MEGA MILLIONS: WHAT IS THE NEW NORMAL

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On October 18, 2013, matrix changes went into effect in the Mega Millions game that raised the top prize odds to about 1 in 259 million. At the same time, the annuity top prize was restructured in a graduated form, allowing a given value of current cash prize dollars to fund a larger advertised jackpot. At the time of these changes, the jackpot had survived five draws.

Seventeen draws later, the jackpot had grown to $636 million, only $4 million shy of the record value established in March 2012! The jackpot was won by two tickets in its 22nd draw. Is this the "new normal" for Mega Millions? How often should we expect to see jackpots like this, given the new matrix and annuity structure?

This sort of question is being asked around the executive suites of many US lotteries in the early winter of 2014. I don't have a definitive answer, but I can share some results from math modeling of the game that might be of interest. The kind of math model that is useful in this case is commonly called a "thousand-year model." A thousand-year model aims to reveal the expected long-term variability of outcomes from a lottery game. It has basically three parts:

1) an account of how sales typically increase from draw to draw in response to an increasing jackpot,

2) an account of how the likelihood of paying the top prize increases as sales in the draw increase, and

3) a process that simulates the random drawing and its outcome: paying the top prize, or not. The model steps through thousands of draws and records the history of each "run": how many successive draws without awarding the top prize, what total value of sales, what total value of prizes paid, and how much profit among the lotteries.

After a model like this has simulated a thousand years of play, we can tabulate the results and get an idea of the likelihood that we will see particular outcomes over the next few years, while we might hope to be managing the game.

This kind of model is particularly useful for projecting effects of changes in the game: not only structural changes to the game itself, but changes in how players respond to jackpots. There is considerable art in developing a good math description of how spending increases from one drawing to the next. The work I describe here is based on math that does a pretty good job of projecting how Mega Millions sales grow in response to jackpots up to $300 million. As of January 2014, there have only been 12 Mega Millions draws with jackpots larger than $300 million, in nine separate runs. Beyond $300 million, each real-world instance we have seen has been a little different, and my current math models are not as good as human intuition in that range. Accordingly, I focus here on how frequently we might expect Mega Millions jackpots to reach $300 million under the current rules.

Clearly, all this is driven by how players respond to developing jackpots.

In the March 2012, the jackpot reached $290 million in draw 17. In December 2013, the jackpot reached $297 million in draw 19, despite having the benefit of a more favorable annuity factor after the first five draws. Adverse weather may have been a factor. However, a math model that does a good job accounting for sales between February 2012 (when Powerball raised its price to $2) and April 2013 (when California joined Powerball) does predict sales consistently higher than we actually saw in the latter part of 2013. Since I am using this same model in the work I report here, I take the precaution of reducing its sales projections by 15%. This brings the projected sales into line with what we experienced in late 2013.

So, with these key assumptions:

- top prize odds 1 in 259 million,
- annuity factor 1.80, and
- sales-for-jackpot about 85% of what we saw in the base period (Feb 2012 to April 2013),

my thousand-year model projects that:

- half of jackpots will be won in draw 10 or later,
- an “average” year might have 10 jackpots, and
- an “average” year might have one or two jackpots over $300 million.

The concept of an “average” year deserves caution. A year is not a long time for a game like Mega Millions. If an “average” year has one or two jackpots over $300 million, this does not mean that a year with none, or with three, is terribly unlikely.

It is precisely this year-to-year variability that thousand-year models help us appreciate. The distribution of jackpots over $300 million across years suggests the following likelihoods:

Number of jackpots >= $300 million in year	Probability
0	17%
1	41%
2	29%
3	11%
More than 3	2%

Another way of thinking about this is in terms of sales dollars. Using my (admittedly imprecise) estimates of sales that come in for all jackpots, including those that grow above $300 million, I estimate that average annual sales of Mega Millions (base game only) might be about $2.9 billion. Year-to-year variability is such that the total would be between $2.3 billion and $3.5 billion about two-thirds of the time.

That’s a pretty broad “normal range”- plus or minus 20%. Yet that is the sort of thing we must deal with in projecting annual performance of our lotteries. We are fortunate to have two big, volatile games rather than just one - the joint variability of two independent games is less than that of either alone.

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