Is the Mega Millions Lottery Ever a Good Bet?

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The Mega Millions lottery is played in 45 states, the US Virgin Islands, and Washington, DC. According to the new rules, which began April 5, 2025, the jackpot prize is always at least $50 million. Despite various popular lottery "strategies" like using lucky numbers, birthdays, anniversaries, astrology, numbers that are "hot," numbers that are "cold," numbers that are "due," and so on, there is no skill in picking winning lottery tickets. Lottery winners are lucky. You can't have a winning strategy predicting something that's unpredictable. Since the chance that a Mega Millions lottery ticket wins the jackpot is always the same, and since jackpots grow when there are no winners and the prize pool rolls over to the next drawing, occasionally the jackpot prize may get large enough that buying a ticket might be a good bet. If that's the case, how much you should bet?

It costs five dollars to buy a Mega Millions ticket. You pick five numbers from 1–70 and a "Mega-number" from 1–24. At the lottery drawing, five winning numbers are randomly selected from the numbers 1–70 along with one winning Mega-number from 1–24. If all five of your selected numbers along with your Mega-number match the winning numbers, you win the jackpot. If nobody wins the jackpot, the prize money is rolled over to the next drawing. This continues until somebody wins the jackpot. The chance of winning the jackpot equals one in 290,472,336. As of this writing, the largest Mega Millions jackpot was \$1.602 billion, won on August 8, 2023, by a single ticket purchased in Neptune Beach, Florida.

Analogies

It's hard to put small probabilities in perspective. Analogies help. If you buy fifty Mega Millions tickets per week, you will win the jackpot on an average of once every 112,000 years. If you drive a mile whenever you buy a ticket, you will drive an average of 608 round trips to the moon until you win the jackpot. Suppose you have one friend in Canada and select someone at random from the entire population of Canada (40 million) and then buy a lottery ticket. You're seven times more likely to choose your friend than win the jackpot.

Opportunity

If the chance of winning the jackpot is so low, why are there winners? The reason is the opportunity afforded by the sales of millions of tickets. You, in particular, may not win the jackpot, but with enough tickets sold, there is a good chance that someone will win. Given enough opportunity, unlikely events happen due to chance. Luck is a group activity. For every lucky jackpot winner, there is an average of about 290 million unlucky losers. In this case, "opportunity" means many tickets being bought for a Mega Millions drawing; however, this is true for rare events in general. For example, suppose you see your long-lost cousin in a café. Amazing! Weird! But lots of people go to cafes and have the opportunity to see their long-lost cousins, with few, if any, winners. You just happen to be the lucky one.

What's important isn't the chance that you win but the chance that someone wins. The chance that a particular ticket is a jackpot winner is always the same, but the chance that some ticket wins increases as the number of tickets purchased for a drawing increases. For example, suppose 20 million different tickets are purchased for each drawing. Then the probability that a particular ticket wins equals one in 290,472,336, the same as always. However, the chance that someone wins equals

$$20{,}000{,}000 / 290{,}472{,}336 = 0.07$$

In 10 Mega Millions drawings, each with 20 million tickets sold, $P(\text{someone wins}) = 0.51$. That's why there are winners.

Law of Large Numbers

The law of large numbers was introduced by the Italian mathematician Gerolamo Cardano in the 16th century when he observed that the accuracy of averages seems to improve with the number of trials. The proof was later given by Jacob Bernoulli in 1713, who restricted his result to "Bernoulli trials," which are independent trials with just two outcomes, "0 or 1," "heads or tails," "win or lose," "yin or yang," etc. A century later, the French mathematician Siméon Poisson generalized the result, and later the results were further generalized.

The basic idea is that in a large number of independent trials of an experiment like coin tossing or making bets in a casino (or elsewhere), the fraction of times an event occurs gets close to its probability. For example, if you toss a coin repeatedly, the fraction of heads, or tails, will eventually get arbitrarily close to 0.5. The Mega Millions analogies given earlier are based on the law of large numbers.

Expected Value

In the casino game craps, you can bet that "7" is the next outcome of the roll of a pair of dice. The chance of winning equals 1/6 (six ways to get a 7 out of 36 combinations, 1–6, 6–1, 2–5, 5–2, 3–4, 4–3) . The payoff odds are 4 to 1, so if you bet \$5 and win, you get \$20 in profit. On any given roll of the dice, you either win or lose this bet, most likely losing. The law of large numbers describes what happens in the long run: You win \$4 per dollar bet about 1/6 of the time and lose your bet about 5/6 of the time, with "about" converging to the actual probabilities. This means that your average, long run winnings per dollar bet, called "expected value," or "EV," equal $\$4 \times (1/6) - \$1 \times (5/6) = -\$.17$. You lose an average of 17 cents per dollar bet. EV can be computed whenever you know the probabilities of winning and losing, the payoff odds, and when you could make the same bet (or ticket purchase) repeatedly and independently a large number of times.

Positive EV is necessary, but not sufficient, for a long run profit. For example, suppose you're using loaded dice when you bet on 7 in craps and Prob(7) = 1/4 instead of 1/6. Then,

$$EV = \$4 \times (1/4) - \$1 \times (3/4) = \$.25$$

In the long run, using your loaded dice, you will win an average of 25 cents per dollar bet. But this is only true if you don't go broke along the way. For example, suppose you bet all your money each time you bet. Even though you have positive EV, the chance equals 3/4 that you will lose a particular bet and go broke. If you get lucky and win and keep betting everything, you are guaranteed to go broke before the "long run," even though the bet has positive EV.

I'm not recommending that you go to a casino and play with loaded

Table 1—EV for Various Mega Millions Jackpots

Jackpot	EV
$500,000,000	-3.278665666
$1,000,000,000	-1.557331349
$1,500,000,000	0.164002967

dice in order to get a positive EV situation. There are fates worse than going broke. Let's look at another game. Blackjack ("21") is a casino game in which card counting strategies can give a dedicated player positive EV in some situations. Winning strategies were the result of computer simulations and popularized in mathematician Edward O. Thorp's book *Beat the Dealer*, published in 1962 and still in print. The same problem applies. Without a money management system, reckless betting can cause a player to go broke, even with positive EV.

If you use a winning blackjack strategy, you will have roughly a 2 percent EV with certain configurations of the deck (EV = 2 percent = 2 cents per dollar bet long run profit, provided that you have money to keep betting). There are some configurations of the deck that favor the casino and some that favor the player, so a skilled blackjack player must be patient and prepare to play for long periods, keeping track of the cards, waiting for positive configurations, and betting accordingly.

The Kelly Criterion

In order to make a profit from a game with positive EV, you must either get lucky or have enough money to reach the smart gambler's Shangri-La, the "long run." Even if you're playing a game with positive EV, you must be careful how you bet. Generally, you should use a "fixed fraction" betting strategy of the type first developed by J.L. Kelly, a mathematician who worked for Bell Labs in the 1950s.

The Kelly criterion, as it's popularly known, optimizes the rate of growth of the player's bankroll for games with positive EV. Fixed fraction betting means you always bet a fixed fraction of the amount you have available for betting. The more you have, the more you bet. The less you have, the less you bet. This is the opposite of strategies like the double-down strategy, where you bet more when you lose to cover your losses—always a bad idea.

For win–lose games, where you either win or lose each time you bet, and where you know the probabilities of winning, p, and losing, q, with payoff odds, b to 1, the Kelly criterion says to always bet this fraction of your bankroll:

$$f = p - q / b$$

If EV is less than or equal to 0, you shouldn't bet. If the payoff odds are 1–1, as they usually are in blackjack, and, say, your chance of winning equals 51 percent, you should bet two percent of your bankroll. If you have $1,000, bet $20. If you have $2,000, bet $40, and so on. Some stock market investors use variations of the Kelly criterion, but the stock market is more complicated than casino games. For example, it's difficult to estimate the probability of "winning" an investment. And investments aren't necessarily win–lose games.

How Much Should You Bet?

The Mega Millions lottery jackpot would be a win–lose game (you either win the jackpot or not) if it weren't for the possibility of having to split the jackpot if you win and someone else also wins. To apply the Kelly criterion for win–lose games, suppose you don't split the jackpot if you win and someone else also wins. (We're not considering the other Mega Millions prizes.) This provides an upper bound on the amount you should bet, since splitting the pot brings down your EV. The probabilities of winning and losing this game are always the same. Table 1 shows EV for various jackpots.

EV is negative until the jackpot gets to almost $1.5 billion and thereafter (the break-even point is about $1.45 billion). For a win–lose game like this, the Kelly fraction of your bankroll to spend in the modified game, which maximizes the long-term expected growth rate of your bankroll, is to bet the fraction

$$f = p - q / b$$

where p = probability you win, q = $1-p$ = probability you lose, and b = payoff odds per dollar bet. If EV is negative, don't bet. If the jackpot is $1.5 billion, since a ticket costs $5, your payoff odds equal b = 1.5 billion / 5 = 300,000,000 to 1. If EV is positive, the fraction of your bankroll that you bet depends on the jackpot size, among other things. Suppose the jackpot is $1.5 billion (it has reached

Table 2—Minimum Bankroll to Use Kelly for Mega Millions with Jackpot Equaling $1.5 Billion

Number of Tickets	Kelly Fraction	Minimum Bankroll
1	0.0000000001	$45,730,879,917
10	0.0000000011	45,730,836,718
100	0.0000000109	45,730,404,741
145,000,000	0.2571273119	2,819,614,901
200,000,000	0.4808895444	2,079,479,605
290,472,336	1.0000000000	1,452,361,680

that amount twice in Mega Millions history). Then the Kelly fraction, f, of your bankroll that you should bet is approximately one in 9 billion. If you have $100 million to gamble, the Kelly criterion says to bet about one cent, which you can't do since a ticket costs $5. In other words, even though EV is positive, and even if you have $100 million to wager, the Kelly criterion essentially says not to bet. In fact, even if you have $1 billion to wager, the Kelly fraction indicates a bet of about 11 cents, less than the cost of a ticket. Since a ticket costs $5, and since Kelly says you bet about 1/9,000,000,000th of your bankroll, your bankroll must be about $5 × (9,000,000,000) = $45 billion in order to buy a ticket.

As the jackpot grows, EV gets larger, but the fraction of your bankroll to bet never exceeds your chance of winning. Since your chance of winning equals roughly one in 290 million (one in 290,472,336, to be precise), you would never bet a fraction of your bankroll more than that if you buy one ticket. When the chance of winning is low, Kelly is very conservative, even when the payoff odds are high. If you buy more than one ticket, your chance of winning increases, and the bankroll needed to buy multiple tickets gets smaller. It is important to note that as you buy multiple tickets, the chance of splitting the pot with someone gets larger. In this discussion, we are not considering splitting the pot and are assuming, for simplicity, that this is a win–lose game.

Buying Multiple Tickets

Suppose you buy 10 (different) tickets instead of one. You're 10 times more likely to win the jackpot than if you bought one ticket. On the other hand, you pay ten times as much as when you buy one ticket. Since the Kelly fraction equals $f = p - q / b$, the size of the bankroll needed to buy x tickets is a function of $1/f$, in the sense that

Minimum bankroll = $(1 / f) \times \$5 \times T$, where T = number of tickets you purchase

This number is large when the number of tickets purchased is small and gets relatively smaller and levels off when the number of tickets purchased gets large. If you buy 10 tickets, the Kelly fraction is about one in 915 million. To use the Kelly system and buy 10 tickets at a cost of $5 each, you need a bankroll of at least

915 million × $5 × 10 = $45.7 billion

About the same, using Kelly, as the $45 billion bankroll you need to buy one ticket. Suppose you buy 200 million tickets. The Kelly fraction is then about 0.48. It follows that to buy 200 million tickets, you need a bankroll of about $2.8 billion. Table 2 shows the bankroll you need to buy multiple tickets of varying numbers when the jackpot equals $1.5 billion. Notice that when you buy all the tickets, the Kelly fraction equals one, and the amount you need to buy all the tickets is just $5 times the number of ticket combinations, about $1.45 billion. As I mentioned earlier, things get more complicated if you have to split the pot if someone else also wins the jackpot. Our discussion is the "best case" scenario in which we ignore the possibility of splitting the pot.

Additionally, if you're buying millions of tickets, there is also the problem of how long it takes to fill out the ticket combinations. In Mega Millions, you can't make a single bet saying that you are buying all possible combinations, like you can at the racetrack. If you fill out three tickets per minute, 24 hours per day, 365 days per year, it will take you about 184 years to fill out all the ticket combinations.

Conclusion

Using the Kelly system, there's no point buying a Mega Millions ticket, even if the jackpot is $1.5 billion and you have positive EV. In fact, because of the low probability of winning, the Kelly system indicates you must have a fortune of more than $45 billion to buy one ticket. Even if you buy multiple tickets, when the probability of winning goes up, the Kelly system always indicates you must have billions to make the wager, and that's only if you don't consider the possibility of another winner splitting the pot, which increases as you buy more tickets (If you buy all possible ticket combinations, you're guaranteed to split the pot with someone.) Also, it's extremely difficult to actually purchase every possible ticket, since you (and your team) have to do it manually. 🅲

Final note: All this math is unnecessary if you have apophenia and buy lottery tickets based on numbers you saw in your oatmeal this morning.

Further Reading

MacLean, L.C., Thorp, E.O., Ziemba, W.T. (ed). 2011. *The Kelly capital growth investment criterion: theory and practice*. Hackensack, New Jersey: World Scientific Publishing.

Orkin, M. 2025. *The story of chance—beyond the margin of error*. Dubuque, Iowa: Innovative Ink.

About the Author

Michael Orkin is a professor, consultant, researcher, and author. His most recent book is *The Story of Chance—Beyond the Margin of Error*, published by Innovative Ink in 2025. He has appeared on numerous podcasts and TV shows and has been an invited speaker at many conferences. Orkin earned a BA in mathematics and a PhD in statistics from the University of California at Berkeley. He is currently a mathematics professor at Berkeley City College and professor of statistics emeritus at California State University, East Bay. Find more of his work at *drmikeorkin.com*.