The weakest link

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THE WEAKEST LINK

A field experiment in rational decision making[1]

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Abstract
We analyze the BBC TV game show "The Weakest Link", using data from 77 episodes, covering 13,380 questions. We focus on the banking decision, where a contestant chooses to secure an amount of money for the eventual winner, or to risk it on a general knowledge question. In the latter case, should he answer correctly, the amount at stake increases exponentially. We show that banking decisions are not rational: a crude rule of thumb performs substantially better than the contestants' strategies. Yet, at least to some extent, contestants do take into account their own ability and the fact that questions are progressively more difficult.

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1. Introduction

A widely discussed question in economics is whether real-life economic agents really are rational, in the sense that they maximize some objective function within the limits imposed by given conditions and constraints placed upon them by their environment (see e.g. Simon, 1964). Even more importantly, if agents do not behave like this, then in what ways does their behavior deviate from that rational model, and to what extent does it comply with at least some elements of rational decision-making?

Empirical evidence on such issues comes primarily from the experimental literature (for a survey, see Kagel and Roth, 1995). Yet, a drawback of this approach is that in experiments the stakes are very low, giving individuals little incentive to make an effort to try to take the right decision. Also, experiments create artificial circumstances that bear little relation to everyday economic environments. Increasingly, therefore, economists look for other situations where subjects are placed in a closely controlled environment, which either is less artificial, or where the stakes are much higher. An example of the first approach is Haan and Kooreman (2002). Examples of the second approach are papers that use data on TV game shows.

TV game shows form an ideal laboratory to study economic decision-making. The rules of the game are well-defined, and the stakes are often substantial. A number of papers have analyzed the behavior of people on such game shows to test models of economic decision making. These include Bennet and Hickman (1993), and Berk, Hughson and Vandezande (1996), who study contestants' behavior on *The Prize is Right*, Gertner (1993), who uses *Card Sharks*, Metrick (1995), who analyzes *Jeopardy!*, and Beetsma and Schotman (2001) who study the Dutch TV game show Lingo. Our paper adds to this literature. We use the BBC TV game show *The Weakest Link*.

In each episode of *The Weakest Link*, 9 contestants participate. The show has 8 rounds. In each round but the last, contestants decide by plurality vote which one of them will not make it to the next round. Ultimately, only one contestant remains, and (s)he will take home all the prize money that has been collected by all contestants throughout the show. The other 8 contestants leave with nothing. During the show, contestants constantly have to make a so-called *banking* decision. Here, a contestant chooses whether to secure a certain amount of money for the ultimate winner of the show, or to risk that money on a general knowledge question. If she chooses the latter, the amount of money available increases substantially should the contestant give the correct answer. But if she answers incorrectly, the money is lost. The game is described in much more detail in section 2.

The Weakest Link provides an ideal environment to study rational decision-making. First, the amounts at stake are substantial, and much higher than in a typical experiment. Second, the pace of the show is extremely high. This implies that contestants have to make quick decisions and that every episode of the show generates a substantial amount of data. For our paper, we studied 77 episodes, which had among them 7,427 banking decisions.

We show that contestants on *The Weakest Link* do not make rational decisions, in the sense that they do not use the strategy that optimizes their expected earnings. We identify a simple rule of thumb that yields much higher earnings. Yet, this does not imply that decisions are purely random. Contestants do take the right variables into account when making their decisions. According to the optimal strategy, a contestant should be more likely to bank when her general knowledge is poorer, when the overall difficulty of the questions is higher, and when the amount of money at stake increases. As we show, that is exactly what they do.

The remainder of this paper is structured as follows. In section 2, we give a full description of *The Weakest Link*: the set-up, the decisions contestants have to make, and other relevant issues. Section 3 gives some descriptive statistics of the episodes we study. Section 4 gives a justification of our approach. We argue why it makes sense to assume that contestants on the show choose their banking behavior to maximize total expected prize money. In section 5 we give a simple model to derive the optimal banking decision as a function of the probability that contestants answer a question correctly. For simplicity, we assume that this probability is constant over contestants, and that it is given. In section 6, we use the observed answers of contestants on the show to formulate an alternative banking strategy. We study whether contestants could have increased their average prize money by using a simple alternative banking strategy. We show that this is indeed the case. Since our simple strategy is not the optimal strategy, the fact that our strategy already beats that of the contestant implies that the strategy they are using is definitely not the optimal one. Yet, there may still be some rationality to the contestants' banking decisions, as we argue in section 7. Sections 8 and 9 show that this is indeed the case. In section 8 we establish that contestants are more likely to bank when questions are more difficult, and when the amount of money at stake is higher – exactly what the optimal strategy would prescribe. In section 9 we argue that, at least in the relevant cases, contestants that are more likely to answer a question correctly, are less likely to bank – again in line with what an optimal strategy would prescribe. Section 10 concludes.

2. The Game

Any of the nine people in the studio here today could win up to £10,000. They don't know each other, however. If they want the prize money, they will have to work as a team, but, eight of them will leave with nothing, as round by round, we lose the player voted the Weakest Link[2].

The Weakest Link is a daily game show that has been broadcast by the British public television network BBC since August 2000. It has rapidly become one of the most popular game shows in the UK. Local versions of The Weakest Link are shown in more than two dozen foreign countries, including Turkey, Hong Kong and the USA, most of them with virtually the same set of rules as the UK version. Part of the success must be attributed to the unorthodox attitude of the British quizmaster, Anne Robinson, who also hosts the show in the USA. Instead of showing empathy and support, she berates the contestants throughout the show by giving sarcastic comments on their supposedly non-existent intelligence and personal traits such as an odd hairstyle[3].

The show starts with nine contestants[4,5] of whom only one will take home the prize money. The eight losing contestants are consecutively eliminated during eight rounds and one final. In every round, the contestants receive trivia questions, starting in the first round with the person whose name is first alphabetically. The players stand in a semi-circle around the quizmaster, and each contestant receives one question at a time, moving in clockwise order. A correct answer yields a 'link' in a 'prize chain', beginning at zero and climbing to £1,000 in nine increments, as shown in figure 1.[6] Whenever the player gives a wrong answer, the chain is broken and all money on the chain is lost.

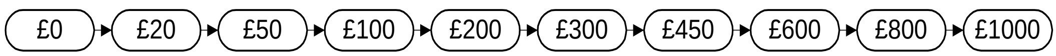

Figure 1. The prize chain

[2] Host Anne Robinson's introduction at the beginning of each show.
[3] The quizmasters of the foreign versions of The Weakest Link all try to imitate Ms. Robinson's sardonic behavior, except for Ms. Cheng, hosting the show in Hong Kong. Ratings in Hong Kong jumped after she adopted a nicer attitude towards the contestants.
[4] The contestants are selected through a pre-selection, in which they have to answer 20 trivia questions over the phone, and an audition in which they have to participate in an entire simulated edition of the show. The contestants spend a couple of hours together in the 'green room' before the actual taping starts. During this time, they receive some instructions, their make-up and microphone. The contestants have enough time to get to know each other a bit. This may influence their voting behavior.
[5] Note that the description in this section applies to the BBC shows we studied. Shows in some other countries (including the US and the Netherlands) only have eight contestants.
[6] Different from other shows, such as *Who wants to be a millionaire*, questions on *The Weakest Link* are not more difficult when the amount of money on the chain is higher.

However, it is not necessary to reach ₤1,000 on the chain to secure winnings and add to the prize money. At any time before a contestant receives a question, he has the option to 'bank' the money on the chain by saying the word 'bank'. The amount on the chain at that time is then added to the prize money, and the chain drops back to zero. After banking, the contestant still has to answer a question. Of course, when the previous contestant did not answer her question, or when a contestant is the first to receive a question in a round, then the amount of money on the chain is zero, so effectively there is no banking decision to be made.

A round ends when time has run out. Any money on the chain that has not been banked before the end of the round is lost. The first round lasts three minutes. Each subsequent round lasts 10 seconds shorter than the preceding one up to round 7. In round 8 the two remaining contestants have 90 seconds. In case time elapses while there is money on the chain, the money is lost. A round may end before time is up when a total of ₤1,000 are banked[7].

As an example, consider the following chain of events in the first round. The first contestant is posed a question and gives the correct answer. If contestant 2 now banks, an amount of £20 is secured. The chain moves back to 0. Now contestant 2 receives a question. She answers correctly as well. Contestant 3 does not bank and gives the correct answer. The chain has now moved to £50. Contestant 4 does not bank and gives the wrong answer. The chain now drops back to zero, and the money on the chain is lost. Contestants 5 and 6 do not bank, but do give the correct answer, moving the chain back to £50. Contestant 7 banks, adding the £50 to the secured money. The amount of secured money now stands at £70. This process will continue until time has run out, or the amount of money secured has reached £1000. At the end of a round, the amount of money secured in that round is added to the total prize money of the show.

[7] If the amount banked in one round exceeds ₤1,000, the excess will not be added to the prize money.

After each round, except round 8, the team gets rid of one player through a voting procedure. Each contestant writes the name of one competitor that she would like to eliminate on a board. Then, one by one, the contestants flip over their boards to reveal whom they have chosen. The person who gets the greatest number of votes will receive one more sneer from the host and is then sent home with the infamous words “You are the weakest link. Goodbye!” In case of a tie, the person who answered the most questions correctly in that particular round – the strongest link – casts the deciding vote, which may be different from her original choice.

The idea of the voting procedure is that contestants should vote for the player they think is the worst among those remaining. This player would be least likely to contribute much to the prize money. Yet the player who gave the most incorrect answers – statistically the weakest link – does have a chance to stay in the game, whereas the strongest player may be voted off. The remaining players move on to the next round. The strongest link in the previous round will now receive the first question. In case the strongest link was voted off, the round starts with the second strongest player.

Evidently, the voting procedure may induce strategic behavior. In round 7 for example, with only three players left, there is a strong incentive for the two weaker players to vote off the strongest link. The weaker players will both have a greater chance of winning the final if they play against each other than if one of them plays against the strongest. Yet the players face a trade-off. Prize money might turn out to be lower than it would have been if the strongest link had not been sent away; the strongest player is likely to answer more questions correctly in round 8 than a weaker player. This trade-off is present in all rounds, albeit not as manifestly as in a situation with only three players remaining. In round 8, the amount banked by the two players is trebled before it is added to the prize money.

Each episode ends with the final, in which the two surviving contestants play against each other head to head. The host alternately asks each contestant five questions. The strongest link in round 8 may choose who goes first. Whoever gives the most correct answers, wins. In case of a tie after both players have answered five questions, the game moves into the 'sudden death' stage. The questions continue in pairs as before. If the first player gets his question right, the other has to get her question right or she loses. If the first player gets his question wrong, the other player has to get her question right in order to win. If both players answer correctly or both answer incorrectly, the questions continue. The winner takes home the prize money accrued during the eight rounds. The losing finalist leaves with nothing.

3. Descriptive statistics

For this paper we watched 77 episodes of *The Weakest Link*, broadcasted on weekdays by the BBC in the period of December 2000 through May 2001.[8] For every episode we recorded the identity of the contestant, all voting decisions in every round, and for every question posed the identity of the person answering, the amount of time left on the clock when the question was posed, whether the question was answered correctly, and the banking decision. Table 1 gives some descriptive statistics of our data set.

We consider 8 episodes per round: the 9th and final round is a shoot-out without banks. Each episode lasts for 45 minutes, yet the effective time, that is, the total time allocated to questions and answers in the first 8 rounds, is only 19 minutes. The number of questions per episode is almost 165, implying an average time of 6.92 seconds per question. Note that this is very short: during this time span contestants not only have to listen to and answer their question, but also have to make a banking decision. Moreover, con-

[8] Note that this period has far more than 77 weekdays. Some episodes broadcasted towards the end of our sample period were reruns of earlier broadcasts. Obviously, we did not include reruns of episodes already in our dataset. On public holidays, celebrity editions were often shown, in which celebrities competed, and the total prize money was donated to charity. Because of the very different character of these shows, we did not include them in our data set. Also, the broadcasting schedule of *The Weakest Link* was sometimes interrupted to report on sports events.

testants need to keep track of the performance of their opponents, to see whom they should vote for. All of these, plus the fear of a ruthless putdown by the host of the show in case of failure, implies that contestants are subject to considerable stress. This will have an effect on their performance, both in answering the questions, and in making banking and voting decisions.[9]

The average prize money was £2,339, out of a possible £10,000. This implies that a total of some £180,000 was awarded to the 77 winners. The lowest payout was £1,080, the highest £3,820, still substantially less than the theoretical maximum 0f £10,000. This implies a considerable variation in the amount taken home by the winner. The average number of correct answers per episode equals 96.5, implying an average probability of answering a question correctly that equals 59%.

The average number of banks per episode equals 28. Given that after every correct answer there is an opportunity to bank, this implies that contestants bank in 29% of all possible cases. The table refers to this number as the probability of banking. The average amount of money earned per bank, which equals total prize money divided by the number of banks, is £75. Yet, the average amount of money earned per correct answer, which equals total prize money divided by the number of correct answers, is only £22. This implies that there are many cases in which a wrong answer was given while there was a substantial amount of money on the chain. The average number of correct answers at a bank stands at 2.14. This implies that the distribution of amounts banked is highly skewed. Given that, on average, a bank is made after slightly more than two correct answers, one would expect that the average amount banked would be slightly more than £50, which is the amount on the chain after two correct answers. Yet, as noticed, this average stands at £75.

[9] Obvious examples of this are a few cases in which a contestant yelled ‘pass’ instead of ‘bank’ before the question was posed, which implied that the chain dropped back to zero, and the contest-

Episodes	77
Number of rounds per episode considered	8
Total time per episode	45 min
Effective time per episode	19 min
Questions per episode	164.74
Correct answers per episode	96.46
Number of banks per episode	28.34
Average prize money per episode	£2,339
Minimum	£1,080
Maximum	£3,820
Average time per question	6.92 sec
Probability of answering correctly	0.586
Probability of banking	0.294
Average money earned per bank	£75.40
Average money earned per correct answer	£22.15
Average number of correct answers at bank	2.14

Table 1. Some descriptive statistics

Table 2 gives some additional information, broken up to individual rounds. From this table, we can see that as the show progresses, it becomes more difficult to answer a question correctly. This may be because the questions themselves become more difficult, or because the amount of stress and fatigue increases. Probably, a combination of these

ant missed the opportunity to really answer a question. Other, admittedly less disastrous cases are those in which a contestant yells 'bank' when there is no money on the chain.

factors is at work.[10] Partly as a result of the increasing difficulty, the prize money that is earned in each round also decreases.[11] Naturally, the average prize money per round also decreases: questions are more difficult to answer, and available time decreases. We also report on the number of cases in which contestants managed to bank the maximum amount of £1000 in a round. In round 1, this happened in 17 episodes[12], in round 2 in 3 episodes. In later rounds, there are no such cases.

round	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Duration of round (sec)	180	170	160	150	140	130	120	90
Probability correct answer	0.764	0.687	0.606	0.570	0.516	0.483	0.434	0.446
Average prize money	638	418	311	246	159	141	123	101
minimum	90	40	20	50	0	0	0	0
maximum	1000	1000	900	850	450	400	460	310
# maximum banks	17	3						

Table 2. Descriptive statistics per round.

4. Strategic decision making on *The Weakest Link*

Ultimately, the expected earnings of a single contestant in *The Weakest Link* depend on the knowledge of all contestants, and on their banking and voting decisions. We

[10] For example, it is our impression that in earlier rounds, there are more multiple choice questions, where contestants can choose between two possible answers. Later in the show, there are more open questions.
[11] Throughout the paper, we report on the prize money in round 8 before the amount is trebled.
[12] During our sample period, there seems to be have been a change of policy with respect to the difficulty of the questions in the first round. During the first 30 episodes in our sample, there has

assume that the goal of a contestant on the show is to maximize these expected earnings. Admittedly, other objectives may play a role as well, such as the desire to appear sympathetic or knowledgeable on national television, to outsmart the host, etc. Yet, we assume that these objectives are only minor[13] compared to the prospect of potentially earning £10,000.

From an economist's point of view, the interesting decisions on the show are the voting and the banking decisions. In this paper, we focus on the banking decision. In future work, we plan to analyze the voting decision. The banking decision is a non-trivial optimization problem. A strategy of always banking late (i.e. when the amount on the chain is high) has the potential of yielding high winnings, but also implies the risk of losing a lot of money when a wrong answer is given.

In our analysis, we implicitly assume that the banking behavior of a contestant does not have an influence on the voting behavior of others. If this were the case, then contestants would have an incentive to bank in a way that increases their chances of survival, rather than only maximizing total prize money. Yet, we do feel that our assumption does not materially affect the analysis. There are several reasons for that. First, if there were an effect of banking behavior on the voting of others, then the most obvious strategy would be to vote for contestants that do not bank properly. Since it is in everybody's interest that the amount of prize money is maximized, it is best to get rid of contestants that do not seem to pursue that goal. In this case, even though banking behavior does influence voting it is still the best strategy to bank in a way that maximizes total prize money. Second, from casual observation, it seems that the likelihood that someone is voted off is primarily determined by his or her quality, and by strategic considerations. In general,

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not been a single case in which the £1000 target was reached in round 1. During the other 47 episodes, this occurred 17 times. Such systematic differences are not found for later rounds.

[13] Also note that the other objectives are partly aligned with the goal of maximizing expected earnings. Indeed, the best way to gain admiration from others by appearing on *The Weakest Link* is by winning the show, which is exactly what needs to be done when maximizing expected earnings.

banking behavior does not seem to have an influence.[14] In future work, we will test this formally.

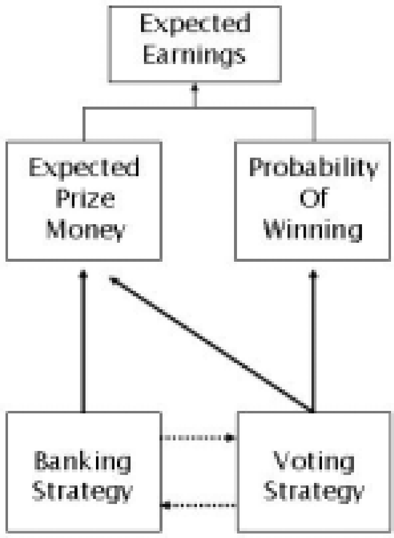

Figure 2. Strategic decision making on *The Weakest Link*

Summarizing, the objective of contestants in the show should be to maximize their expected earnings. As shown in figure 2, expected earnings are the product of the probability of winning and expected total prize money. The probability of winning is determined by voting behavior, as shown by the arrow in figure 2, and the knowledge of the other contestants, which is exogenous once the nine contestants in a show are known. Both the banking behavior and the voting behavior of the contestants determine expected

[14] An exception to this are cases in which a contestant loses a lot of money for the team, by not banking and then giving an incorrect answer. Yet, in such cases, we may again argue that this person is voted off because (s)he failed to use the banking strategy that maximizes total prize money.

total prize money, again shown by arrows in figure 2. Better banking directly yields higher prize money, whereas voting behavior determines who will stay in the show, which ultimately affects the prize money that can be generated. As argued above, we assume that banking behavior does not affect voting behavior, which implies that we assume that the effects of the dotted arrows in figure 2 are absent. Using that figure, we can then see that a strategy that maximizes expected earnings necessarily implies the use of a banking strategy that maximizes the expected total prize money, regardless of the voting strategy.

5. The Optimal Banking Decision: A Simplified Analysis

In this section, we give some flavor as to how the optimal banking decision can be derived. We will study the simplified case in which all contestants have the same probability of answering a question correctly. For simplicity, we do not take time limits into account[15].

Suppose that the probability of giving a correct answer to any question is given by p. Assume that the participants follow a strategy of always banking after s correct answers. The amount of money on the chain after s answers is denoted $M(s)$. Thus $M(1)$=20, $M(2)$=50, etc. We will use the term *attempt* to describe a sequence of correct answers that ends with either a wrong answer, or with a bank. An attempt *starts* when the chain is at zero, and it *ends* when the chain is back to zero, either because a wrong answer was given, or because there was a bank. Thus, by definition, an attempt to bank 20 always consists of only 1 question, either, it is answered correctly, the money is banked and a new attempt starts, or it is answered incorrectly and a new attempt also starts. For a strategy of banking at £50, an attempt may consist of 1 or 2 questions. It consists of only 1

[15] Certainly, if there are no time limits, the players would eventually reach £1,000 in any round. Yet in this section, our goal is to find a strategy that maximizes payoff per question asked.

question when this question is answered incorrectly. It consists of 2 questions when the first question is answered correctly. Whether or not the second question is answered correctly is immaterial. After question 2, the chain always goes back to zero, either because of a wrong answer, or because of a bank. Similarly, an attempt to bank *M(s)* may consist of any number of questions strictly between 0 and s+1.

The *expected payoff per question* now equals the *expected payoff per attempt* divided by the *average number of questions in an attempt*. The *expected payoff per attempt* simply equals $M(s)p^s$. Denote the *average number of questions* for a strategy of banking at *M(s)* as *Q(s)*. We then have

Lemma 1. $Q(s) = \sum_{j=1}^{s} p^{j-1}$

Proof. As noted, for *s*=1, we have *Q(1)=1*. For *s*=2, we have an attempt of 1 question with probability 1-*p* and 2 questions with probability *p*. This yields *Q(2)=1+p*. For *s*=3, we have an attempt of 1 question with probability *1-p*. Otherwise, i.e. with probability *p*, the expected number of further questions in the attempt equals *Q(2)+1*. By induction, *Q(s)=(1-p)+p(Q(s-1)+1)*, for *s*>1. From this, we can derive the formula above. ■

Using lemma 1 and the discussion above, we now have for the expected payoff per question:

$$Payoffs = \frac{M(s)p^s}{\sum_{j=1}^{s} p^{j-1}}$$

By comparing the value of the above expression for different values of *s*, we can derive the optimal banking strategy for different values of *p*. This yields the following

Strategy	Optimal for
BANK at 20	$0.000 \leq p \leq 0.602$
BANK at 200	$0.602 < p \leq 0.724$
BANK at 450	$0.724 < p \leq 0.795$
BANK at 800	$0.795 < p \leq 0.843$
BANK at 1000	$0.843 < p \leq 1.000$

Table 3. Optimal strategies

Note that, surprisingly, it is *never* an optimal strategy to bank at either £50 or £100. Also, banking at £300 or £600 is never an optimal strategy under our assumptions. This can be explained as follows. In figure 4, we give the values for *payoffs*, as defined above, for values of p between 0.50 and 0.65. The four lines give the expected payoff per question of always banking at £20, £50, £100, and £200. For expositional clarity, we have not included the curves for the other possible banking strategies.

Note that even at a relatively high p, such as 0.6, it is still optimal to bank immediately after every correct answer. By equating the expressions for *payoffs* with s=1 and s=2, we can calculate at which value of p, banking at £20 or at £50 yields the same expected payoff. This is p=2/3. But for this value of p, always banking at £100 or at £200 already yield even higher payoffs, as can be seen from the graph. In fact, the strategies of always banking at £50 or at £100 are always dominated by one of the other strategies. A similar analysis holds for banking at £300 or £600. In the case depicted by the figure, for p lower than 0.602, banking at £20 yields the highest payoff, for p higher than 0.602 (but lower than 0.724), it is banking at £200 that yields the highest prize money.

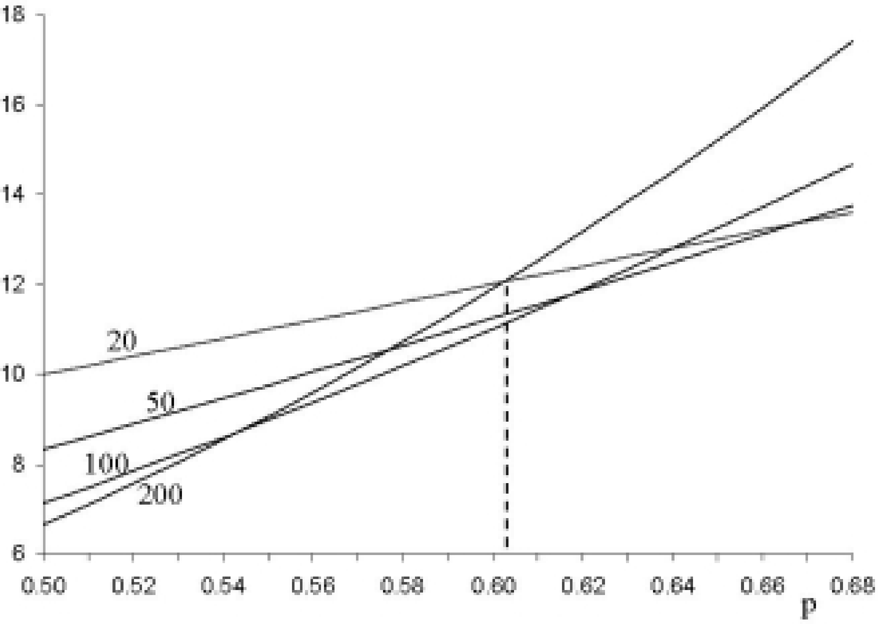

Figure 3. Theoretical payoffs to different banking strategies

6. Simulation Results

In the previous section, we derived the optimal banking strategy for the case in which every contestant had the same probability of answering a question correctly. Of course, this is a simplifying assumption. When qualities differ, contestants can use this information to increase their winnings. Someone with higher quality should bank less often, whereas players with lower quality should bank more often.[16] Also, the *payoff* functions

[16] Remember that a banking decision is made before a player answers a question. Therefore, a contestant's banking decision depends on her estimate of her own quality.

described in the previous section are convex for any s>1. In reality, contestants are heterogeneous with respect to p. Convexity of *payoffs* then implies that in reality a given banking strategy yields higher payoffs on average than what we find in our simplified world. We explain this in more detail at the end of this section.

To evaluate whether contestants in the show do use an optimal banking strategy, that is a banking strategy that maximizes total expected prize money, we have to take into account all contestants' real or perceived qualities, and also how these qualities interact. This is a difficult task. We therefore choose an indirect approach.

Suppose that the contestants in a show always use an extremely naive strategy, by always banking in round i if and only if some amount x_i is on the chain. Clearly, this cannot be the optimal strategy. Here, contestants do not use any information on their own knowledge, successes in earlier rounds, etc. If, however, we are able to show that following such a strategy yields higher prize money than what contestants actually achieve on the show, then we have unambiguously shown that the strategy they use, is not optimal. This is exactly what we do in this section.

For every single show in our sample, we have the sequences of correct and incorrect answers. Based on these sequences, contestants have made their banking decisions. We can however replace those banking decisions with a different banking strategy. For example, take the first round of show 57 in our data set. In this particular round, 26 questions were posed. The observed sequence of correct and incorrect answers in this round was 11111011101111011110111111, where a 0 represents an incorrect answer, and a 1 represents a correct answer. The observed sequence of banking decisions was 00000000000001000100001001, where a 0 represents no bank (including the cases in which a bank was not feasible), and a 1 represents a bank. This yielded a total of £300. Now suppose that contestants would have followed the strategy of banking if and only if the chain was at £100. This implies the following sequence of banking decisions[17]: 0001000001000100001000000100, yielding £500. For this particular example, always banking at £20 would have yielded a total of £440, always banking at £50 a total of £500, at £200 a total of £800, at £450 a total of £900, at £600 a total of £600, and at both £800 and £1000, a total of £0.

We have done this exercise for all possible naive banking strategies, in every single round of every single show in our sample, albeit with a slight adaptation. Note that, when time has almost run out in a round, it is clearly not a good idea to wait until, say, an amount of £100 is on the chain. It is obvious that this amount cannot possibly be reached, given the remaining time. Therefore, we adapt our naive strategies by simply imposing a bank at every possible opportunity during the last 10 seconds of a round.[18]

	avg	**20**	**50**	**100**	**200**	**300**	**450**	**600**	**800**	**1000**
Round 1	638	-227	-194	-121	9	**10**	5	1	-26	-144
Round 2	418	-69	-61	-35	**41**	5	-3	-5	-63	-91
Round 3	311	-26	-42	-27	**8**	-26	-60	-68	-108	-108
Round 4	246	2	-8	-15	**24**	-2	-27	-63	-100	-139
Round 5	159	**44**	24	-2	9	-31	-47	-72	-82	-89
Round 6	141	**34**	11	-14	-21	-56	-43	-54	-67	-83
Round 7	123	**21**	-5	-18	-25	-53	-54	-73	-71	-81
Round 8	101	**15**	-8	-23	-14	-30	-58	-62	-62	-62

Table 4. Additional payoffs of naive banking strategies

[17] Again remember that a bank can only be made before a question is posed. By definition, there cannot be a bank at the first question. Using the strategy here, the first bank will be made *after* the first sequence of 3 correct answers.
[18] The 10-second cut-off is arbitrary. Using a 15-second cut-off hardly affects the results.

Table 4 gives the results of this exercise. The second column gives the actual averages that were achieved by the contestants in each round over all 77 shows. The next columns give, for every round, the additional prize money that would have been achieved with a strategy of always banking at £20. Again, we take the average over all 77 shows. For example, always banking at £20 in round 5 yields on average a prize money in that round that is £44 higher than the £159 achieved by the contestants. Note that this strategy is much worse in earlier rounds, but actually achieves higher prize money in later rounds. The fourth column reports the additional prize money obtained when using the strategy of always banking at £50[19], the fifth column that of always banking at £100, etc. Again, results for round 8 are reported before the prize money in this round has been trebled. The cells typeset in bold are the highest entries in each row. Note that in each round there is a naive strategy that on average does better. In the last four rounds, the best strategy, among the set that we consider, is to always bank at £20, so after each correct answer. In round 1, always banking at £200 or always banking at £300 gives virtually the same payoff. For simplicity, we choose banking at £200, as this is also the best strategy in rounds 2, 3, and 4.

We thus have the following simple rule of thumb. During the first four rounds, bank if and only if there is an amount of £200 on the chain. During the last four rounds, always bank at every correct answer. The jump from always banking at £200 to always banking at £20 may seem extreme, but it is in line with our analysis in the previous section. There, we found that, if probabilities of giving a correct answer are equal across contestants, then it can never be an optimal strategy to bank at £50 or £100.[20]

[19] As noted earlier, this strategy also includes always banking during the last 10 seconds of a round. All our naive banking strategies include this aspect, yet, for conciseness, we will not mention this in the remainder of this section.

[20] Of course, this does not imply that in the real world, with heterogeneous contestants, it can never be optimal to bank at £50 or £100. Our remarks here are only meant to indicate that a rule of thumb that only uses banks at £20 or £200, is more plausible than it may seem at first sight.

amount	**20**	**50**	**100**	**200**	**300**	**450**	**600**	**800**	**1000**
Round 1	15	18	29	**47**	49	48	51	45	37
Round 2	33	36	37	**49**	38	37	36	26	22
Round 3	38	33	36	**44**	35	25	22	16	15
Round 4	47	46	40	**48**	36	26	17	10	7
Round 5	**68**	52	43	38	28	23	17	15	14
Round 6	**57**	49	36	32	19	18	15	12	10
Round 7	**60**	36	30	28	19	16	12	12	11
Round 8	**61**	35	28	28	19	11	10	10	10

Table 5. Number of shows beaten by naive banking strategies

Additional information on our strategies is given in table 5. Here, rather than giving the average additional prize money, we report on the number of shows (out of 77) in which the considered strategy is at least as good as the one chosen by the contestants. For example, in round 5, always banking at £20 would have given prize money that is at least as high as the amount that was actually achieved in 68 out of 77 shows. The entries corresponding to the rule of thumb we have chosen above are typeset in bold.

round	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**TOT**
Money earned by contestants	638	418	311	246	159	141	123	101	2,339
Money earned rule of thumb	647	459	319	270	203	175	144	116	2,565
Relative improvement	1%	10%	3%	10%	28%	24%	17%	15%	10%
Shows strictly beaten	39	45	38	39	64	53	53	38	59
Shows with equal performance	8	4	6	9	4	4	7	23	0

Table 6. Contestants' performance versus rule of thumb

Table 6 gives a summary of the relative performance of our simple rule of thumb. We report on the money earned by the contestants, and the money they could have earned using our rule of thumb. We also give the relative improvement of using our rule reflected in the percent increase in prize money when our rule is used. This establishes the following:

Result 1. *The performance, in terms of average total prize money achieved, of the contestants on the BBC episodes in our sample of The Weakest Link, can be substantially improved upon by using the following simple rule of thumb:*

a) bank at £200 during the first four rounds,

b) bank at £20 during the last four rounds,

c) *bank at every opportunity during the last 10 seconds of any round.*

The improvement of using this rule is particularly impressive in round 5 and 6, where our rule of thumb has just switched to always banking at £20. In round 5, we have an improvement of 28%. The fourth row of the table gives the number of shows in which we do strictly better, the final row the number of shows in which we do equally well. This number is particularly high in round 8. In this round, when there are only two contestants left and prize money is trebled, contestants relatively often already use the strategy of always banking at £20. The final column gives the results for the entire show. Overall, using our rule of thumb would have lead to a higher amount of prize money in 59 out of 77 shows. On average, our rule would have earned the contestants £2,565, an improvement of 10% over their actual performance.[21]

[21] Note that the total amount does not equal the sum of the individual amounts of the previous rounds. This is because the prize money in the last round is trebled.

round	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Observed *p*	0.764	0.687	0.606	0.570	0.516	0.483	0.434	0.446
Suggested by analysis	450	200	200	20	20	20	20	20
Suggested by simulations	200	200	200	200	20	20	20	20

Table 7. Optimal banking strategies

Table 7 gives the optimal banking strategies as suggested by the analysis in the previous section, which assume a constant probability of answering a question correctly, and those suggested by our simulations, which use the actual data generated during the shows. Note that there are two differences: in round 1 and in round 4. Note however from table 5 that, according to the simulations, the difference between banking at £200 or at $450 in round 1 is relatively small. It is likely that the different suggestions here are mainly caused by the fact that the analysis assumes that there is no time limit.

The difference in round 4 is harder to explain. It can be understood as follows. As we noted in the beginning of this section, the function *payoff* as defined in the previous section, is convex for *s*=4. That implies that if contestants are heterogeneous in their probability of answering a question correctly, the real payoffs of always banking at 200 are higher than those derived. This is shown in figure 4. There, at p=0.57, the analysis suggests that banking at £20 yields a higher payoff than banking at £200. Now suppose that one show has p=0.37, and a second show has p=0.77. On average, we still have p=0.57. In the figure, the expected payoffs of banking at £200 are where the dashed line intersects the dotted line at p=0.57. Evidently, these average payoffs are higher than those obtained when banking at £20, which are linear and therefore unaffected by the heterogeneity. In this way, heterogeneity of contestants leads to higher expected payoffs from banking at £200 – but not from banking at £20. Admittedly, the example in the figure is extreme. But in the real world, contestants within one episode are also heterogeneous, which further strengthens the effect of convexity. Since our theoretical analysis assumes homogeneity, it underestimates the returns to banking late, and may therefore lead to a banking strategy that is too conservative.

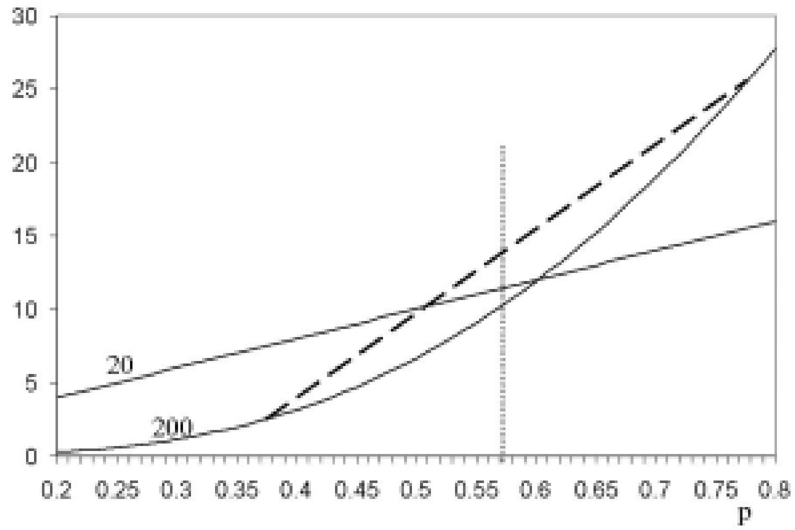

Figure 4. Explaining the difference between theoretical prediction and simulation

7. Rational Aspects of Decision Making

In the previous section we showed that the banking behavior of contestants on *The Weakest Link* is not optimal. Using a simple rule of thumb, we were able to achieve total prize money that is substantially higher than that achieved by the contestants on the show. Yet, this does not necessarily imply that the behavior of contestants does not contain any elements of rationality. Contestants may be boundedly rational, in the sense that although they base their decisions on the right trade-offs, they lack the precise knowledge required to perform the optimization problem underlying this trade-off in a correct fashion.

Consider for example a consumer that tries to maximize utility by spending her budget on two normal goods. When the price of good 1 increases, she buys more of good 2 and less of good 1. However, she is not able to determine the optimal quantities to consume. In that sense, this consumer is aware of the trade-off, but lacks the precise knowledge required to correctly perform the optimization problem. We will argue that decision making on *The Weakest Link* is done in a similar fashion.

A crucial trade-off in the banking decision of *The Weakest Link* is that between the probability of giving a correct answer, and the amount of money that is at stake. Before a contestant receives a question, she can make an estimate of the a priori probability that she will we able to give the correct answer to that question. Arguably, a contestant should be more inclined to bank when she feels that this probability is lower, since the lower the probability of a correct answer, the higher the probability that the amount of money on the chain is lost. Also, a contestant should be more inclined to bank when the amount of money on the chain is high, since the higher this amount, the more money is lost when an incorrect answer is given.

Primarily, the probability that a contestant receives a question to which she knows the correct answer depends on two things. First, it depends on the overall difficulty of the questions. When questions are more difficult, any contestant will be less likely to give a correct answer. Second, it depends on the amount of knowledge of the contestant. When a contestant has more knowledge, she is more likely to answer any question correctly.

The implications of this are as follows. First, we expect that contestants will bank more often when questions are more difficult to answer, and when the amount of money on the chain is higher. In table 2, we saw that, over rounds, the probability of a correct answer is decreasing. From this, we can infer that questions become more difficult to answer as the show proceeds.[22] This leads to the following hypotheses.

Hypothesis 1. *Contestants bank more often in later rounds.*

Hypothesis 2. *Contestants bank more often when the amount of money on the chain is higher.*

We test these hypotheses in section 8.

A further implication of the discussion above is that we expect that a contestant with more knowledge will bank less often. Of course, it is impossible to assess the state of knowledge of all the 693 contestants in our sample. But we can test this hypothesis in a more indirect way. The hypothesis implies that people that do not bank, are on average more knowledgeable. If this is true, then we should have the following:

Hypothesis 3. *Ceteris paribus, there are more correct answers after a decision to bank, than there are after a decision not to bank.*

Obviously, we only expect this relationship to hold conditional on the amount of money at stake, and the round in which the decision is made. We study this issue in section 9.

[22] Note that this does not necessarily imply that the questions *themselves* are more difficult. We only claim that *answering* them is more difficult, which may be partly due to increased stress or fatigue. For our analysis, however, this difference is immaterial.

8. Do increased difficulty and higher stakes imply less banking?

This section tests the hypotheses 1 and 2, formulated in the previous section. First, contestants are more inclined to bank in later rounds. Second, contestants are more inclined to bank when the amount of money on the chain is higher. Hence, we look at banking behavior aggregated over players, and do not take individual knowledge into account. We do that in section 9.

round	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Probability answering correctly	0.76	0.69	0.61	0.57	0.52	0.48	0.43	0.45
Number of banks	4.42	4.25	3.68	3.65	3.00	3.03	2.77	3.56
Probability of banking	0.215	0.244	0.258	0.295	0.295	0.347	0.383	0.619
Money earned per bank	146	98	85	67	53	46	45	28
Money earned per correct answer	32.3	23.3	20.9	19.1	14.9	14.8	15.5	16.8
# correct answers at bank	3.07	2.61	2.40	2.12	1.88	1.71	1.60	1.21

Table 8. Some banking statistics

In order to get a better understanding of the banking behavior on the show, table 8 gives some further statistics. For completeness, we have also included the probability of giving a correct answer in every round. The second row gives the average number of banks in each round. Not surprisingly, this is decreasing. Later rounds are shorter, and fewer correct answers are given, leaving fewer opportunities to bank. Surprisingly, however, the amount of banks jumps up in round 8. The next row gives the probability of banking, that is, the number of banks divided by the number of opportunities to bank. This statistic is increasing, which is consistent with hypothesis 1. The amount of money that is earned per bank is decreasing.

Another interesting statistic is the amount of money that is earned per correct answer. This also takes the cases into account where the amount of money on the chain was lost because an incorrect answer was given. The amount of money that is earned per bank decreases substantially during the first five rounds, but then slightly recovers. Note that by banking after each correct answer, contestants can always secure £20 per correct answer. Yet, in the last five rounds, this amount is not even reached. This is in line with section 5, where we showed that a simple strategy of always banking at £20 outperforms the contestants' strategy in the last four rounds of the show. Finally, we report on the number of correct answers at a bank. To calculate this statistic, we recorded the number of steps that were taken on the chain at every banking decision. The average of these numbers is the number of correct answers at a bank. It thus reflects after how many correct answers the contestants on average decide to bank. This statistic is decreasing throughout the show, again confirming hypothesis 1.

amount	**20**	**50**	**100**	**200**	**300**	**450**	**600**	**800**	**1000**
Round 1	9	24	36	19	8	2	1	0	1
Round 2	14	36	30	16	3	0	0	0	0
Round 3	22	34	31	11	2	0	0	0	0
Round 4	27	42	24	6	0	0	0	0	0
Round 5	33	48	17	1	0	0	0	0	0
Round 6	46	38	15	1	0	0	0	0	0
Round 7	54	35	7	3	0	0	0	0	0
Round 8	82	15	3	0	0	0	0	0	0
Total	34	33	22	8	2	0	0	0	0

Table 9. Frequency distribution of banks (in %)

Table 9 analyzes the contestants' banking strategy in greater detail. To compile this table, we looked at all banks that were done in a certain round. We then made a frequency distribution of this data. For example, the first row in table 9 shows that, out of all banks in round 1, a total of 9% was done when the amount on the chain was £20, 24% when the chain was at £50, 36% when the chain was at £100, etc. Also from this table, it can be seen that as the show progresses, contestants are inclined to bank earlier. The modus of the distribution moves from £100 in round 1, via £50 in round 2 through 5, to £20 in rounds 6, 7, and 8. In the last round 82% of all banks occur at £20 – which brings the contestants reasonably close to the strategy of always banking after every correct answer, that we suggested in section 6.

The most convincing evidence for hypothesis 1 and 2, is given in table 10. There, we give a further breakdown of the probabilities of banking, now conditional on both the round and the amount of money on the chain. For example, the top-left entry indicates that there was a bank in 5.1% of all the cases where the chain was at £20 in round 1. In the table, we have only included the cells with at least 30 observations. For example, we did not include the cell (round 1; 450), since there were only 16 cases where, during round 1, the chain stood at £450.

As can be seen from the table, conditional on the round they are in, contestants do indeed bank more often when the amount on the chain is higher. In every single row, the probability of banking is increasing with the amount of money at stake. Also, we observe that, conditional on the amount of money on the chain, the probability of banking is almost always higher for later rounds.[23] We have thus established the following results.

Result 2. *Contestants bank more often in later rounds.*

Result 3. *Contestants bank more often when the amount of money on the chain is higher.*

[23] The only exceptions being that the probability of banking when the chain is at £100 decreases from 0.800 to 0.756 when going from round 5 to round 6, and the probability of banking when the chain is at £200 decreases from 0.736 to 0.732 when going from round 2 to round 3.

	20	50	100	200	300
Round 1	0.051	0.186	0.426	0.545	0.587
Round 2	0.073	0.295	0.510	0.736	
Round 3	0.108	0.321	0.611	0.732	
Round 4	0.143	0.435	0.670		
Round 5	0.161	0.507	0.800		
Round 6	0.251	0.537	0.756		
Round 7	0.314	0.605			
Round 8	0.650	0.732			

Table 10. Probabilities of banking

As we showed in section 5, contestants do not use the optimal banking strategy when making their decisions on the show. We derived that, given the difficulty of the questions, contestants should bank at £200 in the first four rounds and at £20 in the last four rounds. Obviously, contestants do not follow that strategy. Yet, they do realize that they should bank earlier as the show progresses and the questions become increasingly difficult to answer. In that sense, they are at least boundedly rational.

This is reflected in figure 5. The Z-shaped curve gives the optimal banking strategy (that is, optimal among the naive strategies we considered in section 5). This strategy requires banking at £200 in the first four rounds, which is equivalent to banking after four correct answers. In the last four rounds, it is optimal to bank at £20, that is, after one correct answer. The other curve gives the average number of correct answers at a bank, as given in table 6.

From the figure, we can see that even though contestants do not use the 'right' banking strategy, they at least understand that they should bank more quickly in later rounds. Compared to our strategy, however, contestants bank too early in the first half, and too late in the second half of the show. Thus, contestants fail to find the optimal solution to the maximization problem they face. They could already do much better by following our simple rule of thumb. Yet they do get the sign of the comparative statics right. They change their decision in the right direction when there is a change in the exogenous variables, which in this case are the difficulty of answering the questions and the amount of money at stake.

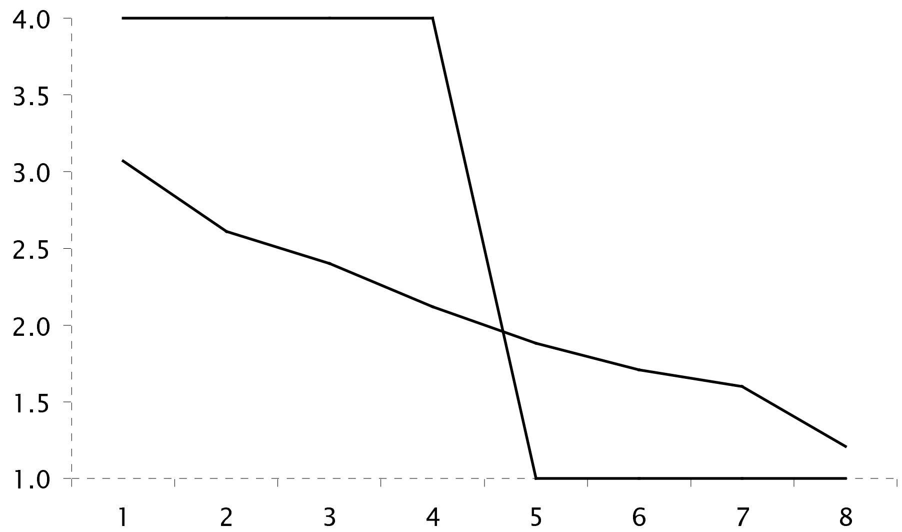

Figure 5. 'Optimal' banking decisions versus observed banking decisions.

9. Does more knowledge imply less banking?

In this section, we test hypothesis 3: it is less likely to observe a correct answer after a bank, than it is to observe a correct answer after a no-bank decision. One way to test this, is to simply count all the cases in which a bank was followed by a correct answer, all cases in which a bank was followed by an incorrect answer, a no-bank was followed by a correct answer, and a no-bank was followed by an incorrect answer. These numbers are, respectively, 1054, 763, 3158, and 1597.[24] These numbers imply that the probability of a correct answer after a bank is 0.580, and that the probability of a correct answer after a no-bank equals 0.664.[25]

Yet, this analysis is incorrect, since we aggregate information over all rounds. As shown in the previous section, the difficulty of answering questions increases throughout the show, and contestants do take this into account when making their banking decision. The fact that there are more correct answers after a no-bank may be entirely due to the fact that contestants bank more often when questions are more difficult. That is, it may be purely a round-effect. To test whether knowledge really affects banking behavior, we need to look at a more disaggregated level.

round	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cases of bank	295	275	234	234	196	189	180	214
Cases of no bank	1158	941	739	609	495	389	296	128
Prob. corr. answer when bank	0.766	0.658	0.585	0.598	0.536	0.460	0.433	0.467
Prob. corr. answer no bank	0.800	0.716	0.650	0.629	0.549	0.537	0.514	0.484
p-value	0.204	0.064	0.076	0.412	0.743	0.082	0.090	0.759

Table 11. Relation between banking and answering questions correctly

Table 11 shows the relationship on the level of rounds. Every column first gives the number of cases of a bank in that round, and then the number of cases of a no-bank. Next, the probabilities of a correct answer conditional on a bank and a no-bank are given. The last row tests for the statistical significance of the difference between the two prob-

[24] Throughout this section, we do not take the banking decisions made during the last 15 seconds of a round into account.
[25] A chi-squared test shows that this difference is significant with a p-value of $2*10^{-10}$.

abilities, using a chi-squared test. The row reports the p-value on the null hypothesis of no difference.

In every single round, the probability of giving a correct answer is higher after a no-bank, which supports our hypothesis. Yet, the chi-squared tests show a mixed picture. The difference is only significant in rounds 2, 3, 6, and 7 – and then only at the 10% -level. We can also do a chi-squared test for the joint significance of the eight individual test statistics. Doing so, we find a p-value of 0.060. This implies that we do find the following

Result 4. *On the round-level, there is a weakly significant relation between banking and the probability of answering a question correctly.*

Table 12 gives the data on an even more disaggregated level – conditional on the round and the amount of money at the chain. We only report the cells in which the chi-squared test is valid, in the sense that the expected value of any of the four cells is at least five. Every individual cell in the table should be read as follows. The first row gives the number of cases in which a banking decision was made, and, out of those cases, the fraction of questions that was answered correctly. The second row does the same for the no-bank decisions. The third row gives the p-value of a chi-squared test. Values with one asterisk are significant at the 5%-level, values with two asterisks are significant at the 1%-level. A subscript minus indicates that the comparison has the wrong sign. For example, the table shows that there were 69 cases of a bank in the first round at £50. In 66% of these cases, the contestant then gave the correct answer. There were 353 cases of a no-bank at £50 in the first round. In 80% of these cases, the contestant then gave the correct answer. This difference is significant at the 5%-level: the p-value of a chi-squared test is 0.016.

	20		50		100		200		
Round 1			69	0.667	112	0.768	64	0.891	Bank
			353	0.799	160	0.788	55	0.836	No bank
			0.016^{*}		0.701		0.387^{-}		p-value
Round 2	21	0.714	96	0.635	95	0.684			
	544	0.719	279	0.695	93	0.753			
	0.964		0.278		0.297				
Round 3	32	0.406	82	0.622	82	0.598			
	477	0.608	193	0.720	56	0.732			
	0.024^{*}		0.107		0.103				
Round 4	48	0.646	102	0.510	64	0.750			
	425	0.609	146	0.678	33	0.636			
	0.623^{-}		0.008^{**}		0.242^{-}				
Round 5	51	0.569	102	0.490					
	375	0.571	106	0.472					
	0.978		0.790^{-}						
Round 6	69	0.493	84	0.393					
	305	0.531	75	0.600					
	0.564		0.009^{**}						
Round 7	95	0.421	66	0.470					
	238	0.504	46	0.522					
	0.170		0.588						
Round 8	172	0.471	35	0.429					
	112	0.473	15	0.600					
	0.970		0.266						

Table 12. Relation between banking and answering questions correctly

Again, we can do a chi-squared test for the joint significance of the 20 individual test statistics. This yields a p-value of 0.027. Thus, when looking at individual cells, we find a significant relation.

	20	**50**	**100**	**overall**
p-value	0.425	0.002	0.640	0.027

Table 13. Tests for joint significance

We can also test for the joint significance of the individual cells for a given amount of money on the chain. We do that in table 13. This yields an interesting result. The relationship we find is highly significant for banks at £50, but not at all for banks at £20 or £100. Thus, even though there is strong evidence that contestants do take their own knowledge into account when making a banking decision at £50, there is no statistical evidence whatsoever that they do the same at £20 or £100. We thus have the following:

Result 5. *There is a strongly significant relation between banking and the probability of answering a question correctly when the amount of money on the chain is £50. However, there is no such relation when that amount is at £20 or £100.*

This result is consistent with the following explanation. Suppose all contestants make an estimate of their own probability of answering a question correctly. All these estimates are in the range of say, 40% – 60%. To be willing to risk £20, for example, contestants feel that they want to be at least 30% sure that they know the right answer. This percentage is likely to be increasing with the amount of money on the chain. For the sake of argument, say it is 50% at £50, and 70% at £100. In this example, nobody will take the risk of not banking at £100, since nobody feels her knowledge is high enough to risk this amount.[26] Therefore, a statistical test will not find a significant relationship between banking at £100 and the probability of giving the right answer. The opposite is true at £20. Here, everybody feels confident enough to take the risk.[27] Again, a statistical test will not find a significant relationship. Yet, at £50, things are different. The contestants that estimate their own probability of answering a question correctly to be between 40% and 50% will bank, whereas those that estimate it to be between 50% and 60%, will not bank. In this case, if the estimates are correct, a statistical test will indeed find that contestants that do bank are less likely to give a correct answer than contestants that do not bank.

This discussion is summarized in figure 6. The horizontal axis gives a contestant's estimate of his own probability of answering a question correctly. The distribution of these probabilities is given by the curve. The cut-off points for £20, £50, and £100 are also given. Nobody wants to risk £100, since the cut-off here is above the upper bound of the distribution of perceived probabilities. Everybody wants to risk £20, since the cut-off here is below the lower bound of the distribution of perceived probabilities. At £50, the worse half of the contestants chooses to bank, whereas the better half chooses not to. This yields a significant relationship between banking and answering a question correctly.

Note that the results in this section confirm the discussion at the end of the previous section. Contestants fail to find the optimal solution to the maximization problem they face. Yet they do get the sign of the comparative statics right. They change their decision in the right direction when there is a change in the exogenous variables, which in this case is their own perceived knowledge. Also note the following. Throughout this section, we implicitly assumed that contestants make an estimate on their own ability in

[26] Admittedly, there are some people that do not bank at £100. This suggests that, in the real world, there is some noise in the decision making process described in this paragraph. Yet, our statistical tests suggest that the extent to which such 'mistakes' are made, is uncorrelated with the knowledge of the contestant.

[27] Admittedly, there is some banking at £20, suggesting some noise in the decision making process described in this paragraph. See previous footnote.

answering a question correctly. Using that estimate, we hypothesized, they decide whether or not to bank. Then we showed that, indeed, in many cases a decision to bank is followed more often by an incorrect answer than by a correct one. But this also implies that the estimates contestants make about their own ability are roughly correct. People that are more likely to answer the next question correctly, also have a higher estimate of their ability to do so. This higher estimate implies that they are less inclined to bank.

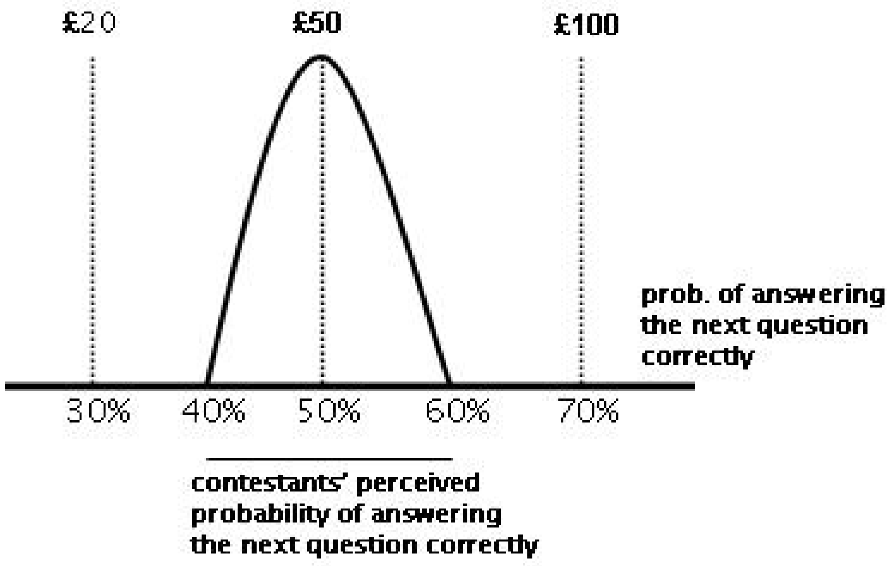

Figure 6. Explaining the outcome of the statistical tests

8. Conclusion

In this paper, we used the BBC game show *The Weakest Link* as a field experiment in rational decision making. We used the banking decision in that game, where a contestant chooses whether to secure a certain amount of money for her team, or to risk that money on a general knowledge question. In the latter case, should the contestant give the correct answer, the amount of money available increases substantially.

We argued that, when the objective of contestants is to maximize their expected winnings, the banking decision should depend on three things. A contestant should be more likely to bank when her general knowledge is better, when the difficulty of the questions is higher, and when the amount of money at stake increases. In this paper, we showed that all this is indeed the case. However, this does not imply that contestants are using the optimal banking strategy. Indeed, we showed that a simple rule of thumb already yields a substantial improvement on the banking behavior of the contestants. The true optimal banking strategy would therefore yield an improvement that is even higher.

Apparently, contestants on the show are boundedly rational. They do take the right variables into account when making their banking decision. When these variables change, they adapt their behavior in the correct direction. Yet, they fail to reach the optimum level of banking. In early rounds, contestants bank too often. But in later rounds, they do not bank often enough. Hence, although contestants do not choose the optimal decision rule, they also do not have a systematic bias relative to our simple rule of thumb, which in itself is also just a constrained optimum.

Of course, for contestants on the show, other concerns may also have an influence on banking behavior. For example, a contestant may be concerned that if she banks too early, she signals that she is not too confident about her own general knowledge, which may be a reason for the others to vote her off. But this is inconsistent with our findings. During earlier rounds, when establishing a reputation is still an issue, contestants bank too early rather than too late.

Also, different from what we assume, contestants may either be risk averse or risk loving. But that is also inconsistent with the results we find. When contestants are risk averse, they should consistently bank more often than the optimal strategy, which is based on risk neutrality, prescribes. When they are risk loving, they should consistently bank less often. Yet, what we find is that they bank more often in early rounds, and less often in later rounds.

The banking decision is not the only strategic decision that contestants have to make when playing *The Weakest Link*. The voting decision also affects their expected earnings. This decision also involves intriguing trade-offs. For example, when there are only three contestants left, voting for the most knowledgeable player increases the probability of ultimately winning the show. Yet, the most knowledgeable player is also the one most likely to substantially increase total prize money. Also, voting decisions seem to be dependent of each other. For example, casual observation suggests that a contestant is more likely to vote for someone who has voted for her in earlier rounds. This is consistent with the notion of fairness as used in e.g. Rabin (1993). In future work we plan to study voting decisions on *The Weakest Link.*

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