeria was used as a case study. This paper is divided into four sections. In section 1, the game of lottery is introduced. Sub-sections 1.1, 1.2 and 1.3 contain discussion on lottery formats, the Oyo State Lottery and different lottery strategies. The methodology employed for this research work is described in section 2. This includes the simulation of selected lottery strategies in section 2.1 and hypothesis testing in section 2.2. The results and discussion are presented in Section 3 while the conclusions drawn from the study are given in section 4.

1.1 Lottery Formats

Draws for lotteries are performed in various ways today. Each lottery format has its own rules for establishing the prize fund and distributing prizes to winners, but drawing a selection of numbered balls without replacement from an urn is still very popular among lottery organizers. The Genoese and Keno formats were described in [21,22] respectively while [23] presented some lotteries and their formats from Nigeria.

1.2 Description of Oyo State Lottery

The Oyo State Lottery is organized by the Oyo State Lottery Commission, a parastatal of the Oyo State government of Nigeria. The lotto which is a 5/79 game opens by 7 a.m. and closes by 7 p.m. every day. Three different kinds of games are organized by the Commission: the Glad draw, the Daily draw and the Saturday draw for which tickets are purchased at 20, 50 and 100 naira per ticket respectively. Tables 1, 2 and 3 respectively show the prize monies for different numbers players are able to match in each of Glad, Daily and Saturday draws. The prize money is calculated by multiplying the fixed value by the prize of the ticket. The organizers pick five winning numbers at random from the first seventy-nine integers. If a player matches less than two numbers, no prize is won. Two, three, four and five matches attract prizes. Five matches entitle the player to the jackpot.

Table 1. Glad draw at ₦20 per ticket

Number of matches	Fixed value (₦)	Amount won (₦)
2/5	75	1,500
3/5	200	4,000
4/5	295	5,800
5/5	3,025	60,500

Source: Oyo State Lottery Commission

Table 2. Daily draw at ₦50 per ticket

Number of matches	Fixed value (₦)	Amount won (₦)
2/5	100	5,000
3/5	206	10,300
4/5	836	41,800
5/5	2,400	120,000

Source: Oyo State Lottery Commission

Table 3. Sat draw at ₦100 per ticket

Number of matches	Fixed value (₦)	Amount won (₦)
2/5	120	12,000
3/5	180	18,000
4/5	720	72,000
5/5	3250	325,000

Source: Oyo State Lottery Commission

1.3 Lottery Strategies

Players use different strategies in determining the winning numbers. Some of these include the use of birthdays, numbers seen in a dream, happiest day and so on. In this study, we shall consider three common strategies. These are the random, low frequency and high frequency strategies. The random strategy involves the use of the random number generator or any other device that can generate numbers randomly. This generates numbers for players to select randomly. The low frequency strategy involves players picking the numbers that occur less frequently in the previous games to play in the subsequent ones while in the high frequency strategy, players pick the numbers that occurs often in the history of the game to play in the subsequent ones.

2 Methodology

In this study, we are interested in answering the following research questions:

1. Does the selection of numbers in Oyo State lottery occur with equal probability?
2. Do the Oyo State lottery winning numbers occur with equal probability?
3. Is the performance of a strategy associated with the amount of historical information considered?
4. Is there a game strategy that outperforms others in the history of the game?

Specifically, the hypotheses for testing are:

H_1: Each number is equally selected by the public,
H_2: The winning numbers occur with equal probability,
H_3: There is no performance difference in the strategies with small amount of historical information,
H_4: There is no performance difference in the strategies with large amount of historical information.
H_5: There is no difference in the performance of the three strategies with full historical information.

2.1 Simulation of Lottery Strategies

The data used for this research work consisted of the year 2011 lottery winning numbers of the Daily draw type of game as collected from the Oyo State Lottery Commission. The data was used to simulate the random, low frequency and high frequency game strategies. The details of the simulation procedure are presented in Appendix A. The effectiveness of each of the lottery strategies was analyzed by comparing the lottery winning numbers, also referred to as historical data, to data simulated using each of the strategies. For this study, the performance of a strategy was gauged by the average number of matches to the winning numbers chosen in a month. The higher the number of matches, the more effective the strategy used by the player [5].

2.2 Hypothesis Testing

Statistical tests were conducted on the simulation results. To test hypothesis H_1, i.e. whether some numbers are more popularly selected than others in the Oyo State Lottery, a runs test was performed at 5% level of significance on a total of 4785 numbers selected in the game of a typical day of June, 2011 (see [24]). For hypothesis H_2, a chi-square goodness of fit test was conducted at 5% level of significance to test whether the winning numbers occur with equal probability. Adjustment for sampling without replacement was made following [24,25]. To test hypotheses H_3 and H_4, i.e. whether small and large amount of historical information had any effect on the strategy performance, the data set was divided into two groups [5]: small and large amount of historical information and a one-way ANOVA test was conducted to check for differences in performance among the three strategies. Furthermore, to test hypothesis H_5, a one-way analysis of variance (ANOVA) test at 5% level of significance was conducted to compare the average performance of the three simulated strategies. Where a significant difference in the performance of the strategies existed, a multiple comparison test (Least Significant Difference Test) was conducted to ascertain which one was significantly different from the other. The ANOVA tests were based on [5].

3 Results and Discussion

In this section, the results of the simulation studies on the lottery strategies are presented and discussed. A discussion of the results on the testing of the different formulated hypotheses is also presented.

3.1 Result of Simulation Studies

From the simulation studies, the random strategy had 28.7% of the total number of matches; the low frequency strategy had 41.2% while the high frequency strategy had 30.1% of the total number of matches. Thus, the low frequency strategy had the highest number of matches from the simulated results.

3.2 Hypothesis H_1

Fig. 1 shows the frequency of selection of each number between 1 and 79 by the public on a typical day, June 21, 2011. It shows that Oyo State lottery numbers do not have equal probability of being selected by the public. Also from Table 4, $|Z|>Z_{1-\alpha/2}$ implies significance at the 5% level and this leads to a decision to reject the hypothesis that each number is equally likely to be selected. This implies that players prefer some numbers over others based on specially selected strategies. Thus lottery numbers selected by players are not chosen at random.

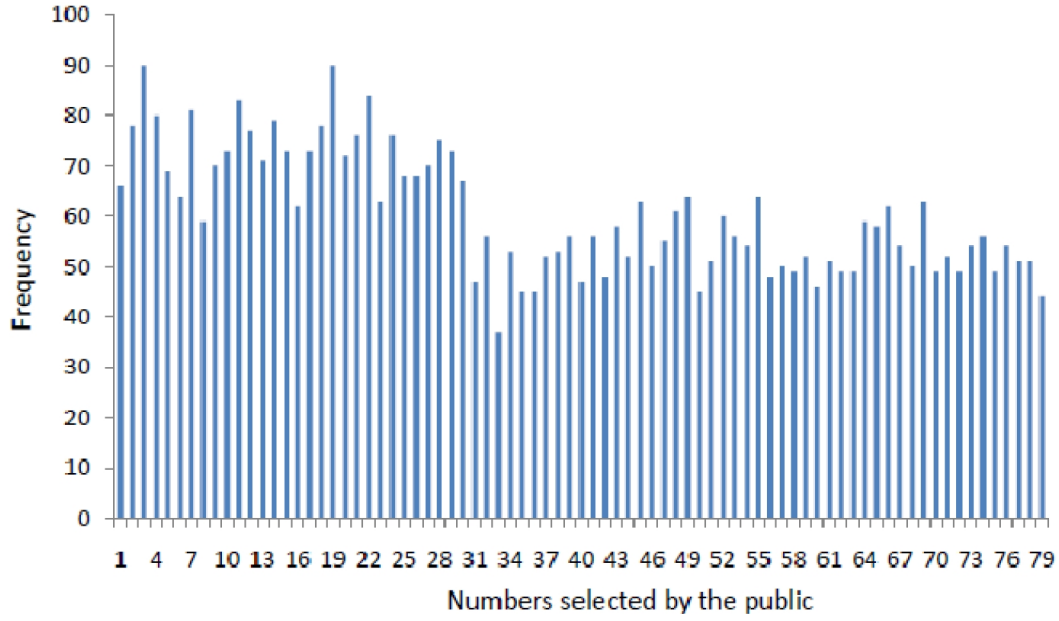

Fig. 1. The number of times that each number was selected by the public on a typical day

Table 4. Results of runs test on numbers selected by the public

N(var1 > 34)	**2384**
Number of observations	4785
Number of runs	1668
Z	-20.98
$Z_{1-\alpha/2}$	1.96

3.3 Hypothesis H_2

The result of the Chi-square test on lottery winning numbers is displayed in Table 5. Since the *P*-values are greater than the significance level of α=.05 in all the cases, the hypothesis that the winning numbers occur with equal probability in all the months is accepted. This implies that the winning lottery numbers appear to be distributed equally in their range. Therefore, one can reasonably believe that the process that the Oyo State Lottery commission is using in generating winning numbers is not biased.

Table 5. Results of chi-square test on the lottery winning numbers

Month	χ^2 Statistic	P-value
January	40.467	.95
February	28.267	.99
March	54.089	.85
April	30.527	.99
May	23.900	.99
June	39.048	.94
July	18.933	.99
August	40.000	.99
September	32.462	.99
October	57.941	.55
November	50.277	.84
December	30.467	.99

3.4 Hypothesis H_3

The results of the one-way ANOVA test to determine if there is a difference in performance in the three lottery game strategies when only a small amount of historical information is used are shown in Table 6. Since *P*=.06 is greater than α=.05, we accept H_3 and conclude that there is no performance difference in the three strategies with small amount of historical information.

Table 6. ANOVA test on all three strategies using small amount of information

	Sum of Squares	Df	Mean Squares	F	Sig.
Between groups	.072	2	.036	3.704	.06
Within groups	.117	12	.010		
Total	.190	14			

3.5 Hypothesis H_4

For the case when a large amount of historical data was used, the results of the one-way ANOVA test conducted are shown in Table 7. Since P=.20 is greater than α=.05, the hypothesis H_4 is accepted and it is concluded that there is no performance difference in the three strategies with large amount of historical information.

Table 7. ANOVA test on all three strategies using large amount of information

	Sum of Squares	Df	Mean Squares	F	Sig.
Between groups	.033	2	.016	1.793	.200
Within groups	.137	15	.009		
Total	.170	17			

Therefore, the introduction of small and large amount of historical information component for the ANOVA tests revealed that no strategy is better than others.

3.6 Hypothesis H_5

Using full historical information, results of the one-way ANOVA test to determine whether there is difference in the performance of the three strategies are shown in Tables 8 and 9. Since P=.013 which is less than .05 (in Table 9), the hypothesis H_5 is rejected and it is concluded that there is significant difference in the performance of the three strategies. This implies that the use of any of the three strategies will yield different results in terms of the numbers of matches with the winning numbers.

Since there is significant difference in the performance of the strategies, a multiple comparison (Least Significant Difference) test was carried out to know the pair of the game strategies that are different from each other. The result of this test is shown in Table 10 and it reveals that the random and low frequency, low and high frequency strategies are significantly different from each other at 5% level of significance. Thus, the low frequency strategy's performance is better than the performance of the other two strategies.

Table 8. Descriptive statistics of lottery strategies

	N	Mean	Standard deviation	Standard Error	95% confidence interval for mean		Minimum	Maximum
Random Strategy	11	0.2336	0.07474	0.02253	0.1834	0.2838	0.14	0.38
Low frequency strategy	11	0.3409	0.09449	0.02849	0.2774	0.4044	0.19	0.50
High frequency strategy	11	0.2236	0.11483	0.03462	0.1465	0.3008	0.02	0.39
Total	33	0.2661	0.10753	0.01872	0.2279	0.3042	0.02	0.50

Table 9. ANOVA table for the strategies

	Sum of squares	Df	Mean squares	F	Sig.
Between groups	0.093	2	0.046	5.035	.013
Within groups	0.277	30	0.009		
Total	0.370	32			

Table 10. Multiple comparisons (Least Significant Difference) test

(I) VAR00001	(J) VAR00002	Mean difference (I-J)	Standard error	Sig.	95% confidence interval	
Random Strategy	Low frequency strategy	-.10727(*)	.04097	.014	-.1910	-.0236
	High frequency strategy	.01000	.04097	.809	-.0737	.0937
Low Frequency Strategy	Random Strategy	.10727(*)	.04097	.014	.0236	.1910
	High frequency Strategy	.11727(*)	.04097	.008	.0336	.2010
High Frequency Strategy	Random Strategy	-.01000	.04097	.809	-.0937	.0737
	Low Frequency Strategy	-.11727(*)	.04097	.008	-.2010	-.0336

**Starred values indicate pairs of means that are significantly different*

4. Conclusion

From the results, the following conclusions can be drawn:

a. Players do not select lottery numbers randomly, but rather based on conscious selection.
b. Oyo State lottery winning numbers are selected with equal probability. Thus, we can say that the process that the Oyo State Lottery Commission is using in generating winning numbers is not biased.
c. From the simulation results, the low frequency strategy has the highest number of matches among the three strategies considered.
d. The introduction of small and large amount of historical information component into the ANOVA tests revealed that no strategy is better than others among the three strategies considered.
e. Using full historical information, however, it was discovered that the three strategies were significantly different from one another at 5%. Further tests revealed that random and low frequency, low and high frequency strategies are significantly different from each other at 5% level of significance. Thus, for this study, the low frequency strategy performed better than the other two strategies.

Competing Interests

Authors have declared that no competing interests exist.

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APPENDIX

A: Simulation Procedure for the Three Lottery Strategies

A. Random Strategy

To simulate the random strategy, random numbers, equivalent to the numbers in each month, are generated from R package. The random numbers are compared to the lottery winning numbers data one on one and the numbers of matches to the winning numbers are recorded for each month. The average numbers of matches are obtained. These are shown in Table A.1.

Table A.1. Random strategy

Month	No of matches	Average
February	5	0.21
March	5	0.19
April	3	0.14
May	3	0.15
June	5	0.24
July	3	0.17
August	7	0.27
September	10	0.38
October	8	0.30
November	8	0.31
December	5	0.21

B. Low Frequency Strategy

To simulate the low frequency strategy, we find the number of matches of the five least frequent numbers of a month in the next month. The average numbers of matches are obtained. These are shown in Tables A.2 and A.3.

Table A.2. Least and most frequent numbers in a month

Month	Least frequent numbers	Most frequent numbers
January	3,7,9,11,12	2,21,39,67,72
February	2,4,6,10,11	28,34,41,66,79
March	1,2,3,6,7	73,74,76,78,79
April	8,9,10,12,13	74,76,77,78,79
May	33,34,35,36,37	71,74,75,78,79
June	18,19,21,22,23	67,69,76,77,79
July	5,13,15,28,39	70,71,73,75,77
August	4,9,16,20,25	71,73,74,75,76
September	8,13.17,24,27	75,76,77,78,79
October	1,10,18,19,23	70,74,75,76,78
November	6,13,19,26,30	71,73,75,76,77
December	4,8,16,25,33	72,73,75,78,79

C. High Frequency Strategy

To simulate the high frequency strategy, we find the number of matches of the five most frequent numbers of a month in the next month. The average numbers of matches are obtained. These are shown in Tables A.2 and A.3.

Table A.3. Number of matches for low frequency and high frequency strategies

Month	Low frequency strategy		High frequency strategy	
	No of matches	Average	No of matches	Average
February	11	0.44	4	0.16
March	5	0.19	9	0.33
April	9	0.41	8	0.02
May	7	0.35	7	0.35
June	7	0.33	4	0.19
July	5	0.28	7	0.39
August	10	0.38	7	0.27
September	7	0.27	6	0.23
October	6	0.22	3	0.11
November	10	0.38	3	0.12
December	12	0.50	7	0.29

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