Banker's strategy in the television show "Deal or No Deal"

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Deal or No Deal is a television game show originally introduced in 2000 in the Netherlands. The main element of the game is a regionally varying number of cases or boxes, each of which contains a card representing certain value of money. At the beginning of the game, a player chooses one case to keep until the end of the game, while its value remains unknown. Then, a number of cases is opened in each round, changing the average of values, which may be contained in the player's case(Channel4, 2016b). Finally, at the end of each round, an analyst called banker offers an amount of money in exchange for the case in possession of the player in order to render continuing the game an unfavorable bet, and hence end the game with as low winnings as possible.

The player has an option to accept the offer or undertake additional round of the game. This decision is made through a more or less subconscious thought process based on their perceived utility of the offered income compared to the utility of playing the next round. Being aware of this, the banker applies a strategy, which is based on the theory of expected value and an assumption that the player is risk-averse. Its main objective is to offer the lowest amount of money with a level of utility higher than the expected value(Brand, 2016).

This concept can be graphically expressed as shown in figure 1. The graphs show two different offers, both made at expected income of GBP 100,000 considering one hypothetical utility function $U(I)$. The point $I_E$represents the combination of the uncertain expected income and its respective utility. $I_O$is a combination of the offered prize and its utility. Point $I_\Omega$represents an offer, at which the player is indifferent between taking the offer and playing on, as $U(I_E) = U(I_\Omega)$. Whether or not the player will take the offer depends on the value ΔU, here defined as $\Delta U = U(I_\Omega) - U(I_O)$. In the image on the left, the offer made is GBP 25,000, and will be rejected, because the utility from continuing the game is higher than the utility from taking the offer, i.e. $\Delta U > 0$. The case shown on the right will result in deal, because $\Delta U < 0$.

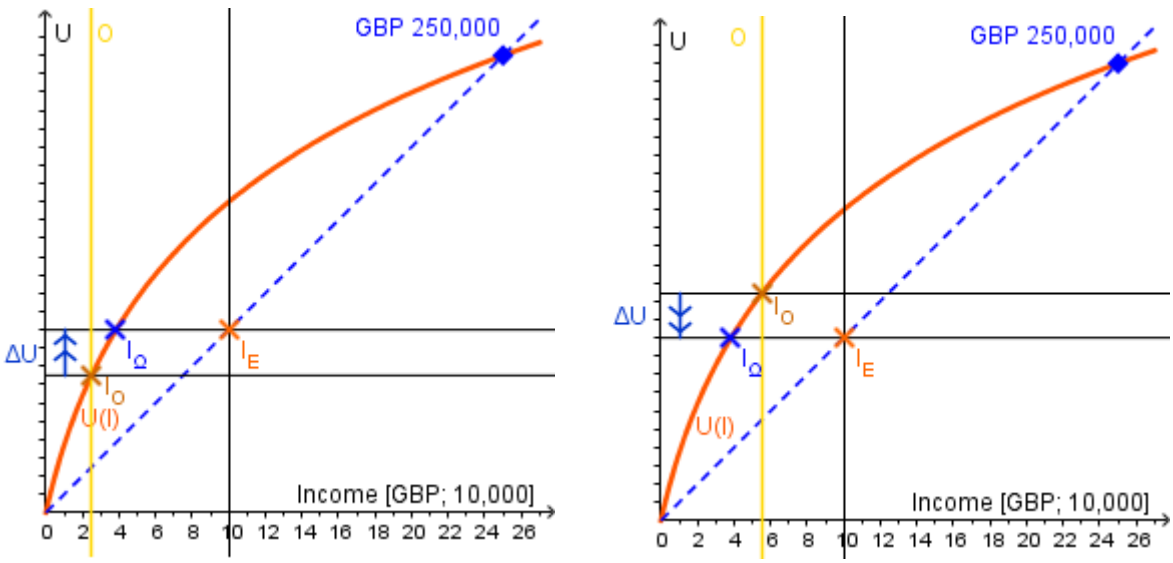

Figure 1: Example situations of the game at the point of an offer (NoDeal; Deal)

As simple as it sounds, the issue with this mathematical approach is that the utility functions differ among individuals and over time, which makes it very hard to determine or even aproximate its shape for a player without detailed background information. The British version of the show attempts to overcome this obstacle by making the contestants spend few days under supervision in a hotel with other potential players. Although this implies additional costs, it provides the banker with some relevant information and eventually decreases the expenses on winnings.

By observing multiple episodes of the British game show, it becomes clear that strategy based on the presented concept is really applied(YouTube, 2013).

Firstly, there is a relatively close statistical relationship between the expected income and a prize offered, which persists across games. As seen in figure 2, which is based on examination of 8 game shows aired throughout the spring 2008, the offered prize is always lower than the expected income. Moreover, there is a correlation coefficient of .79, which suggests that the banker always follows the

same rules, only adjusting them based on the available background information.

Figure 2: Relationship between expected income and offered prize

Secondly, there is a parallel among the games, where the proportion of the offer on the expected income grows with expected income. This is caused by the diminishing marginal utility, forcing the banker to compensate for the ratio between the values of income in points $I_\Omega$and I_E, which increases with growing expected income. However, because the previous offer was rejected, the banker needs to further increase the offer in order to reach a point for which the utility is higher than for the expected offer.

In order to relate this to the real game shows, figure 3 and figure 4 each show two charts per contestant.

Figure 3: Analysis of a May 2008 game - Richard

First of the players chosen for analysis is Richard. At the time of the show, he worked as a cleaner, was married, and wished to arrange a holiday for his winnings. Given this information, the banker knew that Richard's life-changing income was going to be lower than for many other contestants, for which reason he was expected him to be highly rish-averse.

After the first round, with 5 first cases removed from the game, the expected income was at GBP

32,000, which can be considered a good round, as compared to the average value of all cases is about GBP 25,712. The offer made was GBP 10,000, which is less than a third of the expected value.

After next three cases open, the expected income increased to GBP 38,490, while the amount offered grew to GBP 17,000. The contestant already had to think hard about continuing to play the game, which showed that the previous offer was very close to the point of indifference.

Finally, the third round, in which Richard opened 3 low values, raised the ecpected income to GBP 48,918. At this point, the banker was aware, that it was not going to be necessary to increase the offer by as much as on the previous occasion, even though the rise in the expected income was substantially higher. Richard accepted the offer of GBP 22,500.

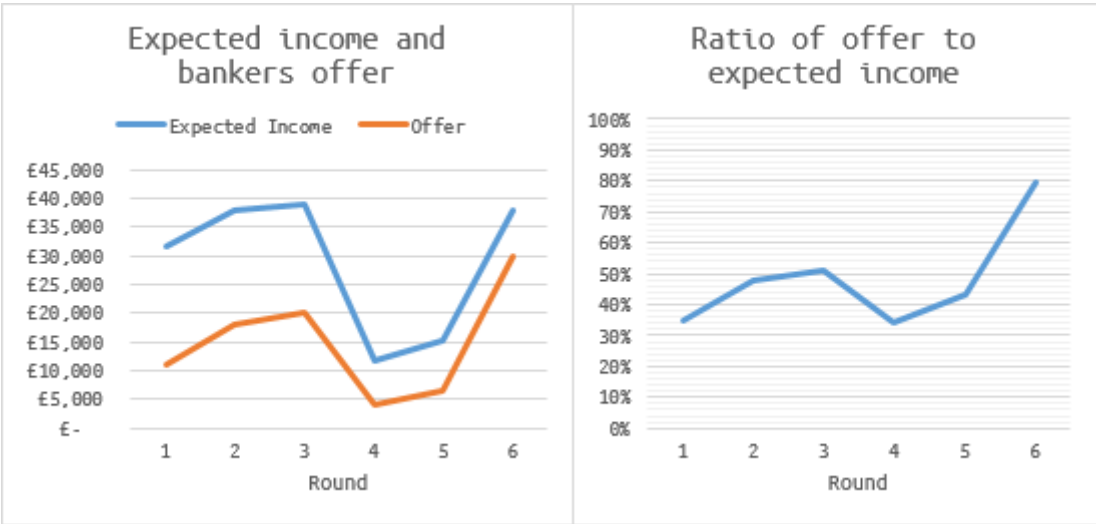

Figure 4: Analysis of a May 2008 game - Mark

In contrast to Richard, Mark, who is a sign language teacher with a hearing disability, proved to be less risk averse, and proved willingness to play the game until an offer relatively higher in proportion to the expected income was made.

Over the course of the first three rounds, Mark managed to increase his expected income up to GBP 38,978. The banker applied his typical strategy and offered Mark GBP 20,000 at the end of round 3. Because of his more risk taking attitude, Mark declined this offer and continued in round four.

First good opportunity for the banker to be less generous with the offer was at the end of round four, where the expected income decreased to GBP 11,719 through opening of 3 out of 5 highest values. However, this only encouraged Mark to continue playing.

In rounds 5 and 6, he opened the rest of the suitcases with one exception. The last two values left in the game at that point were GBP 500 and GBP 75,000, which means that the expected income raised back above GBP 37,000. Because the banker needed to make favorable offer in order not to risk losing the GBP 75,000, he increased the offer to 79%, which proved to be effective.

In result, after observing each game carefully, it is possible to establish that Marks utility function is flatter and less concave compared to the one of Richard. Although based on the data from each game, it may be possible to outline intervals in order to observe its potential shape, the utility

In conclusion, it was shown that the banker is able to make offers lower than the current expected value, thanks to the risk-averse nature of the contestants, which leads to the fact that certain income lower than an uncertain expected income may have higher utility. Depending on the degree of risk aversion in contestants, the banker attempts to approach an offer favorable for the contestant in order to prevent excessive expenses on prizes.

Word count: 1200

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Images generated using Microsoft Office Excel and Geogebra.