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

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Abstract

The popular television game show "Deal or No Deal" offers a unique opportunity for analyzing decision making under risk: it involves very large and wide-ranging stakes, simple stop-go decisions that require minimal skill, knowledge or strategy and near-certainty about the probability distribution. Based on a panel data set of the choices of contestants in all game rounds of 53 episodes from Australia and the Netherlands, we find an average Arrow-Pratt coefficient of relative risk aversion (RRA) between roughly 1 and 2 for initial wealth levels between €0 and €50,000 and assuming full rationality. Risk aversion is lower if we allow for myopic or hyperopic framing. The RRA differs substantially across the contestants and some even exhibit risk seeking behavior. The cross-sectional differences in RRA can be explained in large part by the previous outcomes experienced by the contestants during the game. Most notably, consistent with the "break-even effect", the RRA strongly decreases following earlier losses and risk seeking arises after large losses.

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Deal or No Deal?

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The popular television game show "Deal or No Deal" offers a unique opportunity for analyzing decision making under risk: it involves very large and wide-ranging stakes, simple stop-go decisions that require minimal skill, knowledge or strategy and near-certainty about the probability distribution. Based on a panel data set of the choices of contestants in all game rounds of 53 episodes from Australia and the Netherlands, we find an average Arrow-Pratt coefficient of relative risk aversion (RRA) between roughly 1 and 2 for initial wealth levels between €0 and €50,000 and assuming full rationality. Risk aversion is lower if we allow for myopic or hyperopic framing. The RRA differs substantially across the contestants and some even exhibit risk seeking behavior. The cross-sectional differences in RRA can be explained in large part by the previous outcomes experienced by the contestants during the game. Most notably, consistent with the "break-even effect", the RRA strongly decreases following earlier losses and risk seeking arises after large losses.

I Introduction

THE AMOUNTS AT STAKE are relevant for the validity of various theories of risky choice. For example, there are good reasons to question the expected utility theory for small stakes. As Rabin and Thaler (2001) note, the theory says that risk attitudes derive from changes in marginal utility associated with fluctuations in lifetime wealth, and therefore, people will not be averse to outcomes that do not significantly influence their lifetime wealth. Furthermore, Rabin (2000) shows theoretically that inferring the risk aversion for small stakes leads to unreasonably high risk aversion for large stakes and that reasonable values for large stakes are obtained only when we assume near risk neutrality for small stakes.

The stakes are also relevant for empirical research on risky choice. A large part of the empirical research relies on laboratory experiments or classroom experiments. The key advantage of such experiments relative to real-life data is the possibility to control the probability distribution of the choice alternatives and to ensure that the distribution is known to the decision maker. Nevertheless, experiments generally use hypothetical stakes or small real stakes, and it may well be that subjects are not induced to act optimally and reveal their true preferences and beliefs. For example, Holt and Laury (2002) show that the use of large, real stakes leads to substantially more risk averse behavior than the use of hypothetical or small real stakes does.

Some empirical studies try to deal with the stakes problem by using small nominal amounts in relatively poor countries, so that the subjects face relatively large amounts in real terms. See, for example, Binswanger (1980, 1981), Quizon, Binswanger and Machina (1984) and Kachelmeier and Shehata (1992). Still, the stakes in these experiments are typically not larger than a monthly income and we may ask if the results are representative for larger amounts. Unfortunately, it seems infeasible, financially speaking, to use larger amounts in experiments.

Another approach is to use field study data from television game shows. Notwithstanding some limitations of game show data, the key advantage is that large, real money amounts are at stake.[1] Examples of game show studies include the shows "Card Sharks" (Gertner, 1993), "Jeopardy!" (Metrick, 1995), "Illinois Instant Riches" (Hersch and McDougall, 1997), "Lingo" (Beetsma and Schotman, 2001), "Hoosier

Millionaire" (Fullenkamp, Tenorio and Battalio, 2003) and "Who Wants to be a Millionaire?" (Hartley, Lanot and Walker, 2005).[2]

Unfortunately, analyzing game show data is no panacea. In most game shows the stakes are still modest. One noteworthy exception is "Hoosier Millionaire", where contestants can win $1,000,000. However, in this show, the stakes exhibit little variation across the different game rounds, which makes it difficult to estimate the risk attitudes of the contestants for a wide range of outcomes. Besides this, the $1,000,000 prize is paid out as a long-term annuity and therefore the present value is much smaller. Furthermore, many game shows involve skill (for example, the ability to guess words in "Lingo"), knowledge (for instance, anwering quiz questions in "Who Wants to be a Millionaire?", another high-stakes show), or strategy (for example, to beat opponents in "Jeopardy!"). This makes it difficult for contestants to assess the appropriate probability distribution and introduces a layer of uncertainty in addition to the risk of the game. The same is true for game option elements such as the "lifelines" in "Who Wants to be a Millionaire?", which are difficult to value.

In this study, we will analyze the decisions made in the main game of the blockbuster television game show "Deal or No Deal". This show is developed by the Dutch production company Endemol and was first aired (in its current format) in the Netherlands in December 2002. The game show soon became very popular and was exported to many other countries around the world. For analyzing risky choice, "Deal or No Deal" has a number of favorable design features. The stakes are very high and wide-ranging: with a maximum prize of €5,000,000 and an average prize of roughly €400,000 (in the Netherlands), the game show can send contestants home as multimillionaires - or practically empty-handed. Unlike other game shows, "Deal or No Deal" involves only simple stop-go decisions that require minimal skill, knowledge or strategy. Also, the probability distribution is simple and known with near-certainty. Because of these features, "Deal or No Deal" seems well-suited for analyzing real-life decisions involving real and large risky stakes.

Using 53 shows from Australia and the Netherlands in 2002-2005, we estimate the Pratt-Arrow relative risk aversion (RRA) and examine how it varies across contestants, using a constant relative risk aversion (CRRA) expected utility model.

The game involves multiple game rounds, in each of which contestants must choose between a certain and an uncertain alternative, leading to a panel data set with a time-series dimension (the game rounds) and a cross-section dimension (the contestants). From the time-series we infer a RRA estimate for every individual contestant. Next, we try to explain the cross-sectional differences in the RRA estimates with characteristics of the contestants and the state-of-the-game they face.

Since it involves multiple game rounds, "Deal or No Deal" seems particularly well-suited for analyzing the role of earlier gains and losses. Thaler and 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, or "stickiness" of the reference point that separates gains from losses. The game show seems less suitable for analyzing the influence of the shape of the distribution of incremental outcomes. All contestants generally face a similarly shaped distribution in a given game round, apart from the expected outcome. This complicates the cross-sectional testing of the effect of loss aversion and subjective probability distortion, phenomena documented in, for instance, Kahneman and Tversky (1979) and Tversky and Kahneman (1991).

The remainder of this paper is organized as follows. In section II we describe the game show in greater detail. Next, in section III we discuss our data material. We explain our two-stage research methodology in section IV. In section V we present our empirical results. Finally, we offer some concluding remarks and suggestions for future research in section VI.

II Description of the game show

The television game show "Deal or No Deal" is developed by the Dutch production company Endemol and was first aired in the Netherlands in its current format in December 2002. The show soon became very popular and was exported to many other countries, including Australia.[3]

Each episode of Deal or No Deal included in our sample 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 "Deal or No Deal" is played by the finalist. Only the main game is subject to our research. Except for determining the identity of the finalist, the elimination game does not influence the course of the main game. Furthermore, we stress that the selected contestant has not won any prize before entering the final.

The main game starts with 26 numbered briefcases containing hidden money amounts that are randomly drawn from a known, fixed set of prizes ranging from very small to very large. In the Dutch edition for example, the prizes range from €0.01 to €5,000,000.[4] 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 and each round a "bank" tries to buy the briefcase from the contestant by making him an offer. Prior to each "bank-offer", the finalist obtains information about the unknown prize in his briefcase by choosing one or more of the other 25 briefcases to be opened. As more and more briefcases are opened and the prizes inside are revealed, the uncertainty regarding the prize in the contestant's own briefcase gradually disappears as the game progresses.

In the first round, the finalist selects six briefcases to be opened and subsequently a first bank-offer is made based on the remaining 20 prizes. If the contestant accepts the offer ("Deal"), he walks away with this sure amount and the game ends; if the contestant refuses the offer ("No Deal"), play continues and he enters the second round.

In this second round, the finalist has to open five more briefcases, followed by a new bank-offer. Once again, he has to decide to "Deal" or "No Deal". The numbers of briefcases to be opened in the nine rounds are respectively 6, 5, 4, 3, 2, 1, 1, 1, and 1, and so the set of remaining prizes decreases from 26 to 20, 15, 11, 8, 6, 5, 4, 3 and finally to 2. The remaining amounts and the current bank-offer are displayed on a scoreboard and need not to be memorized by the player. If the contestant rejects all offers he receives the prize in his own briefcase. Figure 1 illustrates the basic structure of the main game.

[INSERT FIGURE 1 ABOUT HERE]

To provide further intuition for the game, Figure 2 shows a typical example of how the main game is displayed on the television screen. A close-up of the contestant is shown in the centre and the prizes in the 26 briefcases are listed to the left and 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.

[INSERT FIGURE 2 ABOUT HERE]

During the course of the game, as additional briefcases are opened, more and more of the initial 26 prizes are eliminated, altering the statistical distribution of the prize in the contestant's briefcase. Apart from the *amounts* in the unopened briefcases, also the *number* of unopened briefcases has an important effect on the statistical distribution. Table I shows how the shape of the distribution changes on average as the game evolves through the nine rounds. The numbers shown are averages across all possible scenarios; in a specific episode, the distribution typically differs from what is reported here, depending on the specific set of remaining prizes. The average expected value does not depend on the game round number. By contrast, the standard deviation, skewness and kurtosis fall significantly as more briefcases are opened. Thus, during the course of the game, the contestants generally are confronted with a decreasingly dispersed, decreasingly skewed and decreasingly fat-tailed prize distribution. In fact, in the ninth round, the distribution is perfectly symmetric, because the contestant then faces a 50/50 gamble involving only two remaining briefcases. This effect of the number of briefcases on the shape of the prize distribution is important when we try to explain the differences in risk attitude between the contestants; see Section IV.

[INSERT TABLE I ABOUT HERE]

Not surprisingly, bank-offers generally are related to the mean of the prizes in the unopened briefcases; when the lower-priced briefcases are opened the "banker" makes a better offer and when the higher-priced briefcases are opened the banker makes a lower offer. However, the bank becomes more generous as the game progresses, making offers that are high relative to the mean. This strategy obviously serves to encourage contestants to continue playing the game and to gradually increase excitement. Usually, the bank is also more generous to unfortunate players who have opened the more valuable briefcases and have seen their expected winnings tumble. Although the contestants do not know the exact bank-offers in advance, the bank behaves consistently according to a clear pattern. We will discuss this pattern later. Bank-offers are not informative, i.e. they cannot be used to determine which of the remaining prizes is in the contestant's briefcase.[5]

The description above applies to the episodes of "Deal or No Deal" in our sample. Except for the monetary amounts at stake, the Dutch and the Austalian edition in our sample are identical. Although the formats of other editions around the world are also quite similar there are some notable differences. With respect to the main game the most important differences concern the number of briefcases, the number of game rounds, the monetary amounts at stake, the information content of bank offers and the presence or absence of special options. Furthermore, in some editions the contestants in the audience from which the finalist is selected are carefully chosen by the producer. These differences are an important consideration in composing our sample.

III Data

In this study, we focus on 53 episodes of “Deal or No Deal” that were broadcasted in the Netherlands (33) and in Australia (20) in the years 2002-2005. The Dutch edition of “Deal or No Deal” is called “*Miljoenenjacht*”. A key advantage of these shows is the relatively high amounts at stake: the contestants may go home with €5,000,000. The first Dutch episode was aired on December 22, 2002.[6] Up to and including June 2005, the show was aired 33 times, divided over five series of weekly episodes and one individual episode. The format of the main game did not change during the sample period. Part of the 33 shows are recorded on videotape by the authors; tapes of the remaining shows are obtained from the Dutch broadcasting company TROS.

In Australia, the debut of “Deal or No Deal” was on July 13, 2003, and the first season consisted of 16 weekly episodes.[7] The show returned on television in February 2004, but as a shorter, daily edition with decimated prizes. In this edition, game options known as “Chance” and “Supercase” are sometimes offered at the discretion of the producer after a contestant has made a “Deal”. These options complicate our analysis because the associated probability distribution is not known and our focus is therefore on the 2003 episodes with large prizes and no special options. Four more shows with large prizes were aired on an incidental basis in August and September 2004 and we included these four shows as well. Copies of all 20 episodes are obtained from a private collection of game show recordings.[8]

The editions in our sample have some important advantages over other editions. For example, the stakes are very large, contestants in the audience of potential finalists are not subject to a strict selection procedure by the producer, bank offers are not informative and complicating game options are absent.

For every contestant we collect data on the eliminated and remaining briefcases, bank-offers and “Deal”/“No Deal” decisions in every game round, leading to a panel data set with a time-series dimension (the game rounds) and a cross-section dimension (the contestants). Furthermore, at the beginning of “Deal or No Deal”, the game show host asks the contestant to introduce himself to the public. Based on this introduction talk and other conversations with the host during the course of the game we collect data on contestant characteristics such as age and education.

Table II shows summary statistics for our sample.

[INSERT TABLE II ABOUT HERE]

About a quarter of the contestants in our sample are females and nearly two-thirds have at least a bachelor degree. Furthermore, the “average” contestant is about 42 years of age; contestants from the Netherlands are older than their counterparts from Australia. On average, contestants walk away with over €150,000 in prize money. Typically, a “deal” is made in the fifth round. The Dutch contestants in our sample were relatively unfortunate in picking their briefcase, since the sample average (€136,164) is well below the average of the 26 prizes (€391,411).

The overrepresentation of males and high-educated contestants in the final game may, in part or in whole, result from the preceding elimination game. For example, the elimination game favors contestants with a relatively high level of general knowledge and/or computational skill. Although some questions require no more than ordinary luck, most questions do require knowledge and/or computational skill. Furthermore, at the end of the Dutch elimination game, just before a last, decisive question, the two remaining contestants can avoid losing and leaving empty-handed by accepting a relatively small prize. Extremely risk averse contestants and/or contestants with a low level of general knowledge or computational skill are most likely to accept this offer. Nevertheless, we doubt there will be a decisive effect on our results. Our study still includes many women and low-educated contestants and their RRA is not significantly different from the rest. Furthermore, the main finding of this study is the role of prior outcomes in explaining the relative differences in RRA. Prior outcomes are random and therefore uncorrelated with contestant characteristics.

IV Methodology

We use a two-stage methodology. The first stage uses a backward induction method to estimate the Arrow-Pratt relative risk aversion (RRA) for every individual contestant based on the time-series of game rounds played by the contestant. In the second stage, we use multivariate regression analysis to explain the cross-sectional variation in the RRA estimates with the characteristics of the contestants and the state-of-the-game they faced.

Stage 1: Estimate RRA for each individual contestant

The time-series of decisions to "Deal" or "No Deal" can be used to derive bounds on each contestant's RRA. In every game round, a unique RRA coefficient can be determined at which the contestant would be indifferent between accepting and rejecting the bank offer. If the contestant accepts the offer, his RRA must be higher than this value; if the offer is rejected, his RRA must be lower. In turn, the bounds can be combined to arrive at a point estimate for the contestant's RRA.

To formalize this idea, we index contestants by $i = 1, \cdots, N$ and game rounds by $r = 1, \cdots, 10$. Furthermore, we use R for the round in which the game ends (i.e., the contestant accepts the bank-offer or, for R = 10, the game is played to the end) and W for contestants' initial wealth. In a given round r, the remaining prizes are denoted by x_r and the associated number of remaining briefcases by n_r. Given r = 1,…,9, x_{r+1} is a subset of n_{r+1} elements from x_r. The collection of all such subsets is denoted by $X(x_r)$. Preferences are modeled using the CRRA utility function

$$u(x|\gamma, W) \equiv \frac{(x+W)^{1-\gamma}}{1-\gamma} \quad (1)$$

with γ for the RRA coefficient.[9] We use $b(x_r)$ for the bank-offer as a function of the remaining prizes x_r. Since the bank-offers are highly predictable (see below), this function is treated as deterministic and known to the contestants.

We now turn to analyzing the expected utility of rejecting a bank-offer, given the remaining prizes x_r. The analysis is complicated by the contestant's option to accept a bank-offer in a later round, similar to the "early-exercise option" of American-style stock options and real options in investment projects. Due to this option, the expected utility of a "No Deal" exceeds the expected utility of playing the game to the end. In the spirit of the decision-tree approach to valuing American-style options and investment projects, we can solve the dynamic programming problem by means of backward induction. Starting with the ninth round, we can determine the optimal stop-go decision in every game round, accounting for the possible scenarios and the optimal decisions in subsequent rounds. Given x_r, the statistical distribution of x_{r+1} is known:

$$\Pr[x_{r+1} = y | x_r] = \binom{n_r}{n_{r+1}}^{-1} \qquad (2)$$

for any given $y \in X(x_r)$, i.e., the probability is simply one divided by the number of possible combinations of n_{r+1} out of n_r. Thus, the expected utility of a "No Deal" is given by:

$$\underbrace{g(x_r, \gamma, W, b)}_{\substack{\text{expected utility of} \\ \text{continuing given the} \\ \text{prizes } x_r}} \equiv \sum_{y \in X(x_r)} \max\{\underbrace{u(b(y)|\gamma, W)}_{\substack{\text{utility of accepting} \\ \text{the offer given the} \\ \text{prizes } y}}, \underbrace{g(y, \gamma, W, b)}_{\substack{\text{expected utility} \\ \text{of continuing given} \\ \text{the prizes } y}}\} \times \underbrace{\binom{n_r}{n_{r+1}}^{-1}}_{\substack{\text{probability of} \\ \text{prizes } y \text{ given} \\ \text{the prizes } x_r}} \qquad (3)$$

for r = 1,…,9. When r = 10, only the contestant's own briefcase remains, so the "bank-offer" equals the prize in this last briefcase, i.e., $b(x_{10}) = x_{10}$, and the contestant need not make any further decisions. Thus,

$$g(x_{10}, \gamma, W, b) \equiv u(x_{10} | \gamma, W) \qquad (4)$$

For a given contestant i and a given round r, we may compute the "switching value" or critical RRA value at which a contestant would be indifferent between stopping ("Deal") and continuing ("No Deal") in the following manner:

$$\hat{\gamma}_{i,r}(W, b) \equiv \{\gamma : g(x_{i,r}, \gamma, W, b) = u(b(x_{i,r}) | \gamma, W)\} \qquad (5)$$

If a contestant accepts a bank-offer, then his certainty equivalent for continuing to play must be lower than the offer. In other words, his RRA will be higher than the switching value, so the switching value for round R provides a lower bound $\hat{\gamma}_i^{\mathrm{L}}(W,b) \equiv \hat{\gamma}_{i,R}(W,b)$ to the contestant's RRA. Similarly, for earlier rounds ($r \le R-1$) RRA will be lower than the switching values $\hat{\gamma}_{i,r}(W,b)$. Since the bank becomes more generous as the game progresses, the lowest upper bound is generally achieved in the penultimate round ($R-1$). More generally, we use $\hat{\gamma}_i^{\mathrm{U}}(W,b) \equiv \min_{r=1,\ldots R-1}(\hat{\gamma}_{i,r}(W,b))$ as the upper bound to the contestant's RRA.[10,11] To estimate the RRA coefficient, we use the arithmetic average of the two bounds:

$$\bar{\gamma}_i(W, b) \equiv \tfrac{1}{2}(\hat{\gamma}_i^{\mathrm{L}}(W,b) + \hat{\gamma}_i^{\mathrm{U}}(W,b)) \qquad (6)$$

By construction, the upper and lower bounds are biased estimates, and by averaging, the positive and negative errors can be expected to cancel out, leading to a better estimate for the true RRA. The upper and lower bound show the same cross-sectional pattern, as we will show in Section V. Thus, while the averaging is important for estimating the level of RRA, it does not materially affect our analysis of the relative differences in risk attitude between contestants.

When using the RRA estimator $\bar{\hat{\gamma}}_i(W,b)$, we have to specify the appropriate initial wealth level (*W*) and bank function (*b*). The higher we set the wealth level, the higher will be the RRA needed to explain a "Deal". Unfortunately, initial wealth is not known due to, e.g., intangible components such as human capital. However, the stakes in the editions of "Deal or No Deal" included in our study are relatively high compared with any reasonable a priori estimate for initial wealth and therefore we may expect our conclusions to be relatively robust with respect to initial wealth levels. Initial wealth levels are linked to the median household income in the Netherlands and Australia, roughly €25,000 for our sample period. Specifically, we consider wealth levels of €0, €25,000 and €50,000.[12]

The results will also depend strongly on the expectations regarding the bank-offers. The higher the expected offers, the more valuable the contestant's "early exercise option" and the higher the RRA needed to explain a "Deal". Fortunately, the bank in the shows we analyzed seemed to adhere to simple rules of thumb. Specifically, the offer as a percentage of the expected prize typically increases in a predictable manner from about seven percent in the first round to about hundred percent in the later rounds. Also, if a contestant opens the more valuable briefcases and the expected prize plummets, the bank typically compensates part of the loss by making a relatively generous offer, often even exceeding the expected value. Table III shows summary statistics for the bank-offers in our sample.

[INSERT TABLE III ABOUT HERE]

The offers clearly depend on the game round number and on $for_{i,r} \equiv E(x_{i,10} | x_{i,r}) / E(x_{i,10})$, or the expected prize in the relevant game round as a fraction of the initial expected prize—an indicator of the fortune experienced during the game. As can be seen from Table III, the bank behaves in a similar way in both countries.[13]

To further quantify the bank behavior, we use the following two-parameter model:

$$E[b(x_{i,r})] = E(x_{10} | x_{i,r}) \times (1 - \exp(\alpha_0 r^2)) \times \exp(\alpha_1 (for_{i,r}^{-1} - 1)) \qquad (7)$$

for $i = 1, \cdots, N$ and $r = 1, \cdots, 9$. The functional form is selected such that the offers lie between zero and the expected prize in the neutral situation ($for_{i,r}$ = 1) if $\alpha_0 \leq 0$ and a "bonus" is given to the unfortunate contestants ($for_{i,r}$ << 1) if $\alpha_1 \geq 0$.

We estimate the two unknown parameters, α_1 and α_2, by minimizing the sum of squared errors in the full sample of bank-offers for all contestants and all rounds.[14] The estimated parameter values are $\hat{\alpha}_0 = -0.050$ and $\hat{\alpha}_1 = 0.002$, and yield the pattern shown in Panel A of Figure 3. Clearly, the percentage offer increases round by round and also it increases following large losses. Panel B shows that the model gives a remarkably good fit, with an overall R-squared of 93%.

[INSERT FIGURE 3 ABOUT HERE]

Since this simple pattern is relatively obvious after seeing a couple of shows, we assume that the contestants are aware of this pattern. We assume a deterministic bank function given by model (7) with parameters equal to our estimates $\hat{\alpha}_0 = -0.050$ and $\hat{\alpha}_1 = 0.002$. Of course, for the contestants in the first shows, when the show had not been aired before, the pattern may not have been so obvious. Also, there remains some uncertainty about the bank-offer. Most notably, the bank-offer to the unluckiest contestants is relatively uncertain and ranges roughly speaking between 100 and 200 percent of the expected prize. Still, the bulk of the uncertainty comes from the uncertainty regarding the contents of the briefcases, especially if large amounts are at stake, and we therefore feel confident to assume a deterministic bank function. Using a stochastic bank function would introduce an extra layer of uncertainty, which would presumably yield RRA estimates below the values reported here.

Our RRA estimates assume that the contestants are fully rational and take into account all possible outcomes and decisions in all subsequent game rounds. This assumption can obviously be questioned because of the cognitive complexity involved. For example, contestants may adopt a less demanding "myopic frame" that focuses only on the bank-offer in the next game round, ignoring the option to reject this offer and continue play. Using a "myopic frame", the expected utility of a "No Deal" is given by:

$$g(x_r, \gamma, W, b) \equiv \sum_{y \in X(x_r)} u(b(y) | \gamma, W) \times \binom{n_r}{n_{r+1}}^{-1} \tag{3'}$$

Similarly, contestants with a "hyperopic frame" would focus only on the prize in their briefcase, ignoring the options to "Deal" in intermediate rounds. For contestants with a hyperopic frame, the expected utility of a "No Deal" is:

$$g(x_r, \gamma, W, b) \equiv \sum_{k=1}^{n_r} u(x_{r,k}) \times n_r^{-1} \tag{3''}$$

We have few prior arguments for choosing a particular frame. A simplified frame that ignores particular options would lower the value of a "No Deal" decision relative to the value of accepting the certain alternative and hence would yield RRA estimates below the values reported here. However, as will be shown later, our main finding in this study relies on risk seeking in particular circumstances and this pattern is not materially affected by myopic or hyperopic framing.

Stage 2: Attribute the differences in RRA

Having estimated the individual RRA scores $\bar{\gamma}_i(W,b)$, $i = 1, \cdots, N$, we subsequently use multivariate regression analysis to explain the cross-sectional variation in the estimates. To explain the variation in the RRA estimates, we consider various variables:

A. Contestant characteristics

At the beginning of "Deal or No Deal" the contestant is asked to introduce himself to the public. Based on this introduction and based on other conversations with the game show host during the course of the game, we are able to determine some characteristics. We include the following variables as regressors in our analysis:

A1. Age (years)

A2. Gender (female/male)

A3. Education (high/low)

A4. Country (Netherlands/Australia)

In some cases, the contestant's age is not explicitly stated. In these cases we estimate the missing values based on the physical appearance of the contestant and other information revealed in the introduction talk, e.g., the age of children. Gender is obviously easy to determine, but it should be noted that usually, the contestant's spouse sits in the audience and is consulted on the decisions to "Deal" or "No Deal". Thus, decisions are often taken effectively by a male-female couple, which may obscure a possible gender effect. Although a contestant's level of education is only rarely explicitly mentioned, it is often clear from the stated profession. We assign "high" to bachelor-degree level or higher (including students) and to equivalent work experience.

B. Previous gains and losses

As discussed above, fortune experienced during the game can be measured by the ratio of current expected prize to initial expected prize. Since the RRA estimate is the average of two bounds calculated from different game rounds, we compute the average of the fortune values in the same two rounds; the resulting variable is denoted by for_i.[15] To distinguish between reactions to gains and reactions to losses, we introduce the dummy variable $loss_i = 1_{for_i \leq 1}$ that takes the value one for losses and zero for gains, and its complement $gain_i = 1_{for_i > 1} = 1 - loss_i$. The following two regressors are included:

B1. Prior losses: $(for_i - 1) \times loss_i$

B2. Prior gains: $(for_i - 1) \times gain_i$

Statistically speaking these regressors are exogenous, which simplifies the analysis of the causal link with the dependent variable (RRA); risk aversion cannot affect the prior outcomes but prior outcomes may affect risk aversion. Furthermore, prior outcomes are random and hence uncorrelated with the other regressors in the model, which simplifies the disentangling of the various effects on RRA.

C. Shape of the distribution

To examine the role of the shape of the distribution of incremental outcomes we include the following two shape parameters:

C1. Standard deviation of the remaining prizes, scaled by the expected prize

C2. Skewness of the remaining prizes

The expected prize is already included in the fortune measure. Higher-order statistics are not included, because mean, standard deviation and skewness almost completely describe the distribution. For example, skewness and kurtosis have an almost perfect correlation of 95 percent in this game.

Due to the structure of the game, the effect of the shape parameters may be affected by endogeneity bias. Specifically, the RRA estimates generally are obtained from the penultimate game round ($R - 1$) and the ultimate game round (R). Due to the increasing trend for the percentage bank-offer, the relevant round numbers will be negatively correlated with the RRA estimates. Unfortunately, the shape of the distribution is also determined in large part by the round number, which may obscure the causal links between the variables. For example, a low skewness is likely to occur in the later stages of the game, when many briefcases have been opened. Risk-averse contestants (high RRA), who stop early in the game always face highly skewed gambles, while the more adventurous contestants (low RRA) choose to play the game until the later stages, when the skewness is low. Thus, we may find a correlation between RRA and skewness even if there is no causal relationship between the two. To avoid such spurious correlation, we use the shape parameters in deviation from the expected values for these parameters in the relevant game round; see Table I. Again, as for the fortune variable, we use the average of the values for the two rounds used to estimate the RRA.[16]

We will use the following linear regression model:

$$E[\bar{\gamma}_i(W,b)] = \beta_0 + \sum_{j=1}^{K} \beta_j z_{i,j} \quad i = 1,\cdots,N \tag{8}$$

where $z_{i,j}$ is the value of the jth regressor, $j = 1,\cdots,K$, for the ith contestant, $i = 1,\cdots,N$. The unknown parameters are estimated by means of ordinary least squares (OLS) regression analysis.

V Results

A. Individual RRA scores

Table IV summarizes our RRA estimates. For a wealth level of €25,000, we find an average RRA of 1.61. Furthermore, the degree of risk aversion differs strongly across the contestants, some exhibiting strong risk averse behavior (RRA > 5) and others risk seeking behavior (RRA < 0). As expected, the estimates decrease if we lower the initial wealth level and increase if we raise the wealth level. However, due to the large amounts at stake, the changes are relatively modest. For example, lowering the wealth level from €25,000 to €0 yields an average RRA of 1.01 and raising the wealth level to €50,000 yields an average RRA of 2.15. As expected, myopic and hyperopic framing (which assume that contestants overlook particular decisions) lead to lower RRA estimates. For example, for W = €25,000, the mean RRA estimate falls from 1.61 to 1.35 for myopic framing and to 0.27 for hyperopic framing.

[INSERT TABLE IV ABOUT HERE]

Other game show studies found RRA estimates ranging from 0.64 (Fullenkamp, Tenorio and Battalio, 2003) to 6.99 (Beetsma and Schotman, 2001).[17] Our estimates are well within this range. Our findings show that the expected utility framework is consistent with observed choice behavior for a “reasonable” or “moderate” degree of risk aversion when large, real money amounts are at stake, even for relatively high wealth levels.

As shown in Table IV, the level of RRA critically depends on the choices regarding initial wealth and mental framing. Regrettably, we lack strong prior arguments for selecting a particular wealth level or mental frame. Fortunately, as will be shown below, the choices for wealth and framing do not materially affect the relative differences in RRA estimates between the contestants. The remainder of this study will focus mainly on the results for W = €25,000 and full rationality (no framing).

B. Regression analysis

We now turn to explaining the cross-sectional differences in RRA. Panel A of Table V shows the OLS regression output for the full model with all regressors. Overall, roughly half of the variation in the RRA estimates can be explained by the model. The most important explanatory variable is prior losses. The positive sign for the regression coefficient suggests that the RRA decreases following losses. In fact, the estimated coefficient implies that contestants become risk seeking after large reductions in the expected prize. This prediction is not based on extrapolation beyond the observed range; the most unfortunate contestants in our sample indeed exhibit risk-seeking behavior by rejecting bank-offers in excess of the average of the remaining prizes. One such contestant, Frank, is discussed at the end of this section.

By contrast, prior gains has no explanatory power. The other variables also have no significant explanatory power. For the contestant characteristics, this may be explained in part or in whole by the lack of sample variation; a substantial part of the contestants in our sample are high-educated and male. Unlike a laboratory experiment, we cannot control these characteristics in game shows. The shape of the prize distribution also has no important role in explaining RRA. This finding may simply reflect that there is hardly any variation in the shape parameters after correcting for the effect of the game round number; as discussed in Section II, all contestants generally face a similarly shaped distribution in a given game round, apart from the mean. Panel B shows the results for a reduced version of the regression model that includes only prior losses. Clearly, hardly anything is lost by excluding the other regressors and prior losses seem the main factor driving RRA in our sample.

[INSERT TABLE V ABOUT HERE]

We interpret the lower RRA following losses as evidence for a "break-even effect" (Thaler and Johnson, 1990): decision-makers become more willing to take risk after previous losses due to incomplete adaption to losses, or a "sticky" reference level that separates gains from losses.[18] A sticky reference level after previous losses implies that relatively many scenarios are seen as "losses". If contestants are risk seeking in the domain of losses, as is true in prospect theory, they may even accept "unfair gambles" to escape these "losses". The interpretation as a "break-even effect" is obviously not consistent with expected utility theory and suggests that phenomena such as framing and the slow updating of the reference level are also relevant when large, real monetary amounts are at stake.

Lower RRA following losses could also be explained by a wealth effect: RRA may be an increasing function of wealth (IRRA), irrespective of gains and losses relative to a subjective reference level. We reject this alternative interpretation for several reasons. First, IRRA does not explain why the RRA becomes negative for the most unfortunate contestants. In the worst case, the contestant goes home empty-handed and returns to his initial wealth level. Thus, to assume that a negative RRA after large losses reflects IRRA, is to assume that contestants were risk seekers before they entered the game show—an implausible assumption. Related to this, the RRA increases so fast that even the Arrow-Pratt measure of *absolute* risk aversion increases in the domain of large losses (IARA). However, economic theory typically assumes decreasing ARA (DARA).[19]

Furthermore, there is substantial variation in the prize money between the two countries in our sample: the Australian show involves a maximum prize of AU$2,000,000, or roughly €1,200,000, while the Dutch show has a maximum of €5,000,000—more than four times as high. If the RRA would be affected significantly by the wealth level per se, then we would expect a significantly higher RRA for Dutch contestants due to the higher stakes. However, we find no evidence in this direction, witness the insignificant effect of the country dummy. Also, in both countries the median contestant stops in round 5; see Table II.

Table VI makes the same point by comparing Dutch "losers" with Australian "winners" and with Australian "losers". The first group consists of the 21 least fortunate Dutch contestants (fortune < 1.16). These Dutch "losers" face an average fortune of 0.42, an average expected prize of roughly €162,000 and have an average RRA of 1.24. We may disentangle the effects of fortune and wealth by comparing these values with those for two subsets of Australian contestants: (i) the set of Australian "winners" (fortune > 0.99) with an average expected prize equal to that of the Dutch "losers" and (ii) the set of Australian "losers" (fortune < 1.00) with fortune equal to that of the Dutch "losers". The Australian "winners" have an average fortune of 1.73 and an average RRA of 2.92. The average RRA for this subset is significantly higher than the average RRA of 1.24 for the Dutch "losers" (p-value = 0.00). Since we control for the expected prize, the difference in average RRA confirms the "break-even effect"; the Dutch "losers" have a lower risk aversion because they experienced prior losses. The contestants in the subset with Australian "losers" have an average expected prize of roughly €40,000 and an average RRA of 0.61. Their RRA is not significantly different from the average RRA of the of Dutch "losers" (p-value = 0.25). Since we control for fortune and given the substantial difference in the stakes, it is unlikely that a "wealth effect" explains why RRA is lower after losses. In brief, the results after controlling for fortune and for stakes support the "break-even effect" and show no sign of a "wealth effect".

[INSERT TABLE VI ABOUT HERE]

C. Robustness analysis

Our conclusions regarding the *level* of RRA depend on the assumptions about the level of initial wealth, the bank's behavior and possible framing effects. However, the conclusions regarding the relative *differences* in RRA and the *drivers* of these differences are more robust. For example, Table VII shows the effect of changing the initial wealth level to $W = €0$ (Panel A) or to $W = €50{,}000$ (Panel B). The general pattern is the same: a large part of the differences in RRA can be explained by prior losses. However, for lower initial wealth levels, the differences in RRA are smaller and a smaller value of the regression coefficient for prior losses is needed to explain the differences, while the reverse is true for higher initial wealth levels. The wealth level also affects the effect of prior gains. Specifically, the RRA of high-fortune contestants is less sensitive to the initial wealth level than the RRA for medium-fortune contestants. As a result, decreasing (increasing) initial wealth leads to a positive (negative) relationship between RRA and prior gains. Nevertheless, the relationship for gains always remains much weaker than for losses, both in terms of economic significance and statistical significance.

[INSERT TABLE VII ABOUT HERE]

Recall that our RRA estimator $\bar{\hat{\gamma}}_i(W,b)$ is a simple average of the upper RRA bound $\hat{\gamma}_i^U(W,b)$ and the lower RRA bound $\hat{\gamma}_i^L(W,b)$. As shown in Table VIII, apart from the level of the RRA estimates, the pattern for the lower bound and the upper bound is comparable with the pattern for the estimator $\bar{\hat{\gamma}}_i(W,b)$.

[INSERT TABLE VIII ABOUT HERE]

As discussed in Section IV, our RRA estimates assume that the contestants are fully rational and account for all possible outcomes and decisions in all game rounds. We may ask if the contestants are boundedly rational in the sense that they adopt a "myopic frame" that focuses only on the bank-offer in the next game round or a "hyperopic frame" that focuses only on the prize in his briefcase. Table IX shows that the "break-even effect" also arises when using RRA estimates derived from the "myopic distribution" and the "hyperopic distribution".

[INSERT TABLE IX ABOUT HERE]

The most striking finding in this study—risk seeking following large initial losses—seems robust for the choice of utility function, initial wealth level and bank behavior. This follows from the fact that the unluckiest players even reject bank-offers that exceed the expected prize and thus enter "unfair gambles". Some contestants even do so in round 9, when only a single, simple decision remains about a simple, symmetric gamble. These contestants will be classified as risk seekers, irrespective of their initial wealth level, their expectation regarding the bank offer and their mental frame. For these contestants, the only reasonable explanation that remains is that risk seeking is a reaction to their prior losses.

Witness Frank, the 36-year old male finalist in the Dutch episode aired on January 1, 2005. Table X shows the gambles presented to him in round 6 to 9 and the decisions he made. Recall that Dutch finalists start with an expected prize of nearly €400,000. In round 7, after several unlucky picks, Frank opens the briefcase with the last remaining large prize (€500,000) and he sees the expected prize tumble from €102,006 to €2,508. The bank then offers him €2,400, or 96 percent of the average of remaining prizes. Frank rejects this offer and play continues. In the subsequent rounds, Frank deliberately chooses to enter unfair gambles, to finally end up with a briefcase worth only €10. Specifically, in round 8 he rejects an offer of 105 percent of the expected prize and in round 9 he rejects a certain €6,000 in favor of a 50/50 gamble of €10 and €10,000. We feel confident to classify such decisions as risk seeking behavior, because they involve single, simple, symmetric gambles with relatively large amounts 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 a reaction to his misfortune experienced during the game.

[INSERT TABLE IX ABOUT HERE]

VI Conclusions

The popular television game show "Deal or No Deal" seems particularly well-suited for analyzing decision making under risk: it involves very large stakes, simple stop-go decisions that require minimal skill, knowledge or strategy and near-certainty about the probability distribution.

Based on the observed choices of contestants in the various game rounds of 53 episodes from Australia and the Netherlands, we find an average Arrow-Pratt coefficient of relative risk aversion (RRA) between roughly 1 and 2 for initial wealth levels between €0 and €50,000 and assuming full rationality. These findings show that the expected utility framework is consistent with the observed choices for a "reasonable" or "moderate" degree of risk aversion when large, real money amounts are at stake, even if we assume relatively high wealth levels. Furthermore, the degree of risk aversion differs strongly across the contestants, some demonstrating strong risk aversion (RRA>5) and others exhibiting risk-seeking behavior (RRA<0).

The differences can be explained in large part by the earlier outcomes experienced by the contestants in the previous rounds of the game. Most notably, RRA generally decreases following losses. Contestants facing a large reduction in the expected prize during the game even exhibit risk seeking behavior. It seems difficult to explain this pattern with RRA being an increasing function of wealth (IRRA). This explanation requires that the contestants were risk seekers before they entered the game show, because their wealth before entering the game equals their wealth in case they go home empty-handed. Furthermore, the same pattern emerges in both countries, despite substantial differences in the amounts at stake; the stakes in the Netherlands are four times those in Australia. This suggests that the pattern in RRA reflects prior losses and gains rather than a wealth effect per se.

Our findings are consistent with the "break-even effect" of Thaler and Johnson (1990): decision-makers become more willing to take risk after previous losses due to incomplete adaption to losses, or a "sticky" reference level that separates gains from losses. This interpretation obviously is not consistent with the expected utility theory and suggests that phenomena such as framing and the slow updating of the reference level are also relevant when large, real monetary amounts are at stake.

We are currently expanding our data set to include episodes from Belgium and Germany, which seem directly comparable to the Dutch and Australian episodes analyzed in this study, both in terms of the prize money at stake and the contestants' wealth level. For further research it would be interesting to also include the results of shows that involve lower stakes and shows from developing countries (e.g., India and Mexico), so as to further disentangle the effect of the wealth level and the effect of prior outcomes.

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Table I

Shape of the prize distribution

The table shows average shape parameters for the statistical distribution of the prizes that remain in a given game round. For every game round number, we draw 1,000,000 random samples with a sample size equal to the number of remaining briefcases in that round. Every prize in the individual samples is drawn without replacement and with an equal probability for every prize. Shown are the average values across all 1,000,000 samples of the expected value (EV) as a fraction of the initial expected value (EV_0), the standard deviation (as a fraction of the expected value), the skewness and the kurtosis. These numbers are based on the prizes in the Dutch shows; very similar results are obtained for Australia.

Game round	Remaining briefcases	EV/EV_0	Stdev/EV	Skewness	Kurtosis
Initial (0)	26	1.000	2.666	3.267	13.394
1	20	1.000	2.551	2.944	11.083
2	15	1.002	2.367	2.513	8.389
3	11	0.998	2.129	2.029	5.860
4	8	0.999	1.864	1.554	3.851
5	6	1.000	1.616	1.151	2.500
6	5	0.999	1.457	0.911	1.842
7	4	1.001	1.258	0.634	1.216
8	3	1.000	0.997	0.314	0.667
9	2	1.001	0.623	0.000	0.250

Table II

Summary statistics

The table shows descriptive statistics for our sample of 53 "Deal or No deal" episodes aired in Australia and the Netherlands in the years 2002 to 2005. The Dutch shows are videotaped by the authors or tapes are obtained from the Dutch broadcasting company TROS. Copies of the Australian shows are obtained from a private collection of game show recordings. The contestants' characteristics age and education are revealed in an introduction talk or in other conversations between the host and the contestant. Age is measured in years. Gender and education are defined as dummy variables, with values of 1 assigned to respectively females and contestants with a high level of education (bachelor-degree level or higher). The stop round is the round in which the bank-offer is accepted; for contestants that played the game to the end, the stop round is set equal to 10. Panel A shows summary statistics for our full sample. Statistics for the Netherlands and for Australia are shown in Panel B and C, respectively. Monetary amounts are reported in Euros; Australian Dollars are converted into Euros using an exchange rate of €0.60 for AU$1.

A. Full Sample (*N* = 53)

	Mean	Stdev	Min	Median	Max
Age (years)	42.11	11.81	20.00	40.00	70.00
Gender (female=1)	0.23	0.43	0.00	0.00	1.00
Education (high=1)	0.62	0.49	0.00	1.00	1.00
Stop round	5.25	1.96	2.00	5.00	10.00
Prize won (€)	150,469.74	187,911.65	3.00	80,000.00	816,000.00
Prize in briefcase (€)	118,755.19	373,804.72	0.01	2,500.00	2,500,000.00

B. The Netherlands (*N* = 33)

	Mean	Stdev	Min	Median	Max
Age (years)	47.55	10.99	30.00	45.00	70.00
Gender (female=1)	0.21	0.42	0.00	0.00	1.00
Education (high=1)	0.58	0.50	0.00	1.00	1.00
Stop round	4.97	1.70	3.00	5.00	10.00
Prize won (€)	207,712.42	211,249.47	10.00	151,000.00	816,000.00
Prize in briefcase (€)	136,163.70	448,236.76	0.01	2,500.00	2.500,000.00

C. Australia (*N* = 20)

	Mean	Stdev	Min	Median	Max
Age (years)	33.15	6.49	20.00	34.50	43.00
Gender (female=1)	0.26	0.45	0.00	0.00	1.00
Education (high=1)	0.70	0.47	0.00	1.00	1.00
Stop round	5.70	2.30	2.00	5.00	10.00
Prize won (€)	56,019.30	79,989.66	3.00	27,075.00	309,000.00
Prize in briefcase (€)	88,519.34	192,864.31	0.30	4,500.00	600,000.00

Table III

Bank-offers

The table shows summary statistics for the bank-offers in our sample of 53 "Deal or No Deal" episodes aired in Australia and the Netherlands in the years 2002 to 2005. The mean bank-offer as a fraction of the expected prize is reported for each game round. The variable $for_{i,r}$ measures the fortune experienced in the previous game rounds by contestant *i* and is defined as the mean of remaining prizes in the relevant round (*r*) as a fraction of the mean of all initial prizes. Statistics are shown for the full sample, for the Dutch subsample, for the Australian subsample, for the subsample of contestants with less than half of the initial expected prize remaining ($for_{i,r} < 0.50$) and for contestants with at least half of the initial expected prize remaining ($for_{i,r} \geq 0.50$). The numbers of observations are shown between parentheses. Bank-offers from rounds with an expected prize less than €1,000 are not considered.

Round	Full sample	The Netherlands	Australia	$for_{i,r} < 0.50$	$for_{i,r} \geq 0.50$
1	0.072 (53)	0.060 (33)	0.093 (20)	0.141 (4)	0.067 (49)
2	0.155 (53)	0.150 (33)	0.162 (20)	0.207 (7)	0.147 (46)
3	0.321 (52)	0.351 (33)	0.269 (19)	0.406 (11)	0.298 (41)
4	0.635 (43)	0.643 (26)	0.624 (17)	0.815 (20)	0.479 (23)
5	0.777 (29)	0.815 (17)	0.723 (12)	0.927 (13)	0.655 (16)
6	0.881 (20)	0.927 (12)	0.811 (8)	0.968 (13)	0.719 (7)
7	0.988 (12)	1.100 (6)	0.877 (6)	1.053 (9)	0.793 (3)
8	1.129 (5)	1.023 (2)	1.199 (3)	1.129 (5)	-
9	1.016 (2)	1.199 (1)	0.833 (1)	1.016 (2)	-

Table IV

RRA Estimates

The table summarizes our estimates for the Arrow-Pratt relative risk aversion (RRA) in our sample of 53 contestants in the game show "Deal or No Deal" in Australia and the Netherlands (2002-2005). Mean, standard deviation, minimum and maximum are shown for the upper bound $\hat{\gamma}_i^U(W,b)$, the lower bound $\hat{\gamma}_i^L(W,b)$ and the average of these two bounds $\bar{\hat{\gamma}}_i(W,b)$, and for various wealth levels ($W=$ €0, $W=$ €25,000 and $W=$ €50,000). Panel A shows the statistics assuming full rationality, i.e., contestants take into account all possible outcomes and decisions in subsequent game rounds. In Panel B, myopic framing is assumed. Under myopic framing, contestants take into account only the bank-offer in the next game round and ignore the option to reject this offer and continue play. In Panel C, hyperopic framing is assumed. Under hyperopic framing, contestants focus only on the prize in their own briefcase, ignoring the options to "Deal" in intermediate rounds.

A. Full rationality

		$W=$ €0	$W=$ €25,000	$W=$ €50,000
Lower bound $\hat{\gamma}_i^L(W,b)$	Mean	0.560	0.805	1.003
	Stdev	0.837	1.495	2.151
	Min	-1.016	-2.530	-4.350
	Max	2.480	5.610	8.430
Average $\bar{\hat{\gamma}}_i(W,b)$	Mean	1.011	1.611	2.150
	Stdev	1.015	1.782	2.664
	Min	-0.643	-1.940	-3.365
	Max	4.170	6.320	9.745
Upper bound $\hat{\gamma}_i^U(W,b)$	Mean	1.462	2.417	3.297
	Stdev	1.379	2.427	3.713
	Min	-0.270	-1.350	-2.380
	Max	6.430	10.070	16.550

B. Myopic frame

		$W=$ €0	$W=$ €25,000	$W=$ €50,000
Lower bound $\hat{\gamma}_i^L(W,b)$	Mean	0.396	0.402	0.363
	Stdev	1.058	2.155	3.268
	Min	-3.880	-8.080	-12.240
	Max	2.480	5.410	8.220
Average $\bar{\hat{\gamma}}_i(W,b)$	Mean	0.914	1.347	1.725
	Stdev	1.068	2.009	3.068
	Min	-0.630	-3.360	-6.065
	Max	4.170	6.220	9.650
Upper bound $\hat{\gamma}_i^U(W,b)$	Mean	1.433	2.293	3.087
	Stdev	1.419	2.595	4.006
	Min	-0.500	-2.640	-4.890
	Max	6.430	10.070	16.550

Table IV (continued)

C. Hyperopic frame

		W = €0	W = €25,000	W = €50,000
Lower bound $\hat{\gamma}_i^L(W,b)$	Mean	0.117	0.066	0.003
	Stdev	0.311	0.654	0.979
	Min	-0.908	-2.524	-4.359
	Max	0.562	0.964	1.252
Average $\bar{\hat{\gamma}}_i(W,b)$	Mean	0.226	0.266	0.381
	Stdev	0.264	0.550	1.258
	Min	-0.417	-1.937	-3.369
	Max	0.655	1.213	7.376
Upper bound $\hat{\gamma}_i^U(W,b)$	Mean	0.336	0.466	0.758
	Stdev	0.269	0.546	1.937
	Min	-0.274	-1.350	-2.380
	Max	0.748	1.462	13.500

Table V

Regression results

The table shows regression results for our sample of 53 "Deal or No Deal" episodes aired in Australia and the Netherlands in the years 2002 to 2005. The dependent variable is the estimated RRA $\bar{\gamma}_i(W,b)$ at a wealth level of $W = €25,000$. Panel A shows the results for the full model that includes all regressors. Panel B shows the results for the reduced model that includes only prior losses as a regressor.

A. Full Model

	Coefficient	Standard error	*t*-statistic	*p*-value
Intercept	3.578	0.531	6.736	0.000
Age	0.125	0.762	0.164	0.870
Gender (f)	-0.564	0.468	-1.206	0.234
Education (h)	-0.240	0.863	-0.278	0.782
Country (NL)	-0.275	0.393	-0.701	0.487
Prior losses	6.718	1.109	6.060	0.000
Prior gains	-2.894	2.282	-1.268	0.211
Stdev/EV	-0.646	0.628	-1.029	0.309
Skewness	-0.899	0.816	-1.102	0.276
R-sq.	0.506			
Adj. R-sq.	0.442			

B. Reduced Model

	Coefficient	Standard error	*t*-statistic	*p*-value
Intercept	2.557	0.238	10.740	0.000
Age				
Gender (f)				
Education (h)				
Country (NL)				
Prior losses	6.022	0.976	6.171	0.000
Prior gains				
Stdev/EV				
Skewness				
R-sq.	0.427			
Adj. R-sq.	0.416			

Table VI

Comparison of Dutch “losers” with Australian “winners” and Australian “losers”

The table shows a comparison of Dutch “losers” with Australian “winners” and Australian “losers”. The subset of Dutch “losers” contains the 23 least fortunate Dutch contestants, the subset of Australian “winners” contains the 12 most fortunate Australian contestants and the subset of Australian “losers” contains the 11 least fortunate Australian contestants. For each subset, the number of contestants (*N*), the mean of remaining prizes (stakes), the ratio of the mean of remaining prizes to the mean of all initial prizes (fortune) and the estimated Arrow-Pratt measure of relative risk aversion (RRA) are shown. The *p*-values are obtained from a *t*-test for equal means of RRA. RRA is estimated assuming an initial wealth level of W = €25,000.

	Dutch “losers” (fortune < 1.16)	Australian “winners” (fortune > 0.99)	Australian “losers” (fortune < 1.00)
N	21	11	9
Stakes (€1,000)	162	161	40
Fortune	0.42	1.73	0.43
RRA	1.24	2.92	0.61
p-value		0.00	0.25

Table VII

Sensitivity for initial wealth level

The table shows regression results for our sample of 53 "Deal or No Deal" episodes aired in Australia and the Netherlands in the years 2002 to 2005. The dependent variable is the estimated RRA $\bar{\gamma}_i(W,b)$. Panel A shows the results for an initial wealth level of W = €0 and Panel B shows the results for W = €50,000.

A. W = €0

	Coefficient	Standard error	*t*-statistic	*p*-value
Intercept	1.297	0.291	4.455	0.000
Age	0.145	0.763	0.190	0.850
Gender (f)	-0.214	0.256	-0.833	0.409
Education (h)	-0.154	0.432	-0.356	0.723
Country (NL)	0.272	0.215	1.265	0.212
Prior losses	2.898	0.607	4.772	0.000
Prior gains	2.324	1.250	1.859	0.070
Stdev/EV	-0.354	0.344	-1.029	0.309
Skewness	-0.167	0.447	-0.373	0.711
R-sq.	0.532			
Adj. R-sq.	0.471			

B. W = €50,000

	Coefficient	Standard error	*t*-statistic	*p*-value
Intercept	5.701	0.804	7.086	0.000
Age	0.362	0.653	0.554	0.582
Gender (f)	-0.875	0.709	-1.234	0.223
Education (h)	-0.154	0.837	-0.184	0.855
Country (NL)	-0.791	0.595	-1.330	0.190
Prior losses	10.186	1.679	6.067	0.000
Prior gains	-7.788	3.456	-2.254	0.029
Stdev/EV	-0.881	0.951	-0.927	0.359
Skewness	-1.678	1.236	-1.357	0.181
R-sq.	0.495			
Adj. R-sq.	0.429			

Table VIII

Upper and lower RRA bounds

The table shows regression results for our sample of 53 "Deal or No Deal" episodes aired in Australia and the Netherlands in the years 2002 to 2005. In Panel A, the dependent variable is the lower RRA bound $\hat{\gamma}_i^L(W,b)$ for $W =$ €25,000. In Panel B the dependent variable is the upper RRA bound $\hat{\gamma}_i^U(W,b)$ for $W =$ €25,000.

A. Lower RRA bound $\hat{\gamma}_i^L(W,b)$

	Coefficient	Standard error	*t*-statistic	*p*-value
Intercept	1.846	0.460	4.011	0.000
Age	0.154	0.607	0.254	0.801
Gender (f)	-0.386	0.405	-0.952	0.346
Education (h)	-0.272	0.943	-0.289	0.774
Country (NL)	0.119	0.340	0.349	0.729
Prior losses	5.759	0.960	5.997	0.000
Prior gains	-2.009	1.977	-1.016	0.315
Stdev/EV	-0.451	0.544	-0.829	0.411
Skewness	0.096	0.707	0.136	0.893
R-sq.	0.470			
Adj. R-sq.	0.401			

B. Upper RRA bound $\hat{\gamma}_i^U(W,b)$

	Coefficient	Standard error	*t*-statistic	*p*-value
Intercept	5.311	0.772	6.881	0.000
Age	0.244	0.473	0.516	0.608
Gender (f)	-0.743	0.680	-1.093	0.280
Education (h)	-0.415	0.637	-0.651	0.518
Country (NL)	-0.670	0.571	-1.174	0.247
Prior losses	7.678	1.611	4.766	0.000
Prior gains	-3.779	3.316	-1.140	0.260
Stdev/EV	-0.842	0.913	-0.922	0.361
Skewness	-1.894	1.186	-1.597	0.117
R-sq.	0.435			
Adj. R-sq.	0.361			

Table IX

Myopic and hyperopic framing

The table shows regression results for our sample of 53 "Deal or No Deal" episodes aired in Australia and the Netherlands in the years 2002 to 2005. The dependent variable is the estimated RRA for $W = €25,000$. Panel A considers the RRA computed using the "myopic distribution", i.e., the distribution of the bank-offer in the next round or the distribution of the prize that the contestant will take home if he decides "Deal" in the next round (myopia). In Panel B, the RRA is computed using the "hyperopic distribution", i.e., the distribution of the remaining prizes, or the distribution of the prize that the contestant will take home if he decides "No Deal" in all game rounds and plays the game to the end (hyperopia).

A. Myopic distribution

	Coefficient	Standard error	*t*-statistic	*p*-value
Intercept	3.578	0.531	6.736	0.000
Age	0.362	0.653	0.554	0.582
Gender (f)	-0.564	0.468	-1.206	0.234
Education (h)	-0.240	0.863	-0.278	0.782
Country (NL)	-0.275	0.393	-0.701	0.487
Prior losses	6.718	1.109	6.060	0.000
Prior gains	-2.894	2.282	-1.268	0.211
Stdev/EV	-0.646	0.628	-1.029	0.309
Skewness	-0.899	0.816	-1.102	0.276
R-sq.	0.506			
Adj. R-sq.	0.442			

B. Hyperopic distribution

	Coefficient	Standard error	*t*-statistic	*p*-value
Intercept	0.667	0.144	4.639	0.000
Age	0.344	0.563	0.611	0.544
Gender (f)	-0.107	0.127	-0.846	0.402
Education (h)	-0.362	0.635	-0.570	0.571
Country (NL)	0.108	0.106	1.017	0.314
Prior losses	2.416	0.300	8.054	0.000
Prior gains	-1.219	0.617	-1.974	0.054
Stdev/EV	-0.256	0.170	-1.506	0.139
Skewness	0.072	0.221	0.324	0.748
R-sq.	0.606			
Adj. R-sq.	0.554			

Table X

Example "Frank"

The table shows the gambles presented to contestant Frank and the "Deal"/"No Deal" decisions made by him in round 6 to 9. This particular episode of the show was broadcasted on Dutch television on January 1, 2005. In round 9, Frank deliberately enters an "unfair" gamble by rejecting a bank-offer of €6,000 or 120 percent of the average of the remaining prizes.

	Remaining Prizes (€)					Exp. Prize (€)	Offer (€)	Offer (%)	Deal / No Deal
Round	0.50	10	20	10,000	500,000				
6	X	X	X	X	X	102,006	75,000	74%	No Deal
7	X	X	X	X		2,508	2,400	96%	No Deal
8		X	X	X		3,343	3,500	105%	No Deal
9		X		X		5,005	6,000	120%	No Deal
10		X				10	—	—	—

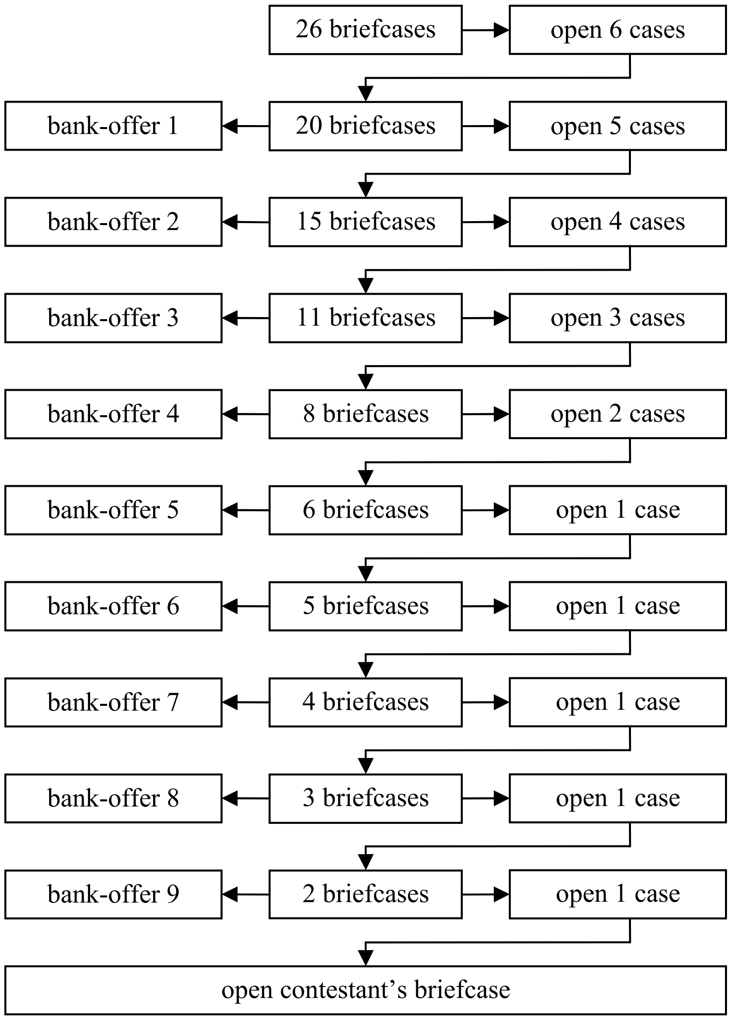


Figure 1: Flow chart of the main game. In every round, the finalist chooses a number of briefcases to be opened, each opened briefcase giving new information about the unknown prize in the contestant's own briefcase. After the prizes in the chosen briefcases are revealed, a "bank-offer" is presented to the finalist. If the contestant accepts the offer ("Deal"), he walks away with the amount offered and the game ends; if the contestant rejects the offer ("No Deal"), play continues and he enters the next round. If the contestant decides "No Deal" in the ninth round, he receives the prize in his own briefcase.

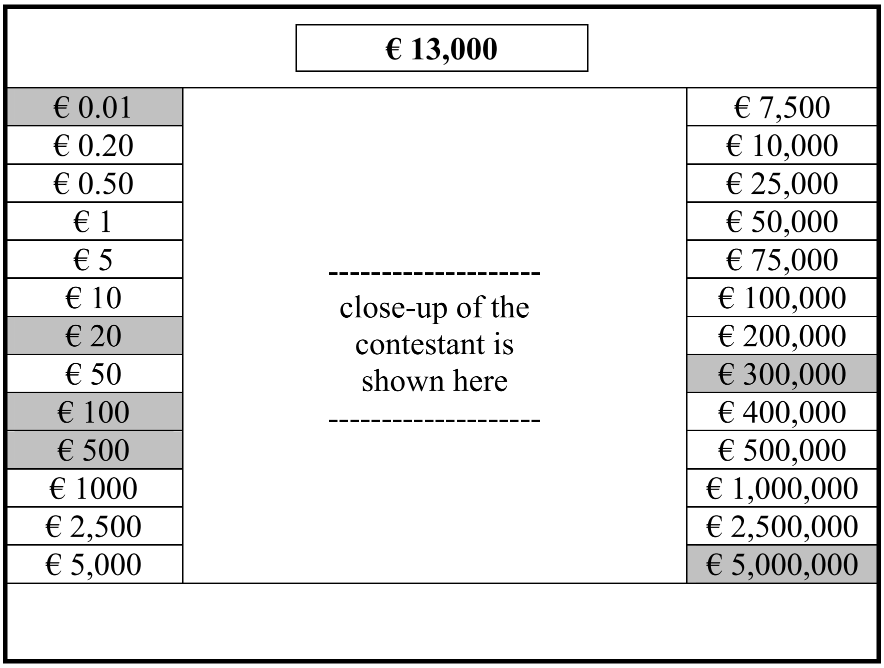
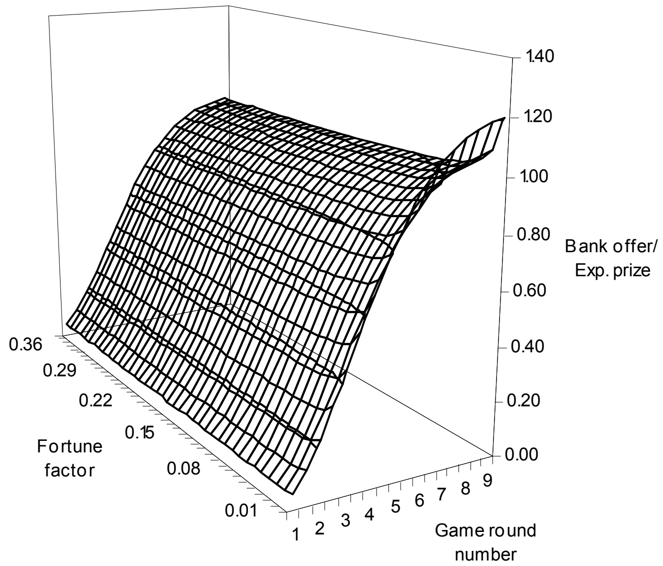


Figure 2: Example of main game as displayed on the television screen. A close-up of the contestant is shown in the centre of the screen. The possible prizes are listed in the columns to the left and right of the contestant. Prizes that are eliminated in earlier rounds are shown in a dark color and remaining 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.

Panel A: Estimated Bank Function



Panel B: Goodness of fit

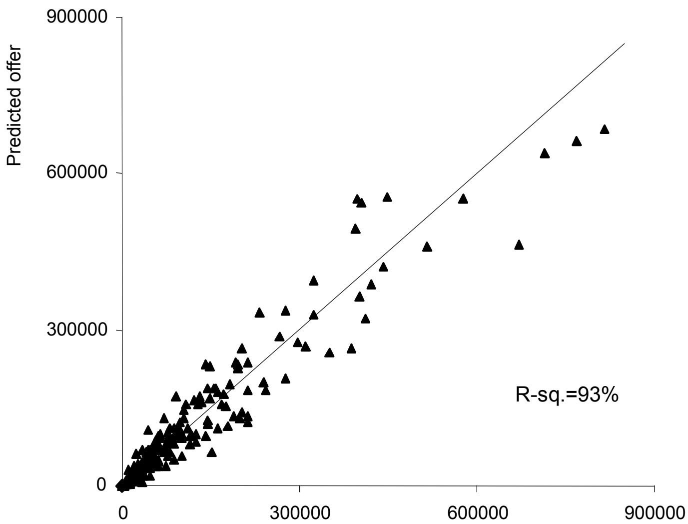


Figure 3: Estimated Bank Function. Panel A shows the estimated relationship between the bank-offer as a fraction of the expected prize, the game round number and the fortune factor (current expected prize as a fraction of the initial expected prize). The parameters of the model $E[b(x_{i,r})] = E(x_{10}|x_{i,r})(1-\exp(\alpha_0 r^2))\exp(\alpha_1(for_{i,r}^{-1}-1))$, $i = 1,\cdots,I; r = 1,\cdots,9$, are estimated by minimizing the sum of squared errors in the full sample of all observed bank-offers. The estimated values are $\hat{\alpha}_0 = -0.050$ and $\hat{\alpha}_1 = 0.002$. The relationship is shown only for low fortune values ($for_{i,r} \leq 0.36$), because the effect of fortune is minimal for higher values. Panel B shows the actual bank-offers in Euros and the predicted bank-offers.

Footnotes

[1] One might argue that the behavior of game show contestants is not representative for behavior outside the studio and that risk attitude parameters inferred from game shows are biased. Contestants may be influenced by e.g. social pressure from the audience, remarks and directions by the game show host and/or the unique event of being on national television. However, the focus of our study is on the relative differences in risk attitude between the contestants and these differences seem less likely to be biased than the risk attitude levels *per se*.

[2] These studies analyze risk attitudes. Game shows are also analyzed for other purposes. For example, Levitt (2004) analyzes "The Weakest Link" to examine racial discrimination among contestants, List (2004) studies "Friend or Foe" to analyze the relationship between age and social preferences, and Bennett and Hickman (1993), Berk, Hughson and Vandezande (1996), and Tenorio and Cason (2002) examine "The Price Is Right" to study rational bidding and game theoretical aspects.

[3] Other examples are Argentina ("*Trato Hecho*"), France ("*A Prendre ou à Laisser*"), Hungary ("*Áll az Alku*"), India ("*Deal Ya No Deal*"), Italy ("*Affari Tuoi*"), Mexico ("*Vas o No Vas*"), Spain ("*Allá Tú*"), Switzerland ("*Deal or No Deal - Das Risiko*") and Turkey ("*Trilyon Avı*"). Only recently, "Deal or No Deal" debuted in the US and the UK.

[4] The complete set of prizes for the Dutch episodes is shown in Figure 1. The average prize is €391,411. For the Australian shows in our sample the maximum is AU$2,000,000 (≈ €1,200,0000) and the average is about AU$155,000 (≈ €93,000).

[5] This is not true for most daily editions of "Deal or No Deal". The bank-offers in the editions from, for example, Italy, France and Spain, are informative and contestants are sometimes offered the option to change their briefcase for one of the other remaining briefcases. This means that contestants are required to apply Bayesian updating, which complicates the analysis of their choices.

[6] "*Miljoenenjacht*" actually started on November 25, 2000. However, the format of the first episodes is completely different from the later shows and involves no briefcases and bank-offers. Rather, in these early shows, the contestant goes home with a prize that depends on the number of correct answers to a series of quiz questions.

[7] In fact, this series consisted of 14 episodes with a total of 16 contestants who played "Deal or No Deal". The unfinished games of four contestants were continued in the subsequent episode and five episodes covered (parts of) the games of two or three contestants. In this study, we treat each game/contestant as a separate episode.

[8] See http://members.iinet.net.au/~powney/gameshow/tradelist.php.

[9] The results using a CARA utility function are very similar and are not reported separately.

[10] When the amounts at stake become small, we may question if the contestant's decisions reveal his true preferences and beliefs. We therefore require a minimum expected prize of €1,000 to compute bounds to the contestant's RRA and put the upper bound equal to the lowest switching value for all rounds $r \leq R$-1 satisfying this minimum expected prize criterion.

[11] For contestants who play the game until the end (R = 10), $\hat{\gamma}_{i,R}(W,b)$ is not a lower bound, because these contestants never accept an offer. Also, in some exceptional cases, $\hat{\gamma}_{i,R}(W,b)$ is not uniquely defined, because the bank-offer is larger than or equal to the largest remaining prize; in these cases, every rational contestant would choose to accept the bank-offer, irrespective of his RRA. In these cases, we estimate the lower bound by the upper bound minus the average distance between the upper and lower bounds for the other contestants. This approach is also used when the expected prize in round R is smaller than €1,000.

[12] Monetary values from the Australian episodes are translated into Euros by using a rate of €0.60 per AU$. Over the period July 2003 – September 2004, the Australian Dollar showed only modest variation when measured against the Euro; he exchange rate ranged between €0.564 and €0.636.

[13] Indeed, a spokesman from Endemol, the production company of "Deal or No Deal", confirmed that the guidelines for bank-offers are the same for all editions included in our sample.

[14] The tenth "round" is not included in the estimation, because the contestant then simply receives the prize in the single remaining briefcase. As in the RRA estimation procedure, we also exclude bank-offers of game rounds with an expected prize less than €1,000.

[15] For contestants for which we had to estimate the lower bound, we simply used the fortune value from the round that was used to compute the upper bound, recognizing that the game round number does not affect the expected prize (see Table I) and hence the expected value of the fortune variable.

[16] Recall that for the contestants who play the game to the end or who face an expected prize smaller than or equal to €1,000, the lower RRA bound is not estimated using information from an actual game round. Thus, for these contestants, the shape parameters are available only for the round used to compute the upper RRA bound. The missing values associated with the lower bounds are set equal to zero; after all, the expected deviation from the average is zero.

[17] Apart from game show studies, the relative or absolute risk aversion coefficient has also been investigated using experimental studies (for example Binswanger, 1981, and Levy, 1994), field surveys (Barsky, Juster, Kimball and Shapiro, 1997), portfolio allocation decisions (Friend and Blume, 1975) and macro data (see Kocherlakota, 1996, for a survey). Overall, the findings are mixed: some studies find decreasing absolute or relative risk aversion, others increasing absolute or relative risk aversion. Also, the range of estimated relative risk aversion is large; both single digit and double-digit coefficients are found.

[18] According to Thaler and Johnson, this phenomenon should be especially relevant when decision-makers have the possibility to break-even on their earlier losses. Unfortunately, we cannot test this qualification here, because the shape of the distribution (apart from the mean) and the possibilities to recover from earlier losses are more or less constant for a given game round number, as discussed before.

[19] The argument is that wealthy individuals are not more risk-averse than poorer ones with regard to the same risk. Thus, as Arrow (1965) notes, DARA is necessary if risky assets are to be “normal goods”, i.e., a rise in wealth leads to an increase in demand for them, whereas IARA implies they are an “inferior good”.