Is *Deal or No Deal* Cheating Its Contestants?

Daniel R. Shifflet, Bowling Green State University

As fans of fair contests, we are lead to believe that game shows proceed with mathematical consistency. However, a slight anomaly in this basic assumption can be found while watching the game play of Deal or No Deal. *During certain situations it seems like the show is cheating its contestants. Could any mathematician let this question go without further analysis? Of course not! So began an investigation into our hypothesis. Using simple statistical notions like expected value and linear regression, we show how to isolate this mathematical irregularity and provide some evidence of its existence. What does this mean? Is foul play afoot? Read on to find out.*

Introduction

In December 2005 a new prime time game show debuted on TV. Titled *Deal or No Deal*, the contest with mathematical implications soon piqued my interests. After a few viewings, I noticed a fairly dependable pattern in the game play. However, I soon witnessed an episode that seemed to deviate greatly from this path. How could a contest with thousands of dollars at stake, rooted in a gambling scenario, be allowed to proceed if it lacked mathematical consistency? In a sense, it seemed that the show was "cheating" its contestants. Eventually my intrigue got the better of me and I decided to test my preliminary observations. What follows are the results.

Game play and Hypothesis

First of all, I need to set up the format of the game. For my data set I analyzed the syndicated 30-minute version of the original show. In short, *Deal or No Deal* offers the opportunity for contestants to win up to $500,000. Before the actual show begins, each of 22 briefcases is randomly assigned a unique amount of money ranging from $0.01 to $500,000 by a third party organization (otherwise uninvolved in the game play). Then, with the cameras rolling, the contestant chooses one of the 22 cases but is not allowed to open it. The amount within will be his prize should he refuse all offers by the Banker to buy the case.

What follows next is a series of rounds where the contestant chooses to open a predetermined number of cases in play, revealing monetary amounts that are then taken out of play. At the end of each round, the Banker makes an offer to buy the contestant's case based (somehow) on the average of the values still known to be in play (the expected value of the game at that point). The contestant then chooses to take the deal or continue to the next round.

Under this format there are 7 possible rounds the contestant can play, with 7 offers he can accept or decline. Contestants can only make a deal after opening the specified number of cases. They cannot deal mid-round. If a contestant takes an offer, the game is officially over. If a contestant refuses all offers, he wins the money in the case. The monetary distributions and round formats are listed in Tables 1 and 2.

If the contestant makes a deal before round 7, the game is usually played out in the hypothetical. That is, they play out the remaining rounds, complete with offers, as if the game were not over. Table 3 lists a quick example of an actual game with five official bank offers and two hypothetical ones.

Table 1 Monetary Amounts

0.01	1	5	10	25	50	100	200	300	400	500
1000	2500	5000	7500	10000	25000	50000	75000	100000	250000	500000

Table 2 Round Formats

Round	1	2	3	4	5	6	7
# Cases to Open	5	5	4	2	2	1	1

Table 3 Deal or No Deal

Round	Cases Opened ($ Values Removed)	Expected Value (Ave. $ Remaining)	Offer for case ($)	Offer as a % of Expected Value	Result
1	1, 10, 2500, 50000, 100000	51,475	13,000	25.25	Denied
2	25, 50, 1000, 7500, 250000	51,375	15,000	29.20	Denied
3	5, 200, 400, 25000	73,863	28,000	37.91	Denied
4	10000, 500000	13,483	6,000	44.50	Denied
5	0.01, 500	20,100	13,000	64.68	Accepted
6	100	26,767	27,000	100.87	N/A
7	5000	37,650	39,000	103.59	N/A
Last Case	75000	N/A	N/A	N/A	N/A
Contestant's Case	300	N/A	N/A	N/A	N/A

I wanted to know which of two possible situations was occurring: Were my calculations wrong and the Banker was playing fair all along, or were my calculations correct and the banker was "fudging the numbers?"

It was in these hypothetical situations like rounds 6 and 7 from Table 3 that I noticed a discrepancy with the competition. During the rounds of games still in play, quick calculations showed the Banker offering contestants far below their expected value. In the hypothetical rounds, however, preliminary observations revealed the offers to be near, or even above, these similar expected values.

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Data and Testing

Over the course of three months I recorded the round by round results of 75 games. First, I split the data into the two situations to be tested; official offers to contestants still playing the game vs. hypothetical offers to contestants who had taken a deal at the end of the previous round or earlier.

Since contestants with large amounts of money in play would obviously get larger offers than contestants with only small amounts of money remaining (official or not), I could not simply compare the values of the offers by the banker. Instead, I had to consider these offers as a percent of the expected value (EV) of the game's outcome. This would give me a value independent of whether the contestant was having a "lucky day" or not. If the Banker is "playing fair," the means of these percentages should hold on a round by round basis across the official and hypothetical cases. Figure 1 illustrates

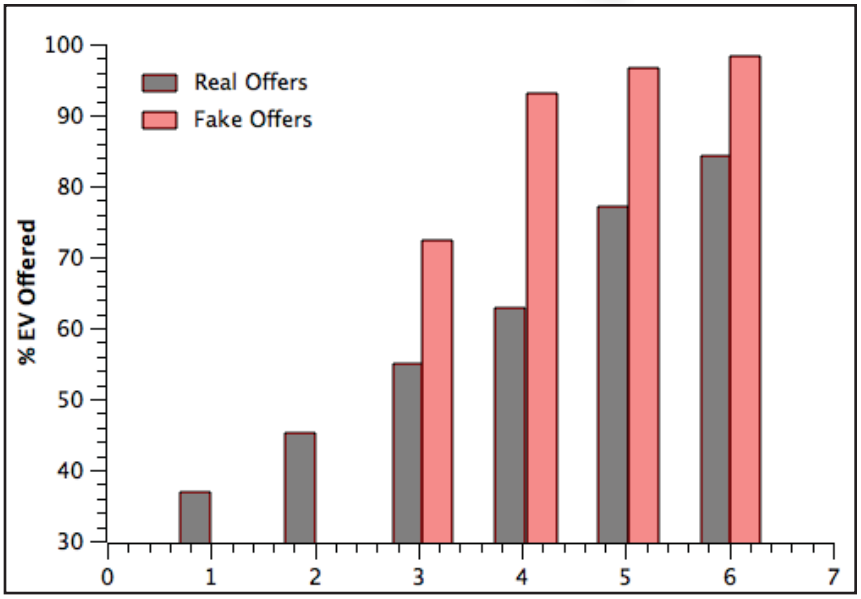

Fig 1 Average percent of the expected value (%EV) offered by round

these averages across this splitting.

Beginning at the end of round 4 (as no contestant took an offer before round 3), an obvious split in the mean offer is revealed. Considering round 6 in Figure 1, contestants still playing the game receive offers from the Banker that average about 76% of their expected value, while those contestants playing hypothetically are told the offer would have been close to 96% of that same expected value. This 20 percentage point difference seems to suggest the Banker does not follow the same set of rules for making offers when the game is still active versus when it is not. While providing exciting evidence in support of my conjecture, one test statistic is hardly proof. To get more substance behind my hypothesis, I had to dig deeper into the data.

While consulting the data more closely, I decided I could turn my focus to one particular round of the contest instead of the game as a whole. Round 5 seemed to hold the most potential, having the greatest discrepancy across the two situations, but there were not enough data points to draw sound conclusions. My set of recordings contributed only 18 examples of hypothetical offers at the end of this round. Generally, in a nod to the Law of Large Numbers, we like to have at least 30 data points before considering a test statistic meaningful. Luckily, the split in Round 6 meets this qualification. With 30 hypothetical offers and 37 actual offers (out of 75 recordings, where the remaining 8 games did not even bother playing out to round 6), I had my round chosen to investigate. To verify that the means computed earlier were not being skewed by a few extreme values, a box plot (Figure 2) seemed like the best place to begin.

Two observations can be made from Figure 2. First, I saw more evidence in support of my earlier calculations. Both the hypothetical and official offers are fairly well clustered around their averages. If anything, the mean of the fake offers may be an underestimate based on a few low values, one of which is an outlier. I will address this point later. The second consequence of this plot is that it urged me to move forward with one more test. In particular, could I consider all the data from this round and turn it into a predictive measurement of the Banker's offers?

A great tool to accomplish this feat is regression. Since intuition suggests the Banker's offers should increase linearly with the expected values of the contestants, I decided a linear model would be the place to

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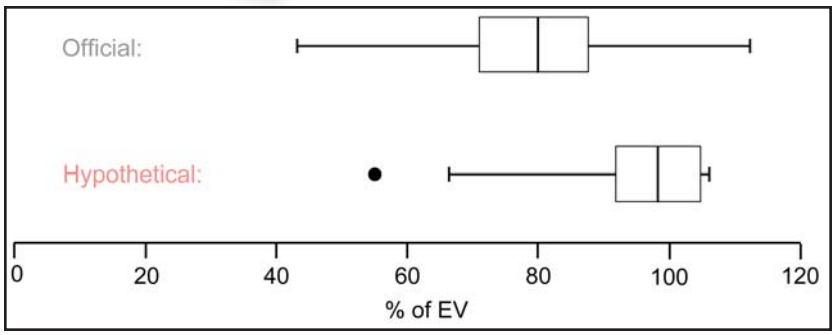

Fig 2 Box and whisker plot of percentage of expected value for round 6 offers

start. By graphing the expected value of the games along the *x*-axis against the corresponding Banker's offers along the *y*-axis, performing linear regression found the equation of the line that "best fits" the data. In this case, such a model would provide me with a more analytical measurement of how the Banker arrives at his offers. The results of round 6 can be seen in Figures 3 and 4.

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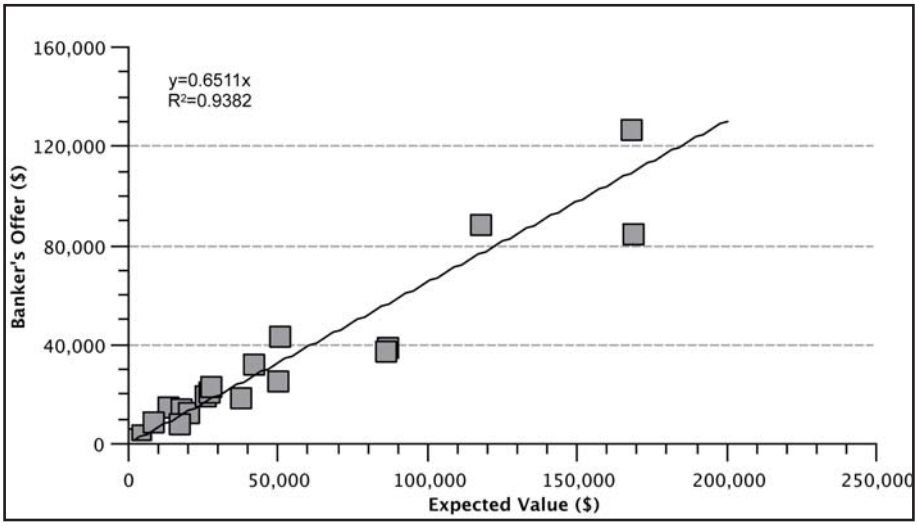

Fig 3 Round 6 official offers

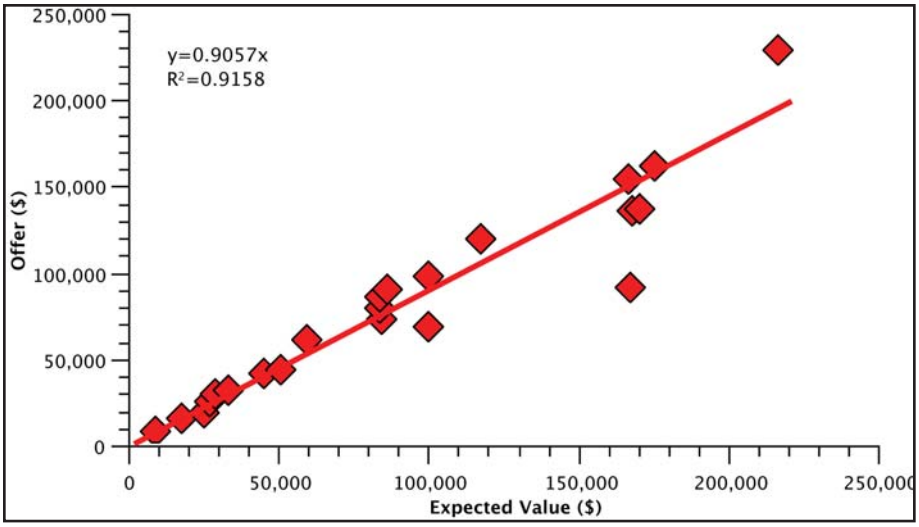

Fig 4 Round 6 predicted offers

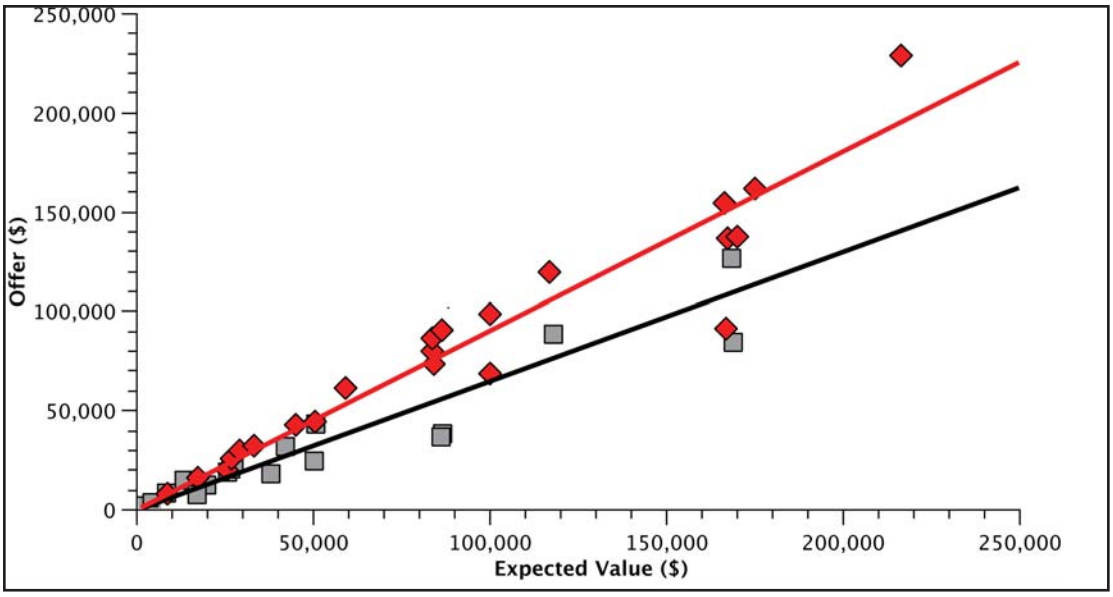

Fig 5 New model for hypothetical

For contestants still in the game in round 6 we get a linear model with a slope of .6511. This corresponds to a prediction that the Banker would make offers around 65.11% of expected value. With an R-Squared value near 0.94 (remember, the closer to 1.00 the better), I had a fair amount of confidence in this model.

For contestants only hypothetically playing the game in round 6 we see a predicted offer of 90.57% of expected value, a drastic increase from the earlier situation. However, I had a bit of concern with a drop in the R-Squared value to 0.916. Why did this happen?

Notice how one data point in Figure 4 (highlighted in black) is sitting a good distance below the trend line. Testing against twice the standard deviation of the data, I found this occurrence to be the same outlier identified earlier. What could have happened to cause this? Maybe the Banker miscalculated, maybe he had a personal vendetta against that particular contestant, or maybe he was trying to keep a little of the money for himself. I couldn't be sure.

In any event I had to decide what to do about the point. Now, removal of an outlier is still controversial in many mathematical circles, but I decided to proceed with this option in the interest of the investigation. Considering the adjusted data (with the outlier removed), the slope of the recalculated trend line becomes 0.9421, or a prediction of offers being above 94% expected value, with an R Squared value of 0.9595. This new model for hypothetical offers is displayed in Figure 5, along with the graph of official offers for comparison.

With this final picture the situation becomes fairly clear. How can the game have such drastically different trends across these two situations without a slight change in the rules?

Conclusions

Considering all this information, there is strong evidence the Banker breaks from his formula for computing deals (whatever it is) during the hypothetical rounds of the game. He seems to be offering more money than he would have if the contestants were still actually playing and able to accept the cash. What does this mean? Is the banker cheating these contestants with inflated offers? It's hard to say.

Since this discrepancy occurs after the game is officially over, the term "cheating"

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may not even apply. In fact, the show itself broadcasts the line "Portions of this program not affecting the outcome of the competition have been edited/recreated" while the final credits role. This may not be an admission of guilt, but it definitely implies the situation painted above could exist.

In the end, it only makes sense that the Banker would make larger offers after the game play is over, if only to increase the drama for those watching at home. Perhaps cheating is too strong of a word, but is it fair for the contestant to think they lost out on one amount of money when they really did not? Should it be changed? I'll leave that answer to the reader. Until then, at least, I know I will be taking all hypothetical offers with a grain of salt.

References

St. John, S. (Producer). (2005). Deal or no deal [Television series]. Hollywood, CA: National Broadcasting Company (NBC).

DAN SHIFFLET, drshiff@bgsu.edu, is currently pursuing his Ph.D. in Mathematics at Bowling Green State University. His major areas of interest are algebra and pop-culture connections to the classroom. A lifetime Ohio student of the subject, Dan enjoys teaching, discussing, and telling corny jokes about math.