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# Deal or No Deal? Decision Making under Risk in a Large-Payoff Game Show

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*We examine the risky choices of contestants in the popular TV game show "Deal or No Deal" and related classroom experiments. Contrary to the traditional view of expected utility theory, the choices can be explained in large part by previous outcomes experienced during the game. Risk aversion decreases after earlier expectations have been shattered by unfavorable outcomes or surpassed by favorable outcomes. Our results point to reference-dependent choice theories such as prospect theory, and suggest that path-dependence is relevant, even when the choice problems are simple and well defined, and when large real monetary amounts are at stake.* (*JEL* D81)

A wide range of theories of risky choice have been developed, including the normative expected utility theory of John von Neumann and Oskar Morgenstern (1944) and the descriptive prospect theory of Daniel Kahneman and Amos Tversky (1979). Although risky choice is fundamental to virtually every branch of economics, empirical testing of these theories has proven to be difficult.

Many of the earliest tests such as those by Maurice Allais (1953), Daniel Ellsberg (1961), and the early work by Kahneman and Tversky were based on either thought experiments or answers to hypothetical questions. With the rising popularity of experimental economics, risky choice experiments with real monetary stakes have become more popular, but because of limited budgets most experiments are limited to small stakes. Some experimental studies try to circumvent this problem by using small nominal amounts in developing countries, so that the subjects face large amounts in real terms; see, for example, Hans P. Binswanger (1980, 1981) and Steven J. Kachelmeier and Mohamed Shehata (1992). Still, the stakes in these experiments are typically not larger than one month's income and thus do not provide evidence about risk attitudes regarding prospects that are significant in relation to lifetime wealth.

Nonexperimental empirical research is typically plagued by what amounts to "joint hypothesis" problems. Researchers cannot directly observe risk preferences for most real-life problems, because the true probability distribution is not known to the subjects and the subjects' beliefs

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are not known to the researcher. For example, to infer the risk attitudes of investors from their investment portfolios, one needs to know what their beliefs are regarding the joint return distribution of the relevant asset classes. Were investors really so risk averse that they required an equity premium of 7 percent per year, or were they surprised by an unexpected number of favorable events or worried about catastrophic events that never occurred? An additional complication arises because of the possible difference between risk and uncertainty: real-life choices rarely come with precise probabilities.

In order to circumvent these problems, some researchers analyze the behavior of contestants in TV game shows, for example "Card Sharks" (Robert H. Gertner 1993), "Jeopardy!" (Andrew Metrick 1995), "Illinois Instant Riches" (Philip L. Hersch and Gerald S. McDougall 1997), "Lingo" (Roel M. W. J. Beetsma and Peter C. Schotman 2001), "Hoosier Millionaire" (Connel R. Fullenkamp, Rafael A. Tenorio, and Robert H. Battalio 2003) and "Who Wants to be a Millionaire?" (Roger Hartley, Gauthier Lanot, and Ian Walker 2006). The advantage of game shows is that the amounts at stake are larger than in experiments and the decision problems are often simpler and better defined than in real life.

The game show we use in this study, "Deal or No Deal," has such desirable features that it almost appears to be designed to be an economics experiment rather than a TV show. Here is the essence of the game. A contestant is shown 26 briefcases which each contain a hidden amount of money, ranging from €0.01 to €5,000,000 (in the Dutch edition). The contestant picks one of the briefcases and then owns its unknown contents. Next, she selects 6 of the other 25 briefcases to open. Each opened briefcase reveals one of the 26 prizes that are *not* in her own briefcase. The contestant is then presented a "bank offer"—the opportunity to walk away with a sure amount of money—and asked the simple question: "Deal or No Deal?" If she says "No Deal," she has to open five more briefcases, followed by a new bank offer. The game continues in this fashion until the contestant either accepts a bank offer, or rejects all offers and receives the contents of her own briefcase. The bank offers depend on the value of the unopened briefcases; if, for example, the contestant opens high-value briefcases, the bank offer falls.

This game show seems well suited for analyzing risky choice. The stakes are very high and wide-ranging: contestants can go home as multimillionaires or practically empty-handed. Unlike other game shows, "Deal or No Deal" involves only simple stop-go decisions ("Deal" or "No Deal") that require minimal skill, knowledge, or strategy, and the probability distribution is simple and known with near-certainty (the bank offers are highly predictable, as discussed later). Finally, the game show involves multiple game rounds, and consequently seems particularly interesting for analyzing path-dependence, or the role of earlier outcomes. Thaler and Eric J. Johnson (1990) conclude that risky choice is affected by prior outcomes in addition to incremental outcomes, due to decision makers incompletely adapting to recent losses and gains. Although "Deal or No Deal" contestants never have to pay money out of their own pockets, they can suffer significant "paper" losses if they open high-value briefcases (causing the expected winnings to fall), and such losses may influence their subsequent choices. (Throughout this study we will use the term "outcomes" to indicate not only monetary pay-offs, but also new information or changed expectations.)

We examine the games of 151 contestants from the Netherlands, Germany, and the United States in 2002–2007. The game originated in the Netherlands and is now broadcast around the world. Although the format of "Deal or No Deal" is generally similar across all editions, there are some noteworthy differences. For example, in the daily versions from Italy, France, and Spain, the banker knows the amounts in the briefcases and may make informative offers, leading to strategic interaction between the banker and the contestant. In the daily edition from Australia, special game options known as "Chance" and "Supercase" are sometimes offered at the discretion of the game-show producer after a contestant has made a "Deal." These options would complicate our analysis, because the associated probability distribution is not known, introducing a layer of uncertainty in addition to the pure risk of the game. For these reasons, we limit our analysis to the games played in the Netherlands, Germany, and the United States.

The three editions have a very similar game format, apart from substantial variation in the amounts at stake. While the average prize that can be won in the Dutch edition is roughly €400,000, the averages in the German and US edition are roughly €25,000 and €100,000, respectively. At first sight, this makes the pooled dataset useful for separating the effect of the amounts at stake from the effect of prior outcomes. (Within one edition, the stakes are strongly confounded with prior outcomes.) However, cross-country differences in culture, wealth, and contestant selection procedure could confound the effect of stakes across the three editions. To isolate the effect of stakes on risky choice, we therefore conduct classroom experiments with a homogeneous student population. In these experiments, we vary the prizes with a factor of ten, so that we can determine if, for example, €100 has the same subjective value when it lies below or above the initial expectations.

Our findings are difficult to reconcile with expected utility theory. The contestants' choices appear to be driven in large part by the previous outcomes experienced during the game. Risk aversion seems to decrease after earlier expectations have been shattered by opening high-value briefcases, consistent with a "break-even effect." Similarly, risk aversion seems to decrease after earlier expectations have been surpassed by opening low-value briefcases, consistent with a "house-money effect."

The orthodox interpretation of expected utility of wealth theory does not allow for these effects, because subjects are assumed to have the same preferences for a given choice problem, irrespective of the path traveled before arriving at this problem. Our results point in the direction of reference-dependent choice theories, such as prospect theory, and indicate that path-dependence is relevant, even when large, real monetary amounts are at stake. We therefore propose a version of prospect theory with a path-dependent reference point as an alternative to expected utility theory.

Of course, we must be careful with rejecting expected utility theory and embracing alternatives like prospect theory. Although the standard implementation of expected utility theory is unable to explain the choices of losers and winners, a better fit could be achieved with a nonstandard utility function that has convex segments (as proposed by, for example, Milton Friedman and Leonard J. Savage 1948, and Harry Markowitz 1952), and depends on prior outcomes. Therefore, this study does not reject or accept any theory. Rather, our main finding is the important role of reference-dependence and path-dependence, phenomena that are not standard in typical implementations of expected utility, but common in prospect theory. Any plausible explanation of the choice behavior in the game will have to account for these phenomena. A theory with static preferences cannot explain why variation of the stakes due to the subject's fortune during the game has a much stronger effect than variation in the initial stakes across different editions of the TV show and experiments.

The remainder of this paper is organized as follows. In Section I, we describe the game show in greater detail. Section II discusses our data material. Section III provides a first analysis of the risk attitudes in "Deal or No Deal" by examining the bank offers and the contestants' decisions to accept ("Deal") or reject ("No Deal") these offers. Section IV analyzes the decisions using expected utility theory with a general, flexible-form expo-power utility function. Section V analyzes the decisions using prospect theory with a simple specification that allows for partial adjustment of the subjective reference point that separates losses from gains. This implementation of prospect theory explains a material part of what expected utility theory leaves unexplained. Section VI reports results from classroom experiments in which students play "Deal or No Deal." The experiments confirm the important role of previous outcomes and suggest that the isolated effect of the amounts at stake is limited compared to the isolated effect of previous outcomes. Section VII offers concluding remarks and suggestions for future research. Finally, an epilogue gives a synopsis of other "Deal or No Deal" studies that became available after our study was first submitted to this journal in October 2005.

## I. Description of the Game Show

The TV game show "Deal or No Deal" was developed by the Dutch production company Endemol and was first aired in the Netherlands in December 2002. The game show soon became very popular and was exported to dozens of other countries, including Germany and the United States. The following description applies to the Dutch episodes of "Deal or No Deal." Except for the monetary amounts, the structure of the main game is similar in the German and US versions used in this study.

Each episode consists of two parts: an elimination game based on quiz questions in order to select one finalist from the audience, and a main game in which this finalist plays "Deal or No Deal." Audience members have not been subjected to an extensive selection procedure: players in the national lottery sponsoring the show are invited to apply for a seat and tickets are subsequently randomly distributed to applicants. Only the main game is the subject of our study. Except for determining the identity of the finalist, the elimination game does not influence the course of the main game. The selected contestant has not won any prize before entering the main game.

The main game starts with a fixed and known set of 26 monetary amounts ranging from €0.01 to €5,000,000, which have been randomly allocated over 26 numbered and closed briefcases. One of the briefcases is selected by the contestant and this briefcase is not to be opened until the end of the game.

The game is played over a maximum of nine rounds. In each round, the finalist chooses one or more of the other 25 briefcases to be opened, revealing the prizes inside. Next, a "banker" tries to buy the briefcase from the contestant by making her an offer. Contestants have a few minutes to evaluate the offer and to decide between "Deal" and "No Deal," and may consult a friend or relative who sits nearby.[1] The remaining prizes and the current bank offer are displayed on a scoreboard and need not be memorized by the contestant. If the contestant accepts the offer ("Deal"), she walks away with this sure amount and the game ends; if the contestant rejects the offer ("No Deal"), the game continues and she enters the next round.

In the first round, the finalist has to select six briefcases to be opened, and the first bank offer is based on the remaining 20 prizes. The numbers of briefcases to be opened in the maximum of eight subsequent rounds are 5, 4, 3, 2, 1, 1, 1, and 1. Accordingly, the number of prizes left in the game decreases to 15, 11, 8, 6, 5, 4, 3, and 2. If the contestant rejects all nine offers she receives the prize in her own briefcase. Figure 1 illustrates the basic structure of the main game.

To provide further intuition for the game, Figure 2 shows a typical example of how the main game is displayed on the TV screen. A close-up of the contestant is shown in the center and the original prizes are listed to the left and the right of the contestant. Eliminated prizes are shown in a dark color and remaining prizes are in a bright color. The bank offer is displayed at the top of the screen.

As can be seen on the scoreboard, the initial prizes are highly dispersed and positively skewed. During the course of the game, the dispersion and the skewness generally fall as more and more briefcases are opened. In fact, in the ninth round, the distribution is perfectly symmetric, because the contestant then faces a 50/50 gamble with two remaining briefcases.

[1] In the US version and in the second German series, three or four friends and/or relatives sit on stage nearby the contestant. In the Dutch version and in the first German series, only one person accompanies the contestant.

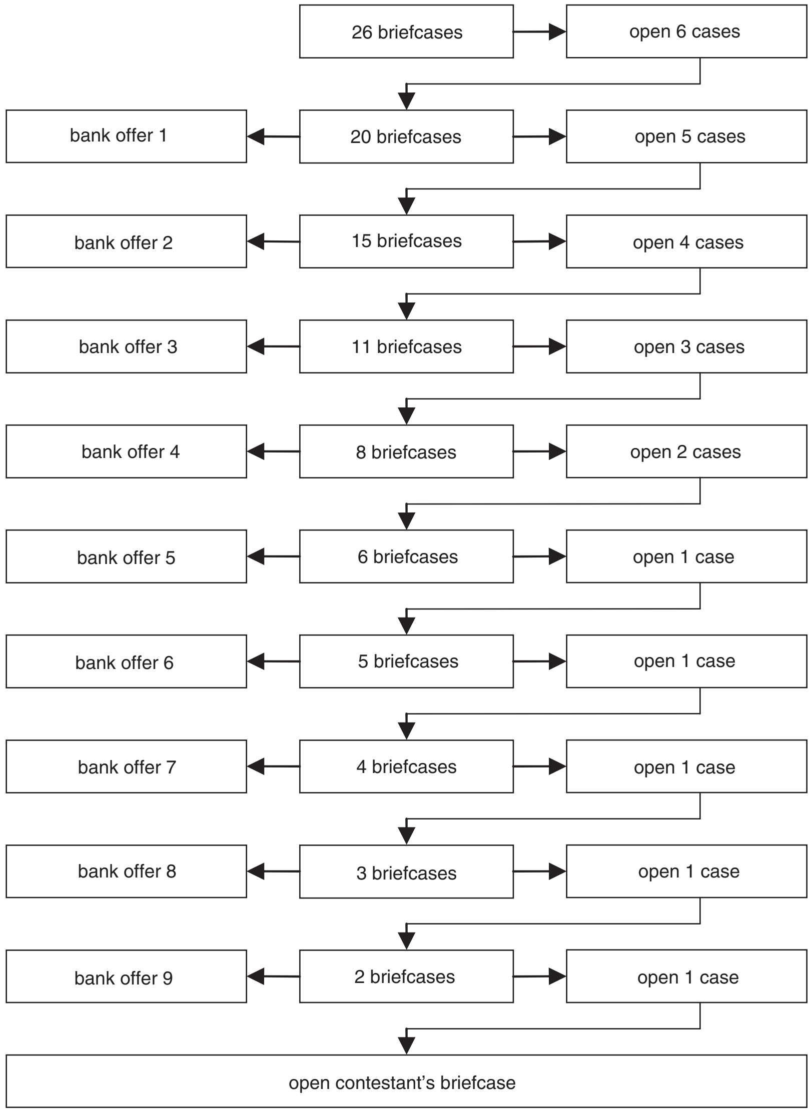


Figure 1. Flow Chart of the Main Game

*Notes:* In each round, the finalist chooses a number of briefcases to be opened, each giving new information about the unknown prize in the contestant's own briefcase. After the prizes in the chosen briefcases are revealed, a "bank offer" is presented to the finalist. If the contestant accepts the offer ("Deal"), she walks away with the amount offered and the game ends; if the contestant rejects the offer ("No Deal"), play continues and she enters the next round. If the contestant decides "No Deal" in the ninth round, she receives the prize in her own briefcase. The flow chart applies to the Dutch and US editions and the second German series. The first German series involves one fewer game round and starts with 20 briefcases.

### A. *Bank Behavior*

Although the contestants do not know the exact bank offers in advance, the banker behaves consistently according to a clear pattern. Four simple rules of thumb summarize this pattern:

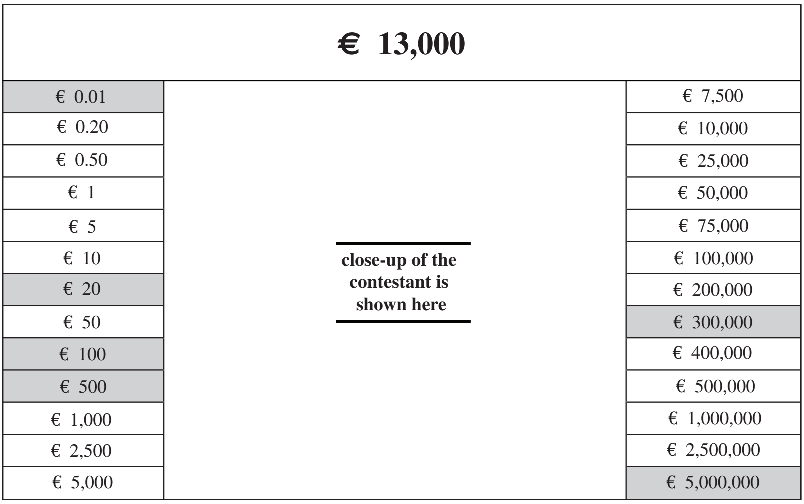


FIGURE 2. EXAMPLE OF THE MAIN GAME AS DISPLAYED ON THE TV SCREEN

*Notes:* A close-up of the contestant is shown in the center of the screen. The possible prizes are listed in the columns to the left and right of the contestant. Prizes eliminated in earlier rounds are shown in a dark color and remaining prizes are in a bright color. The top bar above the contestant shows the bank offer. This example demonstrates the two options open to the contestant after opening six briefcases in the first round: accept a bank offer of €13,000 or continue to play with the remaining 20 briefcases, one of which is the contestant's own. This example reflects the prizes in the Dutch episodes.

Rule 1. Bank offers depend on the value of the unopened briefcases: when the lower (higher) prizes are eliminated, the average remaining prize increases (decreases) and the banker makes a better (worse) offer.

Rule 2. The offer typically starts at a low percentage (usually less than 10 percent) of the average remaining prize in the first round and gradually increases to 100 percent in the later rounds. This strategy obviously serves to encourage contestants to continue playing the game and to gradually increase excitement.

Rule 3. The offers are not informative, that is, they cannot be used to determine which of the remaining prizes is in the contestant's briefcase. Only an independent auditor knows the distribution of the prizes over the briefcases. Indeed, there is no correlation between the percentage bank offer and the relative value of the prize in the contestant's own briefcase.

Rule 4. The banker is generous to losers by offering a relatively high percentage of the average remaining prize. This pattern is consistent with path-dependent risk attitudes. If the game-show producer understands that risk aversion falls after large losses, he may understand that high offers are needed to avoid trivial choices and to keep the game entertaining to watch. Using the same reasoning, we may also expect a premium after large gains; this, however, does not occur, perhaps because with large stakes, the game is already entertaining.

Section III gives descriptive statistics on the bank offers in our sample and Section IV presents a simple model that captures the rules of thumb noted above. The key finding is that the bank offers are highly predictable.

## II. Data

We examine all "Deal or No Deal" decisions of 151 contestants appearing in episodes aired in the Netherlands (51), Germany (47), and the United States (53).

The Dutch edition of "Deal or No Deal" is called *"Miljoenenjacht"* (or "Chasing Millions"). The first Dutch episode was aired on December 22, 2002, and the last in our sample dates from January 1, 2007. In this time span, the game show was aired 51 times, divided over eight series of weekly episodes and four individual episodes aired on New Year's Day, with one contestant per episode. A distinguishing feature of the Dutch edition is the high amounts at stake: the average prize equals roughly €400,000 (€391,411 in episode 1–47 and €419,696 in episode 48–51). Contestants may even go home with €5,000,000. The fact that the Dutch edition is sponsored by a national lottery probably explains why the Dutch format has such large prizes. The large prizes may also have been preferred to stimulate a successful launch of the show and to pave the way for exporting the formula abroad. Part of the 51 shows were recorded on videotape by the authors and tapes of the remaining shows were obtained from the Dutch broadcasting company *TROS*.

In Germany, a first series of *"Deal or No Deal—Die Show der GlücksSpirale"* started on June 23, 2005, and a second series began June 28, 2006.[2] Apart from the number of prizes, the two series are very similar. The first series uses 20 prizes instead of 26 and is played over a maximum of 8 game rounds instead of 9. Because these 8 rounds are exactly equal to round 2–9 of the regular format in terms of the number of remaining prizes and in terms of the number of briefcases that have to be opened, we can analyze this series as if the first round has been skipped. Both series have the same maximum prize (€250,000) and the averages of the initial set of prizes are practically equal (€26,347 versus €25,003, respectively). In the remainder of the paper we will consider the two German series as one combined subsample. The first series was broadcast weekly and lasted for 10 episodes, each with two contestants playing the game sequentially. The second series was aired either once or twice a week and lasted for 27 episodes, with one contestant per episode, bringing the total number of German contestants in our sample to 47. Copies of the first series were obtained from TV station *Sat*.1 and from Endemol's local production company Endemol Deutschland. The second series was recorded by a friend of the authors.

In the United States, the game show debuted on December 19, 2005, for five consecutive nights and returned on TV on February 27, 2006. This second series lasted for 34 episodes until early June 2006. The 39 episodes combined covered the games of 53 contestants, with some contestants starting in one episode and continuing their game in the next. The regular US format has a maximum initial prize of $1,000,000 (roughly €800,000) and an average of $131,478 (€105,182). In the games of six contestants, however, the top prizes and averages were larger to mark the launch and the finale of the second series. All US shows were recorded by the authors. US dollars are translated into euros by using a single fixed rate of €0.80 per $ (the actual exchange rate was within 5 percent of this rate for both the 2005 and 2006 periods).

For each contestant, we collected data on the eliminated and remaining prizes, the bank offers, and the "Deal or No Deal" decisions in every game round, leading to a panel dataset with a time-series dimension (the game rounds) and a cross-section dimension (the contestants).

We also collected data on each contestant's gender, age, and education. Age and education are often revealed in an introductory talk or in other conversations during the game. The level of education is coded as a dummy variable, with a value of 1 assigned to contestants with a bachelor degree level or higher (including students) or equivalent work experience. Although a contestant's level of education is usually not explicitly mentioned, it is often clear from the

[2] An earlier edition called "*Der MillionenDeal*" started on May 1, 2004. The initial average prize was €237,565 and the largest prize was €2,000,000. This edition however lasted for only 6 episodes and is therefore not included here.

Table 1—Summary Statistics

| | Mean | St. dev. | Min. | Median | Max. |
|---|---|---|---|---|---|
| *A. Netherlands* ($N = 51$) | | | | | |
| Age (years) | 45.31 | 11.51 | 21.00 | 43.00 | 70.00 |
| Gender (female = 1) | 0.27 | 0.45 | 0.00 | 0.00 | 1.00 |
| Education (high = 1) | 0.55 | 0.50 | 0.00 | 1.00 | 1.00 |
| Stop Round | 5.22 | 1.75 | 3.00 | 5.00 | 10.00 |
| Best Offer Rejected (percent) | 55.89 | 32.73 | 10.17 | 55.32 | 119.88 |
| Offer Accepted (percent) | 76.27 | 30.99 | 20.77 | 79.29 | 165.50 |
| Amount Won (€) | 227,264.90 | 270,443.20 | 10.00 | 148,000.00 | 1,495,000.00 |
| *B. Germany* ($N = 47$) | | | | | |
| Age (years) | 36.47 | 8.17 | 20.00 | 35.00 | 55.00 |
| Gender (female = 1) | 0.34 | 0.48 | 0.00 | 0.00 | 1.00 |
| Education (high = 1) | 0.47 | 0.50 | 0.00 | 0.00 | 1.00 |
| Stop Round | 8.21 | 1.53 | 5.00 | 8.00 | 10.00 |
| Best Offer Rejected (percent) | 89.07 | 33.90 | 37.31 | 88.22 | 190.40 |
| Offer Accepted (percent) | 91.79 | 19.15 | 52.78 | 95.99 | 149.97 |
| Amount Won (€) | 20,602.56 | 25,946.69 | 0.01 | 14,700.00 | 150,000.00 |
| *C. United States* ($N = 53$) | | | | | |
| Age (years) | 34.98 | 10.03 | 22.00 | 33.00 | 76.00 |
| Gender (female = 1) | 0.57 | 0.50 | 0.00 | 1.00 | 1.00 |
| Education (high = 1) | 0.49 | 0.50 | 0.00 | 0.00 | 1.00 |
| Stop Round | 7.70 | 1.29 | 5.00 | 8.00 | 10.00 |
| Best Offer Rejected (percent) | 80.98 | 17.57 | 44.04 | 83.52 | 112.00 |
| Offer Accepted (percent) | 91.43 | 15.31 | 49.16 | 97.83 | 112.50 |
| Amount Won ($) | 122,544.58 | 119,446.18 | 5.00 | 94,000.00 | 464,000.00 |

*Notes:* The table shows descriptive statistics for our sample of 151 contestants from the Netherlands (51; panel A), Germany (47; panel B) and the United States (53; panel C). The contestants' characteristics, age and education, are revealed in an introductory talk or in other conversations between the host and the contestant. Age is measured in years. Gender is a dummy variable with a value of one assigned to females. Education is a dummy variable that takes a value of one for contestants with a bachelor degree or higher (including students) or equivalent work experience. Stop Round is the round number in which the bank offer is accepted. The round numbers from the first series of German episodes are adjusted by +1 to correct for the lower initial number of briefcases and game rounds; for contestants who played the game to the end, the stop round is set equal to 10. Best Offer Rejected is the highest percentage bank offer the contestant chose to reject ("No Deal"). Offer Accepted is the percentage bank offer accepted by the contestant ("Deal"), or 100 percent for contestants who rejected all offers. Amount Won equals the accepted bank offer in monetary terms, or the prize in the contestant's own briefcase for contestants who rejected all offers.

stated profession. We estimate the missing values for age based on the physical appearance of the contestant and information revealed in the introductory talk, for example, the age of children. However, age, gender, and education do not have significant explanatory power in our analysis. In part or in whole, this may reflect a lack of sampling variation. For example, during the game, the contestant is permitted to consult with friends, family members, or spouse, and therefore decisions in this game are in effect taken by a couple or a group, mitigating the role of the individual contestant's age, gender or education. For the sake of brevity, we will pay no further attention to the role of contestant characteristics. Moreover, prior outcomes are random and unrelated to characteristics, and therefore the characteristics probably would not affect our main conclusions about path-dependence, even if they would affect the level of risk aversion.

Table 1 shows summary statistics for our sample. Compared to the German and US contestants, the Dutch contestants on average accept lower percentage bank offers (76.3 percent versus 91.8 and 91.4 percent) and play roughly three fewer game rounds (5.2 versus 8.2 and 7.7 rounds). These differences may reflect unobserved differences in risk aversion due to differences in wealth, culture, or contestant selection procedure. In addition, increasing relative risk aversion (IRRA) may help to explain the differences. As the Dutch edition involves much larger stakes than the German and US editions, a modest increase in relative risk aversion suffices to yield

Table 2—Bank Offers and Contestants' Decisions

| | Unconditional | | | "Deal" | | | "No Deal" | | |
|---|---|---|---|---|---|---|---|---|---|
| Round | % BO | Stakes | No. | % BO | Stakes | No. | % BO | Stakes | No. |
| *A. Netherlands* ($N = 51$) | | | | | | | | | |
| 1 | 6 | 387,867 | 51 | — | — | 0 | 6 | 387,867 | 51 |
| 2 | 14 | 376,664 | 51 | — | — | 0 | 14 | 376,664 | 51 |
| 3 | 34 | 369,070 | 51 | 36 | 409,802 | 10 | 33 | 359,135 | 41 |
| 4 | 61 | 348,820 | 41 | 69 | 394,860 | 11 | 58 | 331,939 | 30 |
| 5 | 77 | 317,618 | 30 | 82 | 557,680 | 7 | 76 | 244,555 | 23 |
| 6 | 88 | 234,877 | 23 | 90 | 237,416 | 12 | 87 | 232,107 | 11 |
| 7 | 98 | 243,868 | 11 | 104 | 414,106 | 6 | 91 | 39,582 | 5 |
| 8 | 96 | 50,376 | 5 | 100 | 78,401 | 3 | 90 | 8,338 | 2 |
| 9 | 106 | 11,253 | 2 | 91 | 17,500 | 1 | 120 | 5,005 | 1 |
| *B. Germany* ($N = 47$) | | | | | | | | | |
| 1 | 8 | 24,277 | 27 | — | — | 0 | 8 | 24,277 | 27 |
| 2 | 15 | 24,915 | 47 | — | — | 0 | 15 | 24,915 | 47 |
| 3 | 34 | 23,642 | 47 | — | — | 0 | 34 | 23,642 | 47 |
| 4 | 46 | 21,218 | 47 | — | — | 0 | 46 | 21,218 | 47 |
| 5 | 59 | 22,304 | 47 | 59 | 29,976 | 2 | 59 | 21,963 | 45 |
| 6 | 72 | 20,557 | 45 | 67 | 48,038 | 7 | 73 | 15,494 | 38 |
| 7 | 88 | 15,231 | 38 | 85 | 21,216 | 5 | 88 | 14,324 | 33 |
| 8 | 98 | 15,545 | 33 | 91 | 28,813 | 10 | 101 | 9,776 | 23 |
| 9 | 103 | 14,017 | 23 | 109 | 13,925 | 11 | 99 | 14,101 | 12 |
| *C. United States* ($N = 53$) | | | | | | | | | |
| 1 | 11 | 152,551 | 53 | — | — | 0 | 11 | 152,551 | 53 |
| 2 | 21 | 151,885 | 53 | — | — | 0 | 21 | 151,885 | 53 |
| 3 | 36 | 147,103 | 53 | — | — | 0 | 36 | 147,103 | 53 |
| 4 | 50 | 148,299 | 53 | — | — | 0 | 50 | 148,299 | 53 |
| 5 | 62 | 148,832 | 53 | 79 | 118,517 | 1 | 61 | 150,434 | 52 |
| 6 | 73 | 150,549 | 52 | 74 | 139,421 | 9 | 73 | 152,879 | 43 |
| 7 | 88 | 154,875 | 43 | 91 | 204,263 | 15 | 86 | 128,416 | 28 |
| 8 | 92 | 114,281 | 28 | 96 | 183,917 | 14 | 88 | 44,644 | 14 |
| 9 | 98 | 39,922 | 14 | 99 | 53,825 | 8 | 97 | 21,384 | 6 |

*Notes:* The table shows summary statistics for the percentage bank offers and contestants' decisions in our sample of 151 contestants from the Netherlands (51; panel A), Germany (47; panel B) and the United States (53; panel C). The average bank offer as a percentage of the average remaining prize (% BO), the average remaining prize in euros (stakes), and the number of contestants (No.) are reported for each game round ($r = 1, \ldots, 9$). The statistics are also shown separately for contestants accepting the bank offer ("Deal") and for contestants rejecting the bank offer ("No Deal"). The round numbers from the first series of German episodes are adjusted by +1 to correct for the lower initial number of briefcases and game rounds.

sizeable differences in the accepted percentages. Furthermore, the observed differences in the number of rounds played are inflated by the behavior of the banker. The percentage bank offer increases with relatively small steps in the later game rounds and consequently a modest increase in relative risk aversion can yield a large reduction in the number of game rounds played. Thus, the differences between the Dutch contestants on the one hand and the German and US contestants on the other hand are consistent with moderate IRRA.

## A. *Cross-Country Analysis*

Apart from the amounts at stake, the game show format is very similar in the three countries. Still, there are some differences in how contestants are chosen to play that may create differences in the contestant pool. In the Dutch and German episodes in our sample there is a preliminary game in which contestants answer quiz questions, the winner of which gets to play the main game we study. One special feature of the Dutch edition is the existence of a "bail-out offer" at the end of the elimination game: just before a last, decisive question, the two remaining contestants can avoid losing and leaving empty-handed by accepting an unknown prize that is announced to be worth at least €20,000 (approximately 5 percent of the average prize in the main game) and typically turns out to be a prize such as a world trip or a car. If the more risk-averse pre-finalists are more likely to exit the game at this stage, the Dutch finalists might be expected to be less risk averse on average. In the United States, contestants are not selected based on an elimination game but rather the producer selects each contestant individually, and the selection process appears to be based at least in part on the appearance and personalities of the contestants. (The Web site for the show tells prospective contestants to send a video of themselves and their proposed accompanying friends and relatives. The show also conducts open "casting calls.") Contestants (and their friends) thus tend to be attractive and lively. Another concern is that richer and more risk-seeking people may be more willing to spend time attempting to get onto large-stake editions than onto small-stake editions. To circumvent these problems, Section VI complements the analysis of the TV shows with classroom experiments that use a homogeneous student population.

## III. Preliminary Analysis

To get a first glimpse of the risk preferences in "Deal or No Deal," we analyze the offers made by the banker, and the contestants' decisions to accept or reject these offers in the various game rounds.

Several notable features of the game can be seen in Table 2. First, the banker becomes more generous by offering higher percentages as the game progresses ("Rule 2"). The offers typically start at a small fraction of the average prize and approach 100 percent in the later rounds. The strong similarity between the percentages in the Dutch edition (panel A), the German edition (panel B), and the US edition (panel C) suggest that the banker behaves in a similar way across the three editions.[3] The number of remaining contestants in every round clearly shows that the Dutch contestants tend to stop earlier and accept relatively lower bank offers than the German and US contestants do. Again, this may reflect the substantially larger stakes in the Dutch edition, or, alternatively, unobserved differences in risk aversion due to differences in wealth, culture, or contestant selection procedure. Third, the contestants generally exhibit what might be called only "moderate" risk aversion. In the US and German sample, all contestants keep playing until the bank offer is at least half the expected value of the prizes in the unopened briefcases. In round 3 in the Netherlands, 20 percent of the contestants (10 out of 51) do accept deals that average only 36 percent of the expected value of the unopened briefcases, albeit at stakes that exceed €400,000. Many contestants turn down offers of 70 percent or more of amounts exceeding €100,000. Fourth, there can be wide discrepancies, even within a country, in the stakes that contestants face. In the Dutch show, contestants can be playing for many hundreds of thousands of euros, down to a thousand or less. In the later rounds, the contestant is likely to face relatively small stakes, as a consequence of the skewness of the initial set of prizes.

It is not apparent from this table what effect the particular path a player takes can have on the choices she makes. To give an example of the decisions faced by an unlucky player, consider poor Frank, who appeared in the Dutch episode of January 1, 2005 (see Table 3). In round 7, after several unlucky picks, Frank opened the briefcase with the last remaining large prize (€500,000) and saw the expected prize tumble from €102,006 to €2,508. The banker then offered

[3] A spokesman from Endemol, the production company, confirmed that the guidelines for bank offers are the same for all three editions included in our sample.

Table 3—Example "Frank"

| | Game round ($r$) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Prize (€) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 0.01 | x | x | | | | | | | |
| 0.20 | x | x | | | | | | | |
| 0.50 | x | x | x | x | x | x | x | | |
| 1 | x | x | x | x | x | | | | |
| 5 | | | | | | | | | |
| 10 | x | x | x | x | x | x | x | x | x |
| 20 | x | x | x | x | x | x | x | x | |
| 50 | | | | | | | | | |
| 100 | | | | | | | | | |
| 500 | | | | | | | | | |
| 1,000 | x | | | | | | | | |
| 2,500 | x | x | x | | | | | | |
| 5,000 | x | x | | | | | | | |
| 7,500 | | | | | | | | | |
| 10,000 | x | x | x | x | x | x | x | x | x |
| 25,000 | x | x | | | | | | | |
| 50,000 | x | x | x | x | | | | | |
| 75,000 | x | x | x | | | | | | |
| 100,000 | x | x | x | | | | | | |
| 200,000 | x | x | x | x | | | | | |
| 300,000 | x | | | | | | | | |
| 400,000 | x | | | | | | | | |
| 500,000 | x | x | x | x | x | x | | | |
| 1,000,000 | x | | | | | | | | |
| 2,500,000 | | | | | | | | | |
| 5,000,000 | x | | | | | | | | |
| Average (€) | 383,427 | 64,502 | 85,230 | 95,004 | 85,005 | 102,006 | 2,508 | 3,343 | 5,005 |
| Offer (€) | 17,000 | 8,000 | 23,000 | 44,000 | 52,000 | 75,000 | 2,400 | 3,500 | 6,000 |
| Offer (percent) | 4 percent | 12 percent | 27 percent | 46 percent | 61 percent | 74 percent | 96 percent | 105 percent | 120 percent |
| Decision | No deal | No deal | No deal | No deal | No deal | No deal | No deal | No deal | No deal |

*Notes:* The table shows the gambles presented to a Dutch contestant named Frank and the "Deal or No Deal" decisions made by him in game rounds 1–9. This particular episode was broadcast on January 1, 2005. For each game round, the table shows the remaining prizes, the average remaining prize, the bank offer, the percentage bank offer, and the "Deal or No Deal" decision. Frank ended up with a prize of €10.

him €2,400, or 96 percent of the average remaining prize. Frank rejected this offer and play continued. In the subsequent rounds, Frank deliberately chose to enter unfair gambles, to finally end up with a briefcase worth only €10. Specifically, in round 8, he rejected an offer of 105 percent of the average remaining prize; in round 9, he even rejected a certain €6,000 in favor of a 50/50 gamble of €10 or €10,000. We feel confident to classify this last decision as risk-seeking behavior, because it involves a single, simple, symmetric gamble with thousands of euros at stake. Also, unless we are willing to assume that Frank would always accept unfair gambles of this magnitude, the only reasonable explanation for his choice behavior seems to be a reaction to his misfortune experienced earlier in the game.

In contrast, consider the exhilarating ride of Susanne, an extremely fortunate contestant who appeared in the German episode of August 23, 2006 (see Table 4). After a series of very lucky picks, she eliminated the last small prize of €1,000 in round 8. In round 9, she then faced a 50/50 gamble of €100,000 or €150,000, two of the three largest prizes in the German edition. While she was concerned and hesitant in the earlier game rounds, she decidedly rejected the bank offer of €125,000, the expected value of the gamble; a clear display of risk-seeking behavior and one that proved fortuitous in this case, as she finally ended up winning €150,000.

Thus both unlucky Frank and lucky Susanne exhibit very low levels of risk aversion, even risk-seeking, whereas most of the contestants in the shows are at least moderately risk averse.

TABLE 4—EXAMPLE "SUSANNE"

| | Game round ($r$) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Prize (€) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 0.01 | x | x | x | x | | | | | |
| 0.20 | x | x | x | | | | | | |
| 0.50 | x | x | x | x | x | x | x | | |
| 1 | | | | | | | | | |
| 5 | | | | | | | | | |
| 10 | | | | | | | | | |
| 20 | x | x | | | | | | | |
| 50 | x | x | | | | | | | |
| 100 | x | x | x | x | | | | | |
| 200 | | | | | | | | | |
| 300 | x | x | x | | | | | | |
| 400 | x | | | | | | | | |
| 500 | | | | | | | | | |
| 1,000 | x | x | x | x | x | x | x | x | |
| 2,500 | x | x | x | x | x | x | | | |
| 5,000 | x | | | | | | | | |
| 7,500 | | | | | | | | | |
| 10,000 | x | x | | | | | | | |
| 12,500 | x | x | x | | | | | | |
| 15,000 | x | | | | | | | | |
| 20,000 | x | x | | | | | | | |
| 25,000 | x | x | x | x | x | | | | |
| 50,000 | x | | | | | | | | |
| 100,000 | x | x | x | x | x | x | x | x | x |
| 150,000 | x | x | x | x | x | x | x | x | x |
| 250,000 | x | | | | | | | | |
| Average (€) | 32,094 | 21,431 | 26,491 | 34,825 | 46,417 | 50,700 | 62,750 | 83,667 | 125,000 |
| Offer (€) | 3,400 | 4,350 | 10,000 | 15,600 | 25,000 | 31,400 | 46,000 | 75,300 | 125,000 |
| Offer (percent) | 11 percent | 20 percent | 38 percent | 45 percent | 54 percent | 62 percent | 73 percent | 90 percent | 100 percent |
| Decision | No deal | No deal | No deal | No deal | No deal | No deal | No deal | No deal | No deal |

*Notes:* The table shows the gambles presented to a German contestant named Susanne and the "Deal or No Deal" decisions made by her in game rounds 1–9. This particular episode was broadcast on August 23, 2006. For each game round, the table shows the remaining prizes, the average remaining prize, the bank offer, the percentage bank offer, and the "Deal or No Deal" decision. Susanne ended up with a prize of €150,000.

Frank's behavior is consistent with a "break-even" effect, a willingness to gamble in order to get back to some perceived reference point. Susanne's behavior is consistent with a "house-money" effect, an increased willingness to gamble when someone thinks she is playing with "someone else's money."

To systematically analyze the effect of prior outcomes such as the extreme ones experienced by Frank and Suzanne, we first develop a rough classification of game situations in which the contestant is classified as a "loser" or a "winner" and analyze the decisions of contestants in these categories separately.

Our classification takes into account the downside risk and upside potential of rejecting the current bank offer. A contestant is a loser if her average remaining prize after opening one additional briefcase is low, even if the best-case scenario of eliminating the lowest remaining prize would occur. Using $\overline{x}_r$ for the current average, the average remaining prize in the best-case scenario is:

$$BC_r = \frac{n_r \overline{x}_r - x_r^{\min}}{n_r - 1}, \tag{1}$$

where $n_r$ stands for the number of remaining briefcases in game round $r = 1, \cdots, 9$ and $x_r^{\min}$ for the smallest remaining prize. Similarly, winners are classified by the average remaining prize in the worst-case scenario of eliminating the largest remaining prize, $x_r^{\max}$:

TABLE 5—"DEAL OR NO DEAL" DECISIONS AFTER BAD AND GOOD FORTUNE

| | Loser | | | Neutral | | | Winner | | |
|---|---|---|---|---|---|---|---|---|---|
| Round | % BO | No. | % D | % BO | No. | % D | % BO | No. | % D |
| *A. Netherlands* ($N = 51$) | | | | | | | | | |
| 1 | 6 | 17 | 0 | 6 | 17 | 0 | 6 | 17 | 0 |
| 2 | 15 | 17 | 0 | 12 | 17 | 0 | 15 | 17 | 0 |
| 3 | 40 | 17 | 12 | 29 | 17 | 41 | 31 | 17 | 6 |
| 4 | 69 | 14 | 14 | 58 | 13 | 46 | 54 | 14 | 21 |
| 5 | 82 | 10 | 10 | 71 | 10 | 20 | 78 | 10 | 40 |
| 6 | 94 | 8 | 50 | 85 | 7 | 43 | 86 | 8 | 63 |
| 7 | 99 | 4 | 25 | 97 | 3 | 67 | 99 | 4 | 75 |
| 8 | 105 | 1 | 0 | 91 | 3 | 67 | 100 | 1 | 100 |
| 9 | 120 | 1 | 0 | — | 0 | — | 91 | 1 | 100 |
| 2–9 | | 72 | 14 | | 70 | 31 | | 72 | 25 |
| *B. Germany* ($N = 47$) | | | | | | | | | |
| 1 | 7 | 9 | 0 | 7 | 9 | 0 | 8 | 9 | 0 |
| 2 | 16 | 16 | 0 | 13 | 15 | 0 | 14 | 16 | 0 |
| 3 | 35 | 16 | 0 | 33 | 15 | 0 | 33 | 16 | 0 |
| 4 | 46 | 16 | 0 | 44 | 15 | 0 | 47 | 16 | 0 |
| 5 | 65 | 16 | 0 | 54 | 15 | 13 | 57 | 16 | 0 |
| 6 | 83 | 15 | 0 | 67 | 15 | 20 | 66 | 15 | 27 |
| 7 | 107 | 13 | 0 | 80 | 12 | 25 | 76 | 13 | 15 |
| 8 | 117 | 11 | 0 | 89 | 11 | 55 | 86 | 11 | 36 |
| 9 | 107 | 8 | 38 | 106 | 7 | 57 | 98 | 8 | 50 |
| 2–9 | | 111 | 3 | | 105 | 17 | | 111 | 13 |
| *C. United States* ($N = 53$) | | | | | | | | | |
| 1 | 9 | 18 | 0 | 10 | 17 | 0 | 13 | 18 | 0 |
| 2 | 19 | 18 | 0 | 19 | 17 | 0 | 25 | 18 | 0 |
| 3 | 41 | 18 | 0 | 29 | 17 | 0 | 39 | 18 | 0 |
| 4 | 57 | 18 | 0 | 42 | 17 | 0 | 51 | 18 | 0 |
| 5 | 69 | 18 | 0 | 55 | 17 | 6 | 62 | 18 | 0 |
| 6 | 78 | 18 | 11 | 68 | 16 | 31 | 73 | 18 | 11 |
| 7 | 92 | 15 | 27 | 87 | 13 | 23 | 84 | 15 | 53 |
| 8 | 94 | 9 | 22 | 95 | 10 | 70 | 87 | 9 | 56 |
| 9 | 92 | 4 | 50 | 101 | 6 | 67 | 99 | 4 | 50 |
| 2–9 | | 118 | 8 | | 113 | 18 | | 118 | 14 |

*Notes:* The table summarizes the "Deal or No Deal" decisions for our sample of 151 contestants from the Netherlands (51; panel A), Germany (47; panel B) and the United States (53; panel C). The samples are split based on the fortune experienced by contestants during the game. A contestant is classified as a "loser" if her average remaining prize after eliminating the lowest remaining prize is among the worst one-third for all contestants in the same game round; she is a "winner" if the average after eliminating the largest remaining prize is among the best one-third. For each category and game round, the table displays the percentage bank offer ("% BO"), the number of contestants ("No.") and the percentage of contestants choosing "Deal" ("% D"). The round numbers from the first series of German episodes are adjusted by +1 to correct for the lower initial number of briefcases and game rounds.

$$WC_r = \frac{n_r \bar{x}_r - x_r^{\max}}{n_r - 1}. \tag{2}$$

More specifically, we classify a contestant in a given game round as a "loser" if $BC_r$ belongs to the worst one-third for all contestants in that game round and as a "winner" if $WC_r$ belongs to the best one-third.[4] Game situations that satisfy neither of the two conditions (or both in rare occasions) are classified as "neutral."

[4] To account for the variation in the initial set of prizes within an edition (see Section II), $BC_r$ and $BW_r$ are scaled by the initial average prize.

Of course, there are numerous ways one could allocate players into winner and loser categories. The results we show are robust to other classification schemes, provided that the classification of winners accounts for the downside risk of continuing play: the house-money effect—a decreased risk aversion after prior gains—is weak if incremental losses can exceed prior gains. For example, partitioning on just the current average ($\bar{x}_r$) does not distinguish between situations with different dispersion around that average, and therefore takes no account of the downside risk of continuing play.

Table 5 illustrates the effect of previous outcomes on the contestants' choice behavior. We see that, compared to contestants who are in the neutral category, both winners and losers have a stronger tendency to continue play. While 31 percent of all "Deal or No Deal" choices in the neutral group are "Deal" in the Dutch sample, the "Deal" percentage is only 14 percent for losers—despite the generous offers they are presented ("Rule 4"). The low "Deal" percentage for losers suggests that risk aversion decreases when contestants have been unlucky in selecting which briefcases to open. In fact, the strong losers in our sample generally exhibit risk-seeking behavior by rejecting bank offers in excess of the average remaining prize.

The low "Deal" percentage could be explained in part by the smaller stakes faced by losers and a lower risk aversion for small stakes, or increasing relative risk aversion (IRRA). However, the losers generally still have at least thousands or tens of thousands of euros at stake and gambles of this magnitude are typically associated with risk aversion in other empirical studies (including other game show studies and experimental studies). Also, if the stakes explained the low risk aversion of losers, we would expect a higher risk aversion for winners. However, risk aversion seems to decrease when contestants are lucky and have eliminated low-value briefcases. The "Deal" percentage for winners is 25 percent, below the 31 percent for the neutral group.

Interestingly, the same pattern arises in all three countries. The overall "Deal" percentages in the German and US editions are lower than in the Dutch edition, consistent with moderate IRRA and the substantially smaller stakes. Within every edition, however, the losers and winners have relatively low "Deal" percentages.

These results suggest that prior outcomes are an important determinant of risky choice. This is inconsistent with the traditional interpretation of expected utility theory in which the preferences for a given choice problem do not depend on the path traveled before arriving at the choice problem. By contrast, path-dependence can be incorporated quite naturally in prospect theory. The lower risk aversion after misfortune is reminiscent of the break-even effect, or decision makers being more willing to take risks due to incomplete adaptation to previous losses. Similarly, the relatively low "Deal" percentage for winners is consistent with the house-money effect, or a lower risk aversion after earlier gains.

Obviously, this preliminary analysis of "Deal" percentages is rather crude. It does not specify an explicit model of risky choice and it does not account for the precise choices (bank offers and remaining prizes) contestants face. Furthermore, there is no attempt at statistical inference or controlling for confounding effects at this stage of our analysis. The next two sections use a structural choice model and a maximum-likelihood methodology to analyze the "Deal or No Deal" choices in greater detail.

## IV. Expected Utility Theory

This section analyzes the observed "Deal or No Deal" choices with the standard expected utility of wealth theory. The choice of the appropriate class of utility functions is important, because preferences are evaluated on an interval from cents to millions. We do not want to restrict our analysis to a classical power or exponential utility function, because it seems too restrictive to assume constant relative risk aversion (CRRA) or constant absolute risk aversion (CARA) for this interval. To allow for the plausible combination of increasing relative risk aversion (IRRA) and decreasing absolute risk aversion (DARA), we employ a variant of the flexible expo-power family of Atanu Saha (1993) that was used by Mohammed Abdellaoui, Carolina Barrios, and Peter P. Wakker (2007) and by Charles A. Holt and Susan K. Laury (2002):

$$u(x) = \frac{1 - \exp(-\alpha(W+x)^{1-\beta})}{\alpha}. \tag{3}$$

In this function, three parameters are unknown: the risk aversion coefficients $\alpha$ and $\beta$, and the initial wealth parameter $W$. The classical CRRA power function arises as the limiting case where $\alpha \to 0$ and the CARA exponential function arises as the special case where $\beta = 0$. Theoretically, the correct measure of wealth should be lifetime wealth, including the present value of future income. However, lifetime wealth is not observable and it is possible that contestants do not integrate their existing wealth with the payoffs of the game. Therefore, we include initial wealth as a free parameter in our model.

We will estimate the three unknown parameters using a maximum likelihood procedure that measures the likelihood of the observed "Deal or No Deal" decisions based on the "stop value," or the utility of the current bank offer, and the "continuation value," or the expected utility of the unknown winnings when rejecting the offer. In a given round $r$, $B(x_r)$ denotes the bank offer as a function of the set of remaining prizes $x_r$. The stop value is simply:

$$sv(x_r) = u(B(x_r)). \tag{4}$$

Analyzing the continuation value is more complicated. We elaborate on the continuation value, the bank offer model, and the estimation procedure below.

### A. *Continuation Value*

The game involves multiple rounds and the continuation value has to account for the bank offers and optimal decisions in all later rounds. In theory, we can solve the entire dynamic optimization problem by means of backward induction, using Richard E. Bellman's principle of optimality. Starting with the ninth round, we can determine the optimal "Deal or No Deal" decision in each preceding game round, accounting for the possible scenarios and the optimal decisions in subsequent rounds. This approach assumes, however, that the contestant takes into account all possible outcomes and decisions in all subsequent game rounds. Studies on backward induction in simple alternating-offers bargaining experiments suggest that subjects generally do only one or two steps of strategic reasoning and ignore further steps of the backward induction process (see, for example, Johnson et al. 2002; Ken Binmore et al. 2002). This pleads for assuming that the contestants adopt a simplified mental frame of the game.

Our video material indeed suggests that contestants generally look only one round ahead. The game-show host tends to stress what will happen to the bank offer in the next round should particular briefcases be eliminated and the contestants themselves often comment that they will play "just one more round" (although they often change their minds and continue to play later on). We therefore assume a simple "myopic" frame. Using this frame, the contestant compares the current bank offer with the unknown offer in the next round, and ignores the option to continue play thereafter.

Given the current set of prizes ($x_r$), the statistical distribution of the set of prizes in the next round ($x_{r+1}$) is known:

$$\Pr[x_{r+1} = y | x_r] = \binom{n_r}{n_{r+1}}^{-1} = p_r \tag{5}$$

for any given subset $y$ of $n_{r+1}$ elements from $x_r$. In words, the probability is simply one divided by the number of possible combinations of $n_{r+1}$ out of $n_r$. Thus, using $X(x_r)$ for all such subsets, the continuation value for a myopic contestant is given by

$$cv(x_r) = \sum_{y \in X(x_r)} u(B(y))p_r. \tag{6}$$

Given the cognitive burden of multi-stage induction, this frame seems the appropriate choice for this game. However, as a robustness check, we have also replicated our estimates using the rational model of full backward induction and have found that our parameter estimates and the empirical fit did not change materially. In the early game rounds, when backward induction appears most relevant, the myopic model underestimates the continuation value. Still, the myopic model generally correctly predicts "No Deal," because the expected bank offers usually increase substantially during the early rounds, so even the myopic continuation value is generally greater than the stop value. In the later game rounds, backward induction is of less importance, because fewer game rounds remain to be played and because the rate of increase in the expected bank offers slows down. For contestants who reach round nine, such as Frank and Susanne, the decision problem involves just one stage and the myopic model coincides with the rational model. The low propensity of losers and winners in later game rounds to "Deal" is therefore equally puzzling under the assumption of full backward induction.

### B. *Bank Offers*

To apply the myopic model, we need to quantify the behavior of the banker. Section I discussed the bank offers in a qualitative manner. For a contestant who currently faces remaining prizes $x_r$ and percentage bank offer $b_r$ in game round $r = 1, \ldots, 9$, we quantify this behavior using the following simple model:

$$B(x_{r+1}) = b_{r+1}\bar{x}_{r+1}, \tag{7}$$

$$b_{r+1} = b_r + (1 - b_r)\rho^{(9-r)}, \tag{8}$$

where $\rho$, $0 \leq \rho \leq 1$, measures the speed at which the percentage offer goes to 100 percent. Since myopic contestants are assumed to look just one round ahead, the model predicts the offer in the next round only. The bank offer in the first round needs not be predicted, because it is shown on the scoreboard when the first "Deal or No Deal" choice has to be made. $B(x_{10}) = x_{10}$ and $b_{10} = 1$ refer to the prize in the contestant's own briefcase.

The model does not include an explicit premium for losers. However, before misfortune arises, the continuation value is driven mostly by the favorable scenarios, and the precise percentage offers for unfavorable scenarios do not materially affect the results. After bad luck, the premium is included in the current percentage and extrapolated to the next game round.

For each edition, we estimate the value of $\rho$ by fitting the model to the sample of percentage offers made to all contestants in all relevant game rounds using least squares regression analysis. The resulting estimates are very similar for each edition: 0.832 for the Dutch edition, 0.815 for the first German series, 0.735 for the second German series, and 0.777 for the US shows. The model gives a remarkably good fit. Figure 3 illustrates the goodness-of-fit by plotting the predicted bank offers against the actual offers. The results are highly comparable for the three editions in our study, and therefore the figure shows the pooled results. For each individual sample, the model explains well over 70 percent of the total variation in the individual percentage offers. The explanatory power is even higher for monetary offers, with an R-squared of roughly 95 percent for each sample. Arguably, accurate monetary offers are more relevant for accurate risk aversion estimates than accurate percentage offers, because the favorable scenarios with high monetary offers weigh heavily on expected utility. On the other hand, to analyze risk behavior following the elimination of the largest prizes, accurate estimates for low monetary offers are also needed. It is therefore comforting that the fit is good in terms of both percentages and monetary amounts. In addition, if $\rho$ is used as a free parameter in our structural choice models, the optimal values are approximately the same as our estimates, further confirming the goodness.

Since the principle behind the bank offers becomes clear after seeing a few shows, the bank offer model (7)–(8) is treated as deterministic and known to the contestants. Using a stochastic bank offer model would introduce an extra layer of uncertainty, yielding lower continuation values. For losers, the bank offers are hardest to predict, making it even more difficult to rationalize why these contestants continue play.

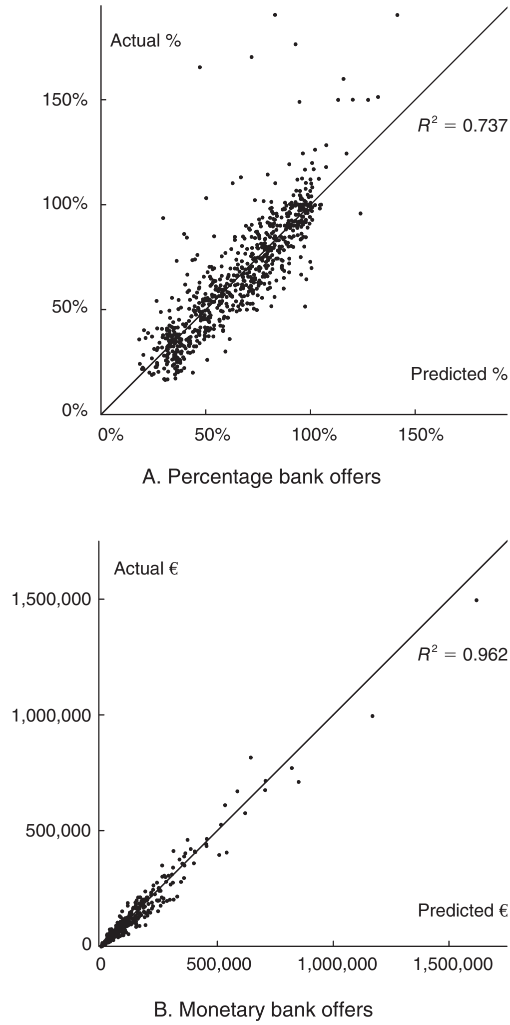


FIGURE 3.
PREDICTED BANK OFFERS VERSUS ACTUAL BANK OFFERS

*Notes:* The figure displays the goodness of our bank offer model by plotting the predicted bank offers versus the actual bank offers for all relevant game rounds in our pooled sample of 151 contestants from the Netherlands, Germany, and the United States. Panel A shows the fit for the percentage bank offers and panel B shows the fit for the monetary bank offers (in euros). A 45-degree line (perfect fit) is added for ease of interpretation.

### C. *Maximum Likelihood Estimation*

In the spirit of Gordon M. Becker, Morris H. DeGroot and Jacob Marschak (1963) and John D. Hey and Chris Orme (1994), we assume that the "Deal or No Deal" decision of a given contestant $i = 1, \ldots, N$ in a given game round $r = 1, \ldots, 9$ is based on the difference between the continuation value and the stop value, or $cv(x_{i,r}) - sv(x_{i,r})$, plus some error. The errors are treated as independent, normally distributed random variables with zero mean and standard deviation $\sigma_{i,r}$. Arguably, the error standard deviation should be higher for difficult choices than for simple choices. A natural indicator of the difficulty of a decision is the standard deviation of the utility of the outcomes used to compute the continuation value:

$$\delta(x_{i,r}) = \sqrt{\sum_{y \in X(x_{i,r})} (u(B(y)) - cv(x_{i,r}))^2 p_r}. \tag{9}$$

We assume that the error standard deviation is proportional to this indicator, that is, $\sigma_{i,r} = \delta(x_{i,r})\sigma$, where $\sigma$ is a constant noise parameter. As a result of this assumption, the simple choices effectively receive a larger weight in the analysis than the difficult ones. We also investigated the data without weighting. The (unreported) results show that the overall fit in the three samples deteriorates. In addition, without weighting, the estimated noise parameters in the three editions strongly diverge, with the Dutch edition having a substantially higher noise level than the German and US editions. The increase in the noise level seems to reflect the higher difficulty of the decisions in the Dutch edition relative to the German and US editions; contestants in the Dutch edition typically face: (a) larger stakes because of the large initial prizes; and (b) more remaining prizes because they exit the game at an earlier stage. The standard deviation of the outcomes (9) picks up these two factors. The deterioration of the fit and the divergence of the estimated noise levels provide additional, empirical arguments for our weighting scheme.

Given these assumptions, we may compute the likelihood of the "Deal or No Deal" decision as

$$l(x_{i,r}) = \begin{cases} \Phi\left(\dfrac{cv(x_{i,r}) - sv(x_{i,r})}{\delta(x_{i,r})\sigma}\right) \text{if "No Deal,"} \\[2ex] \Phi\left(\dfrac{sv(x_{i,r}) - cv(x_{i,r})}{\delta(x_{i,r})\sigma}\right) \text{if "Deal,"} \end{cases} \tag{10}$$

where $\Phi(\cdot)$ is the cumulative standard normal distribution function.[5]

Aggregating the likelihood across contestants, the overall log-likelihood function of the "Deal or No Deal" decisions is given by

$$\ln(L) = \sum_{i=1}^{N} \sum_{r=2}^{R_i} \ln(l(x_{i,r})), \tag{11}$$

where $R_i$ is the last game round played by contestant $i$.

To allow for the possibility that the errors of individual contestants are correlated, we perform a cluster correction on the standard errors (see, for example, Jeffrey M. Wooldridge 2003). Note that the summation starts in the second game round $(r = 2)$. The early German episodes with only eight game rounds effectively start in this game round and, in order to align these episodes with the rest of the sample, we exclude the first round $(r = 1)$ of the editions with nine game rounds. Due to the very conservative bank offers, the choices in the first round are always trivial (no contestant in our sample ever said "Deal"); including these choices does not affect the results, but it would falsely make the early German episodes look more "noisy" than the rest of the sample.

The unknown parameters in our model ($\alpha$, $\beta$, $W$, and $\sigma$) are selected to maximize the overall log-likelihood. To determine if the model works significantly better than a naïve model of risk neutrality, we perform a likelihood ratio test.

[5] This error model allows for violations of first-order stochastic dominance (FSD). The probability of "Deal" is predicted to be larger than zero and smaller than unity, even when the bank offer is smaller than the smallest outcome ("No Deal" dominates "Deal") or larger than the largest outcome ("Deal" dominates "No Deal"). As pointed out by an anonymous referee, a truncated error model can avoid such violations of FSD. In our dataset, however, the bank offer is always substantially larger than the smallest and substantially smaller than the largest outcome, and violations of FSD do not occur.

TABLE 6—EXPECTED UTILITY THEORY RESULTS

| | Netherlands | | Germany | | United States | |
|---|---|---|---|---|---|---|
| $\alpha$ | 0.424 | (0.000) | 1.58e-5 | (0.049) | 4.18e-5 | (0.000) |
| $\beta$ | 0.791 | (0.000) | 0.000 | (1.000) | 0.171 | (0.000) |
| $W$ | 75,203 | (0.034) | 544 | (0.481) | 101,898 | (0.782) |
| $\sigma$ | 0.428 | (0.000) | 0.467 | (0.000) | 0.277 | (0.000) |
| MLL | −0.365 | | −0.340 | | −0.260 | |
| LR | 24.29 | (0.000) | 3.95 | (0.267) | 15.10 | (0.002) |
| Hits | 76 percent | | 85 percent | | 89 percent | |
| No. | 214 | | 327 | | 349 | |
| CC ($0/10^1$) | 1.000 | | 1.000 | | 1.000 | |
| CC ($0/10^2$) | 0.999 | | 1.000 | | 1.000 | |
| CC ($0/10^3$) | 0.994 | | 0.996 | | 0.998 | |
| CC ($0/10^4$) | 0.946 | | 0.960 | | 0.984 | |
| CC ($0/10^5$) | 0.637 | | 0.640 | | 0.859 | |
| CC ($0/10^6$) | 0.141 | | 0.088 | | 0.302 | |

*Notes:* The table displays the estimation results of expected utility theory for our sample of 151 contestants from the Netherlands (51), Germany (47), and the United States (53). Shown are maximum likelihood estimators for the $\alpha$ and $\beta$ parameters and the wealth level ($W$, in euros) of the utility function (3), and the noise parameter $\sigma$. The table also shows the overall mean log-likelihood (MLL), the likelihood ratio (LR) relative to the naïve model of risk neutrality, the percentage of correctly predicted "Deal or No Deal" decisions (Hits), and the total number of "Deal or No Deal" decisions in the sample (No.). Finally, the implied certainty coefficient (CC; certainty equivalent as a fraction of the expected value) is shown for 50/50 gambles of €0 or €$10^z$, $z = 1, \ldots, 6$. $p$-values are shown in parentheses.

## D. *Results*

Table 6 summarizes our estimation results. Apart from coefficient estimates and $p$-values, we have also computed the implied certainty equivalent as a fraction of the expected value, or certainty coefficient (CC), for 50/50 gambles of €0 or €$10^z$, $z = 1, \ldots, 6$. These values help to interpret the coefficient estimates by illustrating the shape of the utility function. Notably, the CC can be interpreted as the critical bank offer (as a fraction of the expected value of the 50/50 gamble) that would make the contestant indifferent between "Deal" and "No Deal." If CC = 1, the contestant is risk neutral. When CC > 1, the contestant is risk seeking, and as CC approaches zero, the contestant becomes extremely risk averse. To help interpret the goodness of the model, we have added the "hit percentage," or the percentage of correctly predicted "Deal or No Deal" decisions.

In the Dutch sample, the risk aversion parameters $\alpha$ and $\beta$ are both significantly different from zero, suggesting that IRRA and DARA are relevant and the classical CRRA power function and CARA exponential function are too restrictive to explain the choices in this game show. The estimated wealth level of €75,203 significantly exceeds zero. Still, given that the median Dutch household income is roughly €25,000 per annum, the initial wealth level seems substantially lower than lifetime wealth, and integration seems incomplete. This deviates from the classical approach of defining utility over wealth and is more in line with utility of income or the type of narrow framing that is typically assumed in prospect theory. A low wealth estimate is also consistent with Matthew Rabin's (2000) observation that plausible risk aversion for small and medium outcomes implies implausibly strong risk aversion for large outcomes if the outcomes are integrated with lifetime wealth. Indeed, the estimates imply near risk neutrality for small stakes, witness the CC of 0.994 for a 50/50 gamble of €0 or €1,000, and increasing the wealth level would imply near risk neutrality for even larger gambles.

Rabin's point is reinforced by comparing our results for large stakes with the laboratory experiments conducted by Holt and Laury (2002) using the lower stakes typical in the lab. Holt and Laury's subjects display significant risk aversion for modest stakes, which, as Rabin notes, implies extreme risk aversion for much larger stakes—behavior our contestants do not display. Indeed, contestants with Holt and Laury's parameter estimates for the utility function would generally accept a "Deal" in the first game round, in contrast to the actual behavior we observe. We conclude, agreeing with Rabin, that expected utility of wealth models has difficulty explaining behavior for both small and large stakes.

The model also does not seem flexible enough to explain the choices for losers and winners simultaneously. The estimated utility function exhibits very strong IRRA, leading to an implausibly low CC of 0.141 for a 50/50 gamble of €0 or €1,000,000. Indeed, the model errs by predicting that winners would stop earlier than they actually do. If risk aversion increases with stakes, winners are predicted to have a stronger propensity to accept a bank offer, the opposite of what we observe; witness for example the "Deal" percentages in Table 5. However, strong IRRA is needed in order to explain the behavior of losers, who reject generous bank offers and continue play even with tens of thousands of euros at stake. Still, the model does not predict risk seeking at small stakes; witness the CC of 0.946 for a 50/50 gamble of €0 or €10,000—roughly Frank's risky choice in round 9. Thus, the model also errs by predicting that losers would stop earlier than they actually do.

Interestingly, the estimated coefficients for the German edition are quite different from the Dutch values. The optimal utility function reduces to the CARA exponential function ($\beta = 0$) and the estimated initial wealth level becomes insignificantly different from zero. Still, on the observed domain of prizes, the two utility functions exhibit a similar pattern of unreasonably strong IRRA and high risk aversion for winners. Again, the model errs by predicting that losers and winners would stop earlier than they actually do. These errors are so substantial in this edition that the fit of the expected utility model is not significantly better than the fit of a naive model that assumes that all contestants are risk neutral and simply "Deal" whenever the bank offer exceeds the average remaining prize.

Contrary to the Dutch and German utility functions, the US utility function approximates the limiting case of the CRRA power function ($\alpha \approx 0$). The CC is again very high for small stakes. For larger stakes, the coefficient decreases but at a slower pace than in the other two countries, reflecting the relatively low propensity to "Deal" for US contestants with relatively large amounts at stake. The decreasing pattern stems from the estimated initial wealth level of €101,898, which yields near risk neutrality for small stakes. Still, initial wealth is not significantly different from zero, because a similar pattern can be obtained if we lower the value of beta relative to alpha and move in the direction of the CARA exponential function.

To further illustrate the effect of prior outcomes, Table 7 shows separate results for losers and winners (as defined in Section III). Confirming the low "Deal" percentages found earlier, the losers and winners are less risk averse and have higher CCs than the neutral group. The losers are in fact best described by a model of risk seeking, which is not surprising given that the losers in our sample often reject bank offers in excess of the average remaining prize. The same pattern arises in each of the three editions, despite sizeable differences in the set of prizes. For example, the Dutch losers on average face larger stakes than the contestants in the US and German neutral groups. Still, risk seeking ($CC > 1$) arises only in the loser group. Overall, these results suggest that the expected utility model fails to capture the strong effect of previous outcomes.

## V. Prospect Theory

In this section, we use prospect theory to analyze the observed "Deal or No Deal" choices. Contestants are assumed to have a narrow focus and evaluate the outcomes in the game without integrating their initial wealth—a typical assumption in prospect theory. Furthermore, we will

Table 7—Path Dependence

| | Loser | | Neutral | | Winner | |
|---|---|---|---|---|---|---|
| *A. Netherlands* | | | | | | |
| $\alpha$ | −244.904 | (0.022) | 0.044 | (0.204) | 0.125 | (0.831) |
| $\beta$ | 0.993 | (0.000) | 0.687 | (0.000) | 0.736 | (0.011) |
| $W$ | 0 | (1.000) | 304 | (0.671) | 3,061 | (0.824) |
| $\sigma$ | 0.627 | (0.000) | 0.323 | (0.000) | 0.309 | (0.000) |
| MLL | −0.300 | | −0.383 | | −0.325 | |
| Hits | 89 percent | | 81 percent | | 83 percent | |
| No. | 72 | | 70 | | 72 | |
| CC ($0/10^1$) | 1.330 | | 0.994 | | 0.999 | |
| CC ($0/10^2$) | 1.338 | | 0.945 | | 0.992 | |
| CC ($0/10^3$) | 1.347 | | 0.723 | | 0.928 | |
| CC ($0/10^4$) | 1.355 | | 0.392 | | 0.630 | |
| CC ($0/10^5$) | 1.363 | | 0.150 | | 0.216 | |
| CC ($0/10^6$) | 1.371 | | 0.032 | | 0.035 | |
| *B. Germany* | | | | | | |
| $\alpha$ | −7.914 | (0.117) | 0.364 | (0.000) | 0.087 | (0.000) |
| $\beta$ | 0.814 | (0.000) | 0.759 | (0.000) | 0.651 | (0.000) |
| $W$ | 930 | (0.825) | 50,926 | (0.481) | 113,582 | (0.180) |
| $\sigma$ | 0.659 | (0.000) | 0.241 | (0.000) | 0.454 | (0.000) |
| MLL | −0.276 | | −0.257 | | −0.278 | |
| Hits | 90 percent | | 87 percent | | 88 percent | |
| No. | 111 | | 105 | | 111 | |
| CC ($0/10^1$) | 1.012 | | 1.000 | | 1.000 | |
| CC ($0/10^2$) | 1.113 | | 0.999 | | 0.999 | |
| CC ($0/10^3$) | 1.584 | | 0.990 | | 0.995 | |
| CC ($0/10^4$) | 1.823 | | 0.911 | | 0.949 | |
| CC ($0/10^5$) | 1.891 | | 0.485 | | 0.614 | |
| CC ($0/10^6$) | 1.929 | | 0.072 | | 0.101 | |
| *C. United States* | | | | | | |
| $\alpha$ | −203.512 | (0.006) | 1.96e-5 | (0.000) | 0.938 | (0.000) |
| $\beta$ | 0.995 | (0.000) | 0.086 | (0.000) | 0.998 | (0.000) |
| $W$ | 54 | (0.691) | 934,904 | (0.331) | 29,468 | (0.107) |
| $\sigma$ | 0.193 | (0.000) | 0.308 | (0.000) | 0.326 | (0.000) |
| MLL | −0.194 | | −0.275 | | −0.253 | |
| Hits | 92 percent | | 86 percent | | 91 percent | |
| No. | 118 | | 113 | | 118 | |
| CC ($0/10^1$) | 1.004 | | 1.000 | | 1.000 | |
| CC ($0/10^2$) | 1.023 | | 1.000 | | 0.999 | |
| CC ($0/10^3$) | 1.054 | | 0.999 | | 0.992 | |
| CC ($0/10^4$) | 1.071 | | 0.986 | | 0.927 | |
| CC ($0/10^5$) | 1.081 | | 0.863 | | 0.646 | |
| CC ($0/10^6$) | 1.089 | | 0.252 | | 0.289 | |

*Notes:* The table shows the maximum likelihood estimation results of expected utility theory for our sample of 151 contestants from the Netherlands (51; panel A), Germany (47; panel B), and the United States (53; panel C). The samples are split based on the fortune experienced during the game. A contestant is classified as a "loser" ("winner") if her average remaining prize after eliminating the lowest (highest) remaining prize is among the worst (best) one-third for all contestants in the same game round. The results are presented in a format similar to the full-sample results in Table 6.

again use the myopic frame that compares the current bank offer with the unknown offer in the next round. Although myopia is commonly assumed in prospect theory, the choice of the relevant frame in this game is actually more important than for expected utility theory. As discussed in Section IV, the myopic frame seems appropriate for expected utility theory. For prospect theory, however, it can be rather restrictive. Prospect theory allows for risk-seeking behavior when in the domain of losses, and risk seekers have a strong incentive to look ahead multiple game rounds to allow for the possibility of winning the largest remaining prize. Indeed, contestants who reject high bank offers often explicitly state that they are playing for the largest remaining prize (rather than a large amount offered by the banker offer in the next round). Preliminary computations revealed that prospect theory generally performs better if we allow contestants to look ahead multiple game rounds. The improvements are limited, however, because risk seeking typically arises at the end of the game. At that stage, only a few or no further game rounds remain and the myopic model then gives a good approximation. Thus, we report only the results with the myopic model in order to be consistent with the previous analysis using expected utility theory.

The stop value and continuation value for prospect theory are defined in the same way as for expected utility theory, with the only difference that the expo-power utility function (3) is replaced by the prospect theory value function, which is defined on changes relative to some reference point:

$$v(x|RP) = \begin{cases} -\lambda(RP - x)^{\alpha} & x \leq RP \\ (x - RP)^{\alpha} & x > RP \end{cases}, \tag{12}$$

where $\lambda > 0$ is the loss-aversion parameter, $RP$ is the reference point that separates losses from gains, and $\alpha > 0$ measures the curvature of the value function. The original formulation of prospect theory allows for different curvature parameters for the domain of losses ($x \leq RP$) and the domain of gains ($x > RP$). To reduce the number of free parameters, we assume here that the curvature is equal for both domains.[6]

### A. *Reference Point Specification*

Kahneman and Tversky's (1979) original treatment of prospect theory equates the reference point with the status quo. Since "Deal or No Deal" contestants never have to pay money out of their own pockets, the reference point would then equal zero and contestants would never experience any losses. The authors recognize, however, that "there are situations in which gains and losses are coded relative to an expectation or aspiration level that differs from the "status quo" (286). They point out that "a person who has not made peace with his losses is likely to accept gambles that would be unacceptable to him otherwise" (287). This point is elaborated by Thaler and Johnson (1990), though neither team offers a formal model of how the reference point changes over time. One recent effort along these lines is by Botond Kőszegi and Rabin (2006, 2007).

The specification of the subjective reference point (or the underlying set of expectations) and how it varies during the game is crucial for our analysis, as it determines whether outcomes enter as gain or loss in the value function and with what magnitude. Slow adjustment or stickiness of the reference point can yield break-even and house-money effects, or a lower risk aversion after losses and after gains. If the reference point adjusts slowly after losses, relatively many remaining outcomes are placed in the domain of losses, where risk seeking applies. Similarly, if

[6] Empirical curvature estimates are often very similar for gains and losses. Tversky and Kahneman (1992), for example, find a median value of 0.88 for both domains. Furthermore, the curvature needs to be the same for both domains in order to be consistent with the definition of loss aversion; see Veronica Köbberling and Wakker (2005).

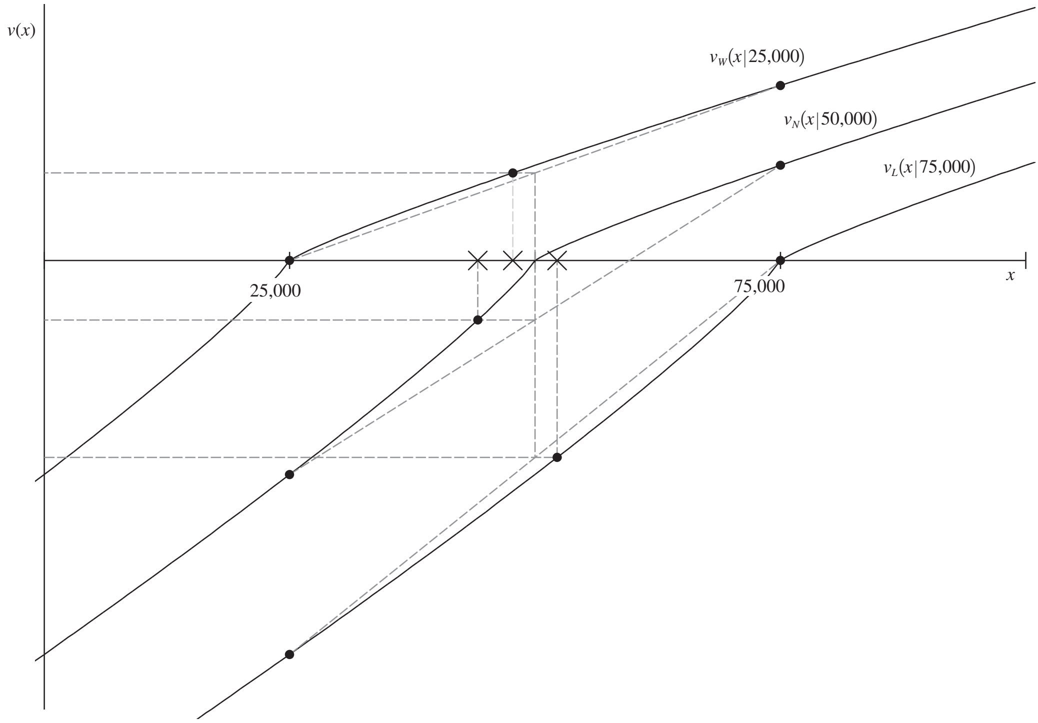


FIGURE 4. BREAK-EVEN AND HOUSE-MONEY EFFECTS IN PROSPECT THEORY

*Notes:* The figure displays the prospect value function (12) for three different levels of the reference point (*RP*) and the associated certainty equivalents (*CEs*) for a 50/50 gamble of €25,000 or €75,000. Value function $v_N(x|50{,}000)$ refers to a neutral situation with $RP_N$ = €50,000 and $CE_N$ = €44,169, $v_W(x|25{,}000)$ to a winner with $RP_W$ = €25,000 and $CE_W$ = €47,745, and $v_L(x|75{,}000)$ to a loser with $RP_L$ = €75,000 and $CE_L$ = €52,255. All three value functions are based on the parameter estimates of Tversky and Kahneman (1992), or $\alpha = 0.88$ and $\lambda = 2.25$. The crosses indicate the certainty equivalents for the 50/50 gamble.

the reference point sticks to an earlier, less favorable value after gains, relatively many remaining prizes are placed in the domain of gains, reducing the role of loss aversion.

Figure 4 illustrates these two effects using a 50/50 gamble of €25,000 or €75,000. Contestants in "Deal or No Deal" face this type of gamble in round 9. The figure shows the value function using the parameter estimates of Tversky and Kahneman (1992), or $\alpha = 0.88$ and $\lambda = 2.25$, and three alternative specifications for the reference point. In a neutral situation without prior outcomes, the reference point may equal the expected value ($RP_N$ = €50,000). In this case, the contestant frames the gamble as losing €25,000 (€50,000–€25,000) or winning €25,000 (€75,000–€50,000). The certainty equivalent of the gamble is $CE_N$ = €44,169, meaning that bank offers below this level would be rejected and higher offers would be accepted. The risk premium of €5,831 is caused by loss aversion, which assigns a larger weight to losses than to gains.

Now consider contestant L, who initially faced much larger stakes than €50,000 and incurred large losses before arriving at the 50/50 gamble in round 9. Suppose that L slowly adjusts to these earlier losses and places his reference point at the largest remaining prize ($RP_L$ = €75,000). In this case, L does not frame the gamble as losing €25,000 or winning €25,000, but rather as losing €50,000 (€75,000–€25,000) or breaking even (€75,000–€75,000). Both prizes are placed in the domain of losses where risk seeking applies. Indeed, L would reject all bank offers below the certainty equivalent of the gamble, $CE_L$ = €52,255, which implies a negative risk premium of €2,255.

Finally, consider contestant W, who initially faced much smaller stakes than €50,000 and incurred large gains before arriving at the 50/50 gamble. Due to slow adjustment, W employs a reference point equal to the smallest remaining prize ($RP_W$ = €25,000) and places both remaining prizes in the domain of gains. In this case, W frames the gamble as one of either breaking even (€25,000–€25,000) or gaining €50,000 (€75,000–€25,000). Since loss aversion does not apply in the domain of gains, the risk aversion of W is lower than in the neutral case and W would reject all bank offers below $CE_W$ = €47,745, implying a risk premium of €2,255, less than the value of €5,831 in the neutral case.

It should be clear from the examples above that a proper specification of the reference point and its dynamics is essential for our analysis. In fact, without slow adjustment, prospect theory does not yield the path-dependence found in this study. Unfortunately, the reference point is not directly observable and prospect theory alone provides minimal guidance for selecting the relevant specification. We therefore need to give the model some freedom and rely on the data to inform us about the relevant specification. To reduce the risk of data mining and to simplify the interpretation of the results, we develop a simple structural model based on elementary assumptions and restrictions for the reference point.

If contestants were confronted with the isolated problem of choosing between the current bank offer and the risky bank offer in the next round, it would seem natural to link the reference point to the current bank offer. The bank offer represents the sure alternative and the opportunity cost of the risky alternative. Furthermore, the bank offer is linked to the average remaining prize and therefore to current expectations regarding future outcomes. A simple specification would be $RP_r = \theta_1 B(x_r)$. If $\theta_1 = 0$, then the reference point equals the status quo ($RP_r = 0$) and all possible outcomes are evaluated as gains; if $\theta_1 > 0$, the reference point is strictly positive and contestant may experience (paper) losses, even though they never have to pay money out of their own pockets. A reference point below the current bank offer, or $\theta_1 < 1$, is conservative (pessimistic) in the sense that relatively few possible bank offers in the next round are classified as losses and relatively many possible outcomes are classified as gains. By contrast, an "optimistic" reference point, or $\theta_1 > 1$, involves relatively many possible losses and few possible gains.

The actual game is dynamic and the bank offer changes in every round, introducing the need to update the reference point. Due to slow adjustment, however, the reference point may be affected by earlier game situations. We may measure the effect of outcomes after earlier round $j$, $0 \leq j < r$, by the relative increase in the average remaining prize, or $d_r^{(j)} = (\bar{x}_r - \bar{x}_j)/\bar{x}_r$. For $j = 0$, $d_r^{(j)}$ measures the change relative to the initial average, or $\bar{x}_0$.

Ideally, our model would include this measure for all earlier game rounds (and possibly also interaction terms). However, due to the strong correlation between the lagged terms and the limited number of observations, we have to limit the number of free parameters. We restrict ourselves to just two terms: $d_r^{(r-2)}$ and $d_r^{(0)}$. The term $d_r^{(r-2)}$ is the longest fixed lag that can be included for all observations (our analysis starts in the second round) and measures recent changes; $d_r^{(0)}$, or the longest variable lag, captures all changes relative to the initial game situation. Adding these two lagged terms to the static model, our dynamic model for the reference point is

$$RP_r = (\theta_1 + \theta_2 d_r^{(r-2)} + \theta_3 d_r^{(0)}) B(x_r). \tag{13}$$

In this model, $\theta_2 < 0$ or $\theta_3 < 0$ implies that the reference points stick to earlier values and that it is higher than the neutral value $\theta_1 B(x_r)$ after decreases in the average remaining prize and lower after increases.

It is not immediately clear how strong the adjustment would be, or if the adjustment parameters would be constant, but it seems realistic to assume that the adjustment is always sufficiently strong to ensure that the reference point is feasible in the next round, i.e., not lower than the smallest possible bank offer and not higher than the largest possible bank offer. We therefore truncate the reference point at the minimum and maximum bank offer, i.e., $\min_{y \in X(x_r)} B(y) \leq RP_r \leq \max_{y \in X(x_r)} B(y)$. This truncation improves the empirical fit of our model and the robustness to the specification of the reference point and its dynamics.

Our complete prospect theory model involves five free parameters: loss aversion $\lambda$, curvature $\alpha$, and the three parameters of the reference point model $\theta_1$, $\theta_2$, and $\theta_3$. We estimate these parameters and the noise parameter $\sigma$ with the same maximum likelihood procedure used for the expected utility analysis. We also apply the same bank offer model.

Our analysis ignores subjective probability transformation and uses the true probabilities as decision weights. The fit of prospect theory could improve if we allow for probability transformation. If losers have a sticky reference point and treat all possible outcomes as losses, they will overweight the probability of the smallest possible loss, strengthening the risk seeking that stems from the convexity of the value function in the domain of losses. For example, applying the Tversky and Kahneman (1992) weighting function and parameter estimates to a gamble with two equally likely losses, the decision weight of the smallest loss is 55 percent rather than 50 percent. Still, we prefer to focus on the effect of the reference point in this study and we ignore probability weighting for the sake of parsimony. This simplification is unlikely to be material, especially in the most important later rounds, when the relevant probabilities are medium to large and the decision weights would be relatively close to the actual probabilities (as illustrated by the 50/50 gamble).

## B. *Results*

Table 8 summarizes our results. For the Dutch edition, the curvature and loss aversion parameters are significantly different from unity. The curvature of the value function is needed to explain why some contestants reject bank offers in excess of the average remaining prize; loss aversion explains why the average contestant accepts a bank offer below the average prize. Both parameters take values that are comparable with the typical results in experimental studies. Indeed, setting these parameters equal to the Tversky and Kahneman (1992) parameter values does not change our conclusions.

The parameter $\theta_1$ is significantly larger than zero, implying that contestants do experience (paper) losses, consistent with the idea that the reference point is based on expectations and that diminished expectations represent losses. The parameter is also significantly smaller than unity, indicating that the reference point generally takes a conservative value below the current bank offer.

The adjustment parameters $\theta_2$ and $\theta_3$ are significantly smaller than zero, meaning that the reference point tends to stick to earlier values and is higher than the neutral value after losses and lower after gains. In magnitude, $\theta_2$ is much larger than $\theta_3$, suggesting that the effect of recent outcomes is much stronger than the effect of initial expectations. However, the changes in the average remaining prize during the last two game rounds are generally much smaller than the changes during the entire game, limiting the effect of the parameter value. In addition, in case of large changes, the reference point often falls outside the range of feasible outcomes. In these cases, the reference point is set equal to the smallest or largest possible bank offer (see above), further limiting the effect of the parameter value.

The slow adjustment of the reference point lowers the propensity of losers and winners to "Deal." Not surprisingly, the prospect theory model yields substantially smaller errors for losers and winners and the overall log-likelihood is significantly higher than for the expected utility model. While the expected utility model correctly predicted 76 percent of the "Deal or No Deal" decisions, the hit percentage of the prospect theory model is 85 percent.

Table 8—Prospect Theory Results

| | Netherlands | | Germany | | United States | |
|---|---|---|---|---|---|---|
| $\lambda$ | 2.375 | (0.013) | 4.501 | (0.008) | 4.528 | (0.001) |
| $\alpha$ | 0.516 | (0.000) | 0.486 | (0.000) | 0.836 | (0.000) |
| $\theta^1$ | 0.474 | (0.000) | 1.096 | (0.000) | 1.163 | (0.000) |
| $\theta^2$ | −0.285 | (0.000) | −0.026 | (0.000) | 0.031 | (0.329) |
| $\theta^3$ | −0.028 | (0.000) | −0.052 | (0.000) | −0.093 | (0.023) |
| $\sigma$ | 0.345 | (0.000) | 0.533 | (0.000) | 0.193 | (0.000) |
| MLL | −0.309 | | −0.303 | | −0.228 | |
| LR | 48.41 | (0.000) | 27.44 | (0.000) | 37.28 | (0.000) |
| Hits | 85 percent | | 89 percent | | 91 percent | |
| No. | 214 | | 327 | | 349 | |

*Notes:* The table shows the estimation results of prospect theory for our sample of 151 contestants from the Netherlands (51), Germany (47), and the United States (53). Shown are maximum likelihood estimators for the loss aversion ($\lambda$) and curvature ($\alpha$) of the value function, the three parameters of the reference point model $\theta_1$, $\theta_2$, and $\theta_3$, and the noise parameter $\sigma$. The table also shows the overall mean log-likelihood (MLL), the likelihood ratio (LR) relative to the naïve model of risk neutrality, the percentage of correctly predicted "Deal or No Deal" decisions (Hits), and the total number of "Deal or No Deal" decisions in the sample (No.). $p$-values are shown in parentheses.

The results for the German and US samples are somewhat different from the results for the Dutch sample, but still confirm the important role of slow adjustment. The difference seems related to the relatively large stakes and the associated high propensity to "Deal" in the Dutch edition. In the German and US samples, the reference point is substantially higher in relative terms than in the Dutch sample. The relatively high reference point helps explain why the German and US contestants stop in later rounds and demand higher percentage bank offers than the Dutch contestants. Relatively many outcomes are placed in the domain of losses, where risk seeking applies. In such a situation, a relatively strong loss aversion is needed to explain "Deals." Indeed, the loss aversion estimates are substantially higher than for the Dutch sample. Again, stickiness is highly significant. However, the most recent outcomes seem less important and the reference point now sticks primarily to the initial situation. This seems related to the German and US contestants on average playing more game rounds than the Dutch contestants. In later rounds, many briefcases have already been opened, but relatively few briefcases have been opened in the last few rounds. The last two game rounds played in the German and US edition therefore generally reveal less information than in the Dutch edition. The model again materially reduces the errors for losers and winners and fits the data significantly better than the expected utility model in these two samples.

These results are consistent with our earlier finding that the losers and winners have a low propensity to "Deal" (see Table 5). Clearly, prospect theory with a dynamic but sticky reference point is a plausible explanation for this path-dependent pattern. Still, we stress that our analysis of prospect theory serves merely to explore and illustrate one possible explanation, and that it leaves several questions unanswered. For example, we have assumed homogeneous preferences and no subjective probability transformation. The empirical fit may improve even further if we would allow for heterogeneous preferences and probability weighting. Further improvements may come from allowing for a different curvature in the domains of losses and gains, from allowing for different partial adjustment after gains and losses, and from stakes-dependent curvature and loss aversion. We leave these issues for further research.

## VI. Experiments

The previous sections have demonstrated the strong effect of prior outcomes or path-dependence of risk attitudes. Also, the amounts at stake seem to be important, with a stronger propensity to deal for larger stakes levels. Prior outcomes and stakes are, however, highly confounded within every edition of the game show: unfavorable outcomes (opening high-value briefcases) lower the stakes and favorable outcomes (opening low-value briefcases) raise the stakes. The stronger the effect of stakes, the easier it is to explain the weak propensity to "Deal" of losers, but the more difficult it is to explain the low "Deal" percentage of winners. To analyze the isolated effect of the amounts at stake, we conduct a series of classroom experiments in which students at Erasmus University play "Deal or No Deal." We consider two variations to the same experiment that use monetary amounts that differ by a factor of ten, but draw from the same student population.

Both experiments use real monetary payoffs to avoid incentive problems (see, for example, Holt and Laury 2002). In order to compare the choices in the experiments with those in the original TV show and to provide a common basis for comparisons between the two experiments, each experiment uses the original scenarios from the Dutch edition.[7] At the time of the experiments, only the first 40 episodes were available. The original monetary amounts were scaled down by a factor of 1,000 or 10,000, with the smallest amounts rounded up to one cent. Despite the strong scaling, the resulting stakes are still unusually high for experimental research. Although the scenarios were predetermined, the subjects were not "deceived" in the sense that the game was not manipulated to encourage or avoid particular situations or behaviors. Rather, the subjects were randomly assigned to a scenario generated by chance at an earlier point in time (in the original episode). The risk that the students would recognize the original episodes seems small, because the scenarios are not easy to remember and the original episodes were broadcast at least six months earlier. Indeed, the experimental "Deal or No Deal" decisions are statistically unrelated to which of the remaining prizes is in the contestant's own briefcase.

We replicated the original game show as closely as possible in a classroom, using a game show host (a popular lecturer at Erasmus University) and live audience (the student subjects and our research team). Video cameras were pointed at the contestant, recording all her actions. The game situation (unopened briefcases, remaining prizes, and bank offers) was displayed on a computer monitor in front of the stage (for the host and the contestant) and projected on a large screen in front of the classroom (for the audience). This setup was intended to create the type of distress that contestants must experience in the TV studio. Our approach seems effective, because the audience was very excited and enthusiastic during the experiment, applauding and shouting hints, and most contestants showed clear symptoms of distress.

All our subjects were students, about 20 years of age. A total of 160 business or economics students were randomly selected from a larger population of students at Erasmus University who applied to participate in experiments during the academic year 2005–2006. Although each experiment required only 40 subjects, 80 students were invited to guarantee a large audience and to ensure that a sufficient number of subjects were available in the event that some subjects did not show up. Thus, approximately half of the students were selected to play the game. To control for a possible gender effect, we ensured that the gender of the subjects matched the gender of the contestants in the original episodes.

At the beginning of both experiments we handed out the instructions to each subject, consisting of the original instructions to contestants in the TV show plus a cover sheet explaining our experiment. Next, the games started. Each individual game lasted about 5 to 10 minutes, and each experiment (40 games) lasted roughly 5 hours, equally divided in an afternoon session with one half of the subjects and games, and an evening session with the other half.

[7] Original prizes and offers are not available when a subject continues play after a "Deal" in the TV episode. The "missing outcomes" for the prizes are selected randomly (but held constant across the experiments), and the bank offers are set according to the pattern observed in the original episodes.

### A. *Small-Stake Experiment*

In the first experiment, the original prizes and bank offers from the Dutch edition were divided by 10,000, resulting in an average prize of roughly €40 and a maximum prize of €500.

The overall level of risk aversion in this experiment is lower than in the original TV show. Contestants on average stop later (round 6.9 versus 5.2 for the TV show) and reject higher percentage bank offers. Still, the changes seem modest given that the initial stakes are 10,000 times smaller than in the TV show. In the TV show, contestants generally become risk neutral or risk seeking when "only" thousands or tens of thousands of euros remain at stake. In the experiment, the stakes are much smaller, but the average contestant is clearly risk averse. This suggests that the effect of stakes on risk attitudes in this game is relatively weak. By contrast, the effect of prior outcomes is very strong; witness for example the (untabulated) "Deal" percentages (for rounds 2–9 combined) of 3, 21, and 19 for "loser," "neutral," and "winner," respectively.

The first column of Table 9 shows the maximum likelihood estimation results. The estimated utility function exhibits the same pattern of extreme IRRA as for the original shows, but now at a much smaller scale. See, for example, the CC of 0.072 for a 50/50 gamble of €0 or €1,000. It follows from Rabin's (2000) observation that plausible levels of risk aversion require much lower initial wealth levels for small-stake gambles than for large-stake gambles. Indeed, initial wealth is estimated to be €11 in this experiment, roughly a factor of 10,000 lower than for the original TV sample. As for the original episodes, the model errs by predicting that the losers and winners would stop earlier than they actually do. Prospect theory with a sticky reference point fits the data substantially better than the expected utility model, both in terms of the log-likelihood and in terms of the hit percentage.

### B. *Large-Stake Experiment*

The modest change in the choices in the first experiment relative to the large-stake TV show suggests that the effect of stakes is limited in this game. Of course, the classroom experiment is not directly comparable with the TV version, because, for example, the experiment is not broadcast on TV and uses a different type of contestant (students). Our second experiment therefore investigates the effect of stakes by replicating the first experiment with larger stakes.

The experiment uses the same design as before, with the only difference being that the original monetary amounts are divided by 1,000 rather than by 10,000, resulting in an average prize of roughly €400 and a maximum prize of €5,000 —extraordinarily large amounts for experiments. For this experiment, 80 new subjects were drawn from the same population, excluding students involved in the first experiment.

Based on the strong IRRA in the first experiment, the expected utility model would predict a much higher risk aversion in this experiment. However, the average stop round is exactly equal to the average for the small-stake experiment (round 6.9), and subjects reject similar percentage bank offers (the highest rejected bank offer averages 82.5 percent versus 82.4 percent for the small-stake experiment). Therefore, the isolated effect of stakes seems much weaker than suggested by the estimated IRRA in the individual experiments.

The second column of Table 9 displays the maximum likelihood estimation results. With increased stakes but similar choices, the expected utility model needs a different utility function to rationalize the choices. In fact, the estimated utility function seems scaled in proportion to the stakes, so that the 50/50 gamble of €0 or €1,000 now involves approximately the same CC as the 50/50 gamble of €0 or €100 in the small-stake experiment. By contrast, for prospect theory, the estimated parameters are roughly the same as for the small-stake version and a substantially better fit is achieved relative to the implementation of expected utility theory.

Table 9—Experimental Results

| | Small stakes | | Large stakes | | Pooled | |
|---|---|---|---|---|---|---|
| *A. Expected utility theory* | | | | | | |
| $\alpha$ | 0.019 | (0.000) | 0.002 | (0.001) | 0.002 | (0.001) |
| $\beta$ | 0.000 | (1.000) | 0.000 | (1.000) | 0.000 | (1.000) |
| $W$ | 11 | (0.920) | 50 | (0.930) | 0 | (1.000) |
| $\sigma$ | 0.306 | (0.000) | 0.294 | (0.000) | 0.354 | (0.000) |
| MLL | −0.342 | | −0.337 | | −0.351 | |
| LR | 10.17 | (0.017) | 10.14 | (0.017) | 9.37 | (0.025) |
| Hits | 81 percent | | 83 percent | | 80 percent | |
| No. | 231 | | 234 | | 465 | |
| CC ($0/10^1$) | 0.953 | | 0.995 | | 0.995 | |
| CC ($0/10^2$) | 0.583 | | 0.953 | | 0.953 | |
| CC ($0/10^3$) | 0.072 | | 0.588 | | 0.586 | |
| CC ($0/10^4$) | 0.007 | | 0.074 | | 0.074 | |
| CC ($0/10^5$) | 0.001 | | 0.007 | | 0.007 | |
| CC ($0/10^6$) | 0.000 | | 0.001 | | 0.001 | |
| *B. Prospect theory* | | | | | | |
| $\lambda$ | 2.307 | (0.000) | 2.678 | (0.000) | 2.518 | (0.000) |
| $\alpha$ | 0.732 | (0.000) | 0.695 | (0.000) | 0.693 | (0.000) |
| $\theta_1$ | 1.045 | (0.000) | 1.024 | (0.000) | 1.023 | (0.000) |
| $\theta_2$ | −0.119 | (0.000) | 0.019 | (0.000) | 0.013 | (0.250) |
| $\theta_3$ | −0.086 | (0.000) | −0.046 | (0.000) | −0.049 | (0.000) |
| $\sigma$ | 0.267 | (0.000) | 0.196 | (0.000) | 0.218 | (0.000) |
| MLL | −0.275 | | −0.265 | | −0.272 | |
| LR | 40.94 | (0.000) | 44.04 | (0.000) | 83.29 | (0.000) |
| Hits | 87 percent | | 88 percent | | 87 percent | |
| No. | 231 | | 234 | | 465 | |

*Notes:* The table shows the maximum likelihood estimation results for our choice experiments. The first column (small stakes) displays the results for the experiment with the original monetary amounts in the Dutch TV format of "Deal or No Deal" divided by 10,000; the second column (large stakes) displays the results for the experiment with prizes scaled down by a factor of 1,000; and the third column (pooled) displays the results for the two samples combined. Panel A shows the results for expected utility theory. Panel B shows the results for prospect theory. The results are presented in the same format as the results in Table 6 and Table 8, respectively.

In both experiments, risk aversion is strongly affected by prior outcomes, which are strongly related to the level of stakes *within* the experiments, but the stakes do not materially affect risk aversion *across* the experiments. Since the stakes are increased by a factor of ten and all other conditions are held constant, the only plausible explanation seems that prior outcomes rather than stakes are the main driver of risk aversion in this game.

## C. *Pooled Sample*

The last column of Table 9 shows the results for the pooled sample of the two experiments. As noted above, the choice behavior in the two samples is very similar, despite the large differences in the stakes. The important role of the stakes in the individual samples and the weak role across the two samples lead to two very different utility functions. Stakes appear to matter more in relative terms than in absolute terms. Combining both samples will cause problems for the expected utility model, since the model assigns an important role to the absolute level of stakes. Using a single utility function for the pooled sample indeed significantly worsens the fit relative to the individual samples. The prospect theory model does not suffer from this problem because it attributes the low "Deal" propensity of losers and winners in each sample to the slow adjustment of a reference point that is proportional to the stakes in each sample. In this way, the model relies on changes in the relative level of the stakes rather than the absolute level of the stakes. Whether outcomes are gains or losses depends on the context. An amount of €100 is likely to be placed in the domain of gains in the small-stake experiment (where the average prize is roughly €40), but the same amount is probably placed in the domain of losses in the large-stake experiment (with an average prize of roughly €400).

## VII. Conclusions

The behavior of contestants in game shows cannot always be generalized to what an ordinary person does in everyday life when making risky decisions. While the contestants have to make decisions in just a few minutes in front of millions of viewers, many real-life decisions involving large sums of money are neither made in a hurry nor in the limelight. Still, we believe that the choices in this particular game show are worthy of study, because the decision problems are simple and well-defined, and the amounts at stake are very large. Furthermore, prior to the show, contestants have had considerable time to think about what they might do in various situations, and during the show they are encouraged to discuss those contingencies with a friend or relative who sits in the audience. In this sense, the choices may be more deliberate and considered than might appear at first glance. Indeed, it seems plausible that our contestants have given more thought to their choices on the show than to some of the other financial choices they have made in their lives, such as selecting a mortgage or retirement savings investment strategy.

What does our analysis tell us? First, we observe, on average, what might be called “moderate” levels of risk aversion. Even when hundreds of thousands of euros are at stake, many contestants are rejecting offers in excess of 75 percent of the expected value. In an expected utility of wealth framework, this level of risk aversion for large stakes is hard to reconcile with the same moderate level of risk aversion found in small-stake experiments—both ours, and those conducted by other experimentalists. Second, although risk aversion is moderate on average, the offers people accept vary greatly among the contestants; some demonstrate strong risk aversion by stopping in the early game rounds and accepting relatively conservative bank offers, while others exhibit clear risk-seeking behavior by rejecting offers above the average remaining prize and thus deliberately entering “unfair gambles.” While some of this variation is undoubtedly due to differences in individual risk attitudes, a considerable part of the variation can be explained by the outcomes experienced by the contestants in the previous rounds of the game. Most notably, risk aversion generally decreases after prior expectations have been shattered by eliminating high-value briefcases or after earlier expectations have been surpassed by opening low-value briefcases. This path-dependent pattern occurs in all three editions of the game, despite sizeable differences in the initial stakes across the editions. “Losers” and “winners” generally have a weaker propensity to “Deal” than their “neutral” counterparts.

The relatively low risk aversion of losers and winners is hard to explain with expected utility theory and points in the direction of reference-dependent choice theories such as prospect theory. Indeed, our findings seem consistent with the break-even effect (losers becoming more willing to take risk due to incomplete adaptation to prior losses), and the house-money effect (a low risk aversion for winners due to incomplete adaptation to prior gains). A simple version of prospect theory with a sticky reference point explains the “Deal or No Deal” decisions substantially better than expected utility theory. These findings suggest that reference-dependence and path-dependence are important, even when the decision problems are simple and well-defined, and when large real monetary amounts are at stake.

Of course, we must be careful with rejecting expected utility theory and embracing prospect theory. We use the flexible expo-power utility function, which embeds the most popular implementations of expected utility theory, and find that this function is unable to provide an explanation for the choices of losers and winners in this game show. However, a (nonstandard) utility function that has risk-seeking segments and depends on prior outcomes could achieve a better fit. Such exotic specifications blur the boundary between the two theories, and we therefore do not reject or accept one of the two.

Our main finding is the important role of reference-dependence and path-dependence, phenomena that are often ignored in implementations of expected utility theory. Previous choice problems are a key determinant of the framing of a given choice problem. An amount is likely to be considered as "large" in the context of a game where it lies above prior expectations, but the same amount is probably evaluated as "small" in a game where it lies below prior expectations. For contestants who expected to win hundreds of thousands, an amount of €10,000 probably seems "small"; the same amount is likely to appear much "larger" when thousands or tens of thousands were expected.

To isolate the effect of the amounts at stake, we conducted two series of choice experiments that use a homogeneous student population and mimic the TV show as closely as possible in a classroom. We find that a tenfold increase of the initial stakes does not materially affect the choices. Moreover, the choices in the experiments are remarkably similar to those in the original TV show, despite the fact that the experimental stakes are only a small fraction of the original stakes. Consistent with the TV version, the break-even effect and the house-money effect also emerge in the experiments. These experimental findings reinforce our conclusion that choices are strongly affected by previous outcomes. The combination of (a) a strong effect of variation in stakes caused by a subject's fortune within a game and (b) a weak effect of variation in the initial stakes across games calls for a choice model that properly accounts for the context of the choice problem and its dynamics.

This study has focused on episodes from the Netherlands, Germany, and the United States, because these episodes have a very similar game format. For further research, it would be interesting to collect more international data in order to obtain more degrees of freedom to analyze the effect of prior outcomes in greater detail and to examine the role of the cultural, social, or economic background of the contestant. It would also be interesting to further extend our choice experiments. While the stakes are much smaller, experiments do allow the researcher to control contestant characteristics, rules, and situations, and to more closely monitor contestants and their behavior. Our experiments were designed to mimic the TV studio and used real monetary payoffs, but further experiments may also take place in the behavioral laboratory and employ some sort of random-lottery incentive system to reduce the costs.

## VII. Epilogue

Following the success of "Deal or No Deal" in the Netherlands, the game show was sold to dozens of countries worldwide. Other research groups have investigated episodes of editions other than those used in this study. Their analyses employ not only different datasets, but also different research methodologies and different (implementation of) decision theories, and the results sometimes seem contradictory. Reconciling the seemingly disparate results will be a valuable exercise, but is beyond the scope of this study. We will limit ourselves at this point to a synopsis of the available studies, which are presented below in alphabetical order, and some concluding remarks.

Using the UK edition, Steffen Andersen et al. (2006b) estimate various structural choice models, assuming a homoskedastic error structure and accounting for forward-looking behavior. Their expected utility estimates suggest CRRA and initial wealth roughly equal to average annual UK income; their rank-dependent expected utility estimates indicate modest probability weighting along with a concave utility function; their prospect theory estimates indicate no loss aversion and modest probability weighting for gains, using several plausible specifications of the reference point. Andersen et al. (2006a) study the UK television shows and related lab experiments using a mixture model in which decision makers use two criteria: one is essentially rank-dependent expected utility, and the other is essentially a probabilistic income threshold. They find evidence that both criteria are used in the game show and that lab subjects place a much greater weight on the income threshold.

Guido Baltussen, Thierry Post, and Martijn J. van den Assem (2007) compare various editions of "Deal or No Deal." Their sample includes editions from the same country that employ very different initial sets of prizes. Comparing editions from the same country can separate the effect of current stakes and prior outcomes without introducing cross-country effects, in the same way as changing the initial stakes in our experiments. Consistent with reference-dependence and path-dependence, they find that contestants in large- and small-stake editions respond in a similar way to the stakes relative to their initial level, even though the initial stakes are widely different across the various editions.

Pavlo Blavatskyy and Ganna Pogrebna (forthcoming) show that Italian and UK contestants do not exhibit lower risk aversion when the probability of a large prize is small, and they interpret this as evidence against the overweighting of small probabilities. Blavatskyy and Pogrebna (2007b) find that the fit and relative performance of alternative decision theories depends heavily on the assumed error structure in the Italian and UK datasets. Pogrebna (2008) finds that Italian contestants generally do not follow naïve advice from the audience. Blavatskyy and Pogrebna (2007a) analyze the UK, French, and Italian editions, which sometimes include a swap option that allows contestants to exchange their briefcase for another unopened briefcase. Blavatskyy and Pogrebna (2006) conduct a nonparametric test of ten popular decision theories using the UK and Italian edition.

Matilde Bombardini and Francesco Trebbi (2007) use the Italian edition to estimate a structural dynamic CRRA expected utility model and find that the risk aversion is moderate on average and shows substantial variation across individual contestants. They also find that contestants are practically risk neutral when faced with small stakes and risk averse when faced with large stakes. Accounting for strategic interaction between the banker and the contestant (the Italian banker knows the contents of the unopened briefcases) does not change their conclusions.

Fabrizio Botti et al. (2007) estimate various structural expected utility models for the Italian edition, assuming that contestants ignore subsequent bank offers and compare the current bank offer with the set of remaining prizes. They find that the CARA specification fits the data significantly better than the CRRA and expo-power specifications, and they also report a gender effect (males are more risk averse) and substantial unobserved heterogeneity in risk aversion.

Cary A. Deck, Jungmin Lee, and Javier A. Reyes (2008) estimate structural CRRA and CARA expected utility models for Mexican episodes of "Deal or No Deal." They consider both forward-looking contestants and myopic contestants who look forward only one game round, and they vary the level of forecasting sophistication by the contestants. They find a moderate level of average risk aversion and considerable individual variation in risk attitudes, with some contestants being extremely risk averse while others are risk seeking.

Using the Australian edition, Nicolas de Roos and Yianis Sarafidis (2006) estimate structural dynamic CARA and CRRA expected utility models using random effects and random coefficients models. Their models produce plausible estimates of risk aversion, and suggest substantial heterogeneity in decision making, both between contestants and between decisions made by the same contestant. They also find that rank-dependent expected utility substantially improves the explanatory power. In addition to these main game results, they also investigate contestants' choices in special "Chance" and "Supercase" game rounds, which are specific for the Australian edition. Risk attitudes elicited in these additional game rounds seem to be similar to risk attitudes elicited in the main game. Also using Australian data, Daniel Mulino et al. (2006) estimate a structural dynamic CRRA expected utility model. Their estimates reveal moderate risk aversion on average and considerable variation across contestants. They also find that risk aversion depends on contestant characteristics such as age and gender, but not on wealth. Like De Roos and Sarafidis, they investigate the choices in the "Chance" and "Supercase" rounds, but they do find a difference in risk attitudes between these special rounds and the main game.

Clearly, "Deal or No Deal" can be studied for several research purposes and with a variety of methodologies and theories, and different studies can lead to different, sometimes opposing conclusions. Some final remarks may be useful to evaluate the existing studies and to guide further research. First, to analyze risk attitudes without the confounding effect of ambiguity and strategic insight, it is useful to analyze the basic version of the game. Of course, the more exotic versions with special game options and informative bank offers are interesting for other purposes, as demonstrated in some of the above studies. Second, to disentangle the effect of the amounts at stake and the effect of previous outcomes, it is useful to analyze multiple game show editions or choice experiments with different initial amounts at stake. Within one edition or experiment, current stakes and prior outcomes are perfectly correlated, and the two effects cannot be separated. Third, when using parametric structural models, it seems important to analyze the robustness for the assumed mental frame and error structure. For example, we found a relatively poor fit for models that assume that contestants focus on the set of remaining prizes rather than the next round's bank offer, and also for models that assume that the error variance is equal for all choice problems, irrespective of the level of the stakes or the variation in the prizes.

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