CESifo WORKING PAPERS

6587
2017

July 2017

Contests as Selection Mechanisms: The Impact of Risk Aversion

Christoph March, Marco Sahm

CESifo

Impressum:

CESifo Working Papers
ISSN 2364-1428 (electronic version)
Publisher and distributor: Munich Society for the Promotion of Economic Research - CESifo GmbH
The international platform of Ludwigs-Maximilians University's Center for Economic Studies and the ifo Institute
Poschingerstr. 5, 81679 Munich, Germany
Telephone +49 (0)89 2180-2740, Telefax +49 (0)89 2180-17845, email office@cesifo.de
Editors: Clemens Fuest, Oliver Falck, Jasmin Gröschl
www.cesifo-group.org/wp

An electronic version of the paper may be downloaded
· from the SSRN website: www.SSRN.com
· from the RePEc website: www.RePEc.org
· from the CESifo website: www.CESifo-group.org/wp

CESifo *Working Paper No. 6587*
Category 13: Behavioural Economics

Contests as Selection Mechanisms: The Impact of Risk Aversion

Abstract

We investigate how individual risk preferences affect the likelihood of selecting the more able contestant within a two-player Tullock contest. Our theoretical model yields two main predictions: First, an increase in the risk aversion of a player worsens her odds unless she already has a sufficiently large advantage. Second, if the prize money is sufficiently large, a less able but less risk averse contestant can achieve an equal or even higher probability of winning than a more able but more risk averse opponent. In a laboratory experiment we confirm both, the non-monotonic impact and the compensating effect of risk aversion on winning probabilities. Our results suggest a novel explanation for the gender gap and the optimality of limited monetary incentives in selection contests.

JEL-Codes: C720, D720, J310, K410, M510, M520.

Keywords: selection contest, risk aversion, competitive balance, gender gap.

Christoph March
TU Munich
Arcisstraße 21
Germany – 80333 Munich
christoph.march@tum.de

Marco Sahm
University of Bamberg
Feldkirchenstraße 21
Germany – 96047 Bamberg
marco.sahm@uni-bamberg.de

1 Introduction

Contests are situations in which participants compete for some exogenous rent (prize) by spending non-refundable effort which increases their likelihood of winning (see e.g. Konrad, 2009). In environments where individuals' abilities are not directly observable or verifiable, contests are frequently employed as mechanisms to select the most able candidate. Examples from all areas of life abound. To mention only a few, think of promotion contests in business, election campaigns in politics, or qualifying races in sports. It is well accepted that such contests involve a certain element of randomness (or "luck"). However, as the saying "May the best man win!" illustrates, employing contests as a selection device relies on the estimation that the most able contestant wins most of the time.

In fact, the winning probability of the most able measures how efficient the contest is as a selection mechanism. Unlike in rent seeking contests, the efficiency loss from employing scarce resources in an unproductive way while fighting over the rent plays a minor role in selection contests, because the rent itself is usually small compared to the social surplus that is generated afterwards by the selected candidate. Instead, the main inefficiency in selection contests usually arises due to the possibility that it does not select the most able contestant. For example, the (dissipated) premium in a promotion contest is small compared to the profit the respective firm forgoes by not selecting the most able manager and thereby staying below the production frontier. Similarly, the (dissipated) prize money in the olympic team trials is small compared to the positive externality society forgoes by not selecting the strongest athletes to represent their country.

The estimation that the most able has the highest winning probability is well-founded if contestants differ only in abilities (Tullock, 1980). Yet, contestants usually differ also in other aspects, like available resources (initial endowments), motivations (valuations of winning), or attitudes towards risk. With such additional heterogeneity between candidates, it becomes questionable whether the most able still wins most of the time. For example, Leininger (1993) and Baik (1994) show that a better motivated contestant may have better odds than a more able opponent. Similarly, we may ask whether higher readiness to assume risk can compensate for lower ability: Is the president-elect indeed best suited for holding office or just the candidate who had the courage to invest more money into the campaign? Is the winner of the famous Tour de France really the most talented cyclist or simply the athlete who fears least the negative health effects of high-performance sport? And (how) does it depend on the compensation scheme for managers whether promotion contests select competent experts or fearless gamblers, women or men?

In this paper, we aim to shed light on such questions, both theoretically and experimentally. To this end, we investigate the relative impact of individual abilities and risk preferences on the winning probabilities in simple two-person Tullock contests. Our experimental results confirm two theoretical predictions that are of particular interest. First, we observe that the impact of risk preferences on winning probabilities is non-monotonic: an increase in the risk aversion of a player worsens her odds unless her advantage (due to higher abilities or lower risk aversion) is sufficiently large. Second, we find a compensating effect: a less able but less risk averse contestant can achieve an equal or even higher probability of winning than a more able but more risk averse opponent if the prize is sufficiently large. The crucial role of the prize, i.e. the rent from winning, has been largely neglected by the related literature so far but is intuitive: risk assessment plays a bigger role for higher stakes, and stakes increase in the prize.

In theory, the impact of risk preferences on the behaviour in contests is generally ambiguous (see e.g. Konrad and Schlesinger, 1997). This general ambiguity stems from two opposing effects induced by risk aversion (see e.g. Skaperdas and Gan, 1995): According to the *gambling effect*, a more risk averse participant has an incentive to invest less in the contest since doing so reduces his safe payment. On the other hand, investing more reduces the probability of losing which is why a more risk averse participant also has an incentive to invest more. This has been termed the *self-protection effect*. In general, it is not clear which of the two effects dominates. Moreover, the behaviour of risk averse contestants usually depends also on higher order risk attitudes like *prudence* (also referred to as *downside risk aversion*, see e.g. Treich, 2010). Empirical studies, however, find a positive correlation between prudence and risk aversion (see e.g. Noussair et al., 2014).

We thus restrict our theoretical analysis to examples from the class of preferences which exhibit such positive correlation. Specifically, we focus on contests with linear production functions for lotteries and participants with constant absolute risk aversion (CARA). This enables us to derive closed-form expressions for both, equilibrium efforts and winning probabilities, and to formally separate between the gambling effect and the self-protection effect.

Our model yields the following comparative statics: First and very intuitive, an agent's probability of winning increases in his own ability level and decreases in his opponent's ability level. Second, an agent's probability of winning is either decreasing or inverted U-shaped (increasing or U-shaped) in his own (his opponent's) degree of risk aversion. The potential non-monotonicity stems from the two opposing effects described above. The gambling effect, however, dominates the self-protection effect whenever the player's advantage (due to higher abilities or lower risk aversion) is not too large. As this is, ceteris paribus, never the case if the player's degree of risk aversion (and hence prudence) is sufficiently high, pronounced (downside) risk aversion always lowers the chance of winning.

Third, we characterise the Nash winner, i.e. the player with the higher probability of winning. As known from the literature, if participants only differ with respect to ability (risk preferences), the more able (less risk averse) participant has the higher probability of winning (see Baik, 1994, Skaperdas and Gan, 1995, Cornes and Hartley, 2003). It is then straightforward to see that the more able participant will always have the higher probability of winning if he is also less risk averse. However, in a contest between two participants, one of which has a higher ability (the *gifted*) while the other is less risk averse (the *venturesome*), two cases have to be distinguished. If differences in ability are predominant, the *venturesome* will never be the Nash winner and his winning probability decreases in the prize money. Intuitively, with predominance of differences in ability, risk considerations do not play a prominent role and, hence, participants behave as if they differed with respect to abilities only. By contrast, if differences in risk preferences are predominant, the *venturesome* is the Nash winner if and only if the prize money is sufficiently high. Moreover, his winning probability is U-shaped in the prize money. To gain some intuition for this result, note that risk considerations are not a big issue if stakes are low. Hence, for low rents, participants behave as if there was predominance of differences in abilities. However, as the prize money increases, the predominance of differences in risk preferences becomes the decisive factor: Both participants increase their investments, but this increase is bigger for the less (downside) risk averse participant.

We validate the robustness of our predictions complementing our theoretical analyses with numerical simulations for contestants with constant relative risk aversion (CRRA). Qualitatively, the results confirm the validity of the comparative statics. Quantitatively, though, the impact of risk aversion is considerably smaller than for CARA preferences.

To test the comparative statics of the model empirically, we conduct an experiment in which subjects are repeatedly matched to compete in a two-player Tullock contest for a prize which is low at first and quintupled in the final contests. We implement two treatments with, respectively, symmetric and asymmetric contests. In the latter case, one of the subject's effort is twice as effective as the other subject's effort in each match. Finally, our design informs each subject in each match about (a proxy for) their opponent's degree of risk aversion before efforts are selected.

Our results fully confirm three comparative statics of the model: First, the winning probability increases (decreases) as the own (the opponent's) ability increases. Second, the winning probability is inverse U-shaped in the own degree of risk aversion. In particular, as predicted by the model, if and only if the winning probability is relatively high, it is increasing in the own degree of risk aversion. Third, the probability of winning is increasing in the opponent's degree of risk aversion.

Though we also confirm that the winning probability of the *venturesome* is increasing in the size of the prize money, the increase is small and not significant if he is also the less able contestant. Moreover, the *venturesome* is never the Nash winner in our experiment, not even if the prize is high. However, our results suggest that lower risk aversion can compensate lower ability to some degree. Accordingly, an even higher prize might favor the *venturesome* sufficiently to become the Nash winner (on average).

The remainder of this article is organised as follows: In Section 2, we explain the relation and contribution to the existing literature. Section 3 contains our theoretical analyses. In Section 4, we summarise our experimental design and procedures. The experimental results are presented in Section 5. In Section 6, we discuss several applications of our findings which offer, for example, a novel explanation for the gender gap and the optimality of limited monetary incentives in selection contests. Section 7 concludes. An online-appendix contains supplementary material with the proofs, complementary theoretical and statistical results, and the experimental instructions.

2 Related Literature

In this section, we briefly review the related literature on risk preferences in contests and highlight our theoretical and experimental contributions.

2.1 Theoretical Contributions

Relatively few theoretical papers explicitly address the role of risk preferences in contests. Most of them assume homogeneous players and focus on aggregate effort (rent dissipation). In general, the influence of risk aversion on aggregate effort in symmetric contests with a finite number of players and general contest success functions is ambiguous (Konrad and Schlesinger, 1997). However, the aggregate effort of risk averse participants will be lower than the aggregate effort of risk neutral players if the participants are also prudent (Millner and Pratt, 1991, Treich, 2010). For contests with many participants (Hillman and Katz, 1984, Cornes and Hartley, 2012) or certain conditions on the participants' comparative prudence (Sahm, 2017), this result generalises in the sense that rent dissipation is the smaller the higher the participants' common level of risk aversion.

Whereas all these papers examine how changes in common risk preferences influence aggregate behaviour and rent dissipation *across* contests, we ask how differing risk preferences affect individual behaviour and winning probabilities *within* a given contest. This question has not yet been addressed in the literature for general risk preferences but only for the specific cases of CARA (Skaperdas and Gan, 1995, Cornes and Hartley, 2003) and CRRA (Bozhinov, 2006), both of which imply prudence.[1] Among other things, these articles show that, ceteris paribus, the less risk averse of any two participants exerts more effort and, therefore, has the better chance of winning.

Taking this result as a basis, our theoretical analysis advances the studies of lottery contests between participants with asymmetric CARA-preferences by Skaperdas and Gan (1995) and Cornes and Hartley (2003) in several respects. First, while they focus on the role of risk aversion for effort provision and rent dissipation, we emphasise its impact on winning probabilities and the consequences for contest design. Second, we consider a second source of heterogeneity assuming differing abilities.[2] This allows to study the interplay of two asymmetric individual characteristics which gives rise to our main results: the potentially non-monotonic impact and the compensating effect of risk aversion on winning probabilities. Finally, we are more specific about the contest success functions assuming linear production functions for lotteries. This allows for an original and comprehensive comparative statics analysis with respect to both, the players' characteristics (ability and risk aversion) and the contest design (prize money), and generates testable hypotheses for our experimental inspection.

2.2 Experimental Contributions

Our paper also contributes to a large and growing experimental literature on contests (Dechenaux et al., 2015, Sheremeta, 2013). So far, this literature has mainly focused on *overbidding* and *overspreading*, i.e. the tendency of efforts to be considerably higher than Nash equilibrium predictions and strongly dispersed. Most closely related to this paper are studies which investigate asymmetric contests in which contestants differ with respect to at least one characteristic, in

[1] Note the difference to the models of Hvide (2002) and Hvide and Kristiansen (2003), in which players have the same attitude towards risk ex-ante but where risk taking is a strategic variable that is endogenously determined in the equilibrium of the contest.

[2] Though in principle Cornes and Hartley (2003) accommodate differences in both abilities and attitudes towards risk, most of their related results (e.g. Propositions 3.4 and 5.1) rest upon the additional assumption of participants being homogeneous with respect to abilities.

particular ability and/or risk aversion.

A major focus of experimental papers studying contestants with heterogeneous abilities is the *discouragement effect*, the theoretical prediction that asymmetries lead to lower individual and aggregate effort. Intuitively, if an agent feels disadvantaged, he might be discouraged and reduce his effort which, in turn, induces his opponent to reduce his effort as well. The experimental evidence by and large confirms the discouragement effect (e.g. Fonseca, 2009, Anderson and Freeborn, 2010, Kimbrough et al., 2014). March and Sahm (2017) discusses the contribution to this literature in greater detail.

Experimental studies which consider risk preferences mainly study the impact on efforts. Despite the ambiguous theoretical predictions, most of these studies find that risk aversion significantly reduces mean individual effort (e.g. Millner and Pratt, 1991, Anderson and Freeborn, 2010, Sheremeta, 2011).[3] As our theoretical analysis will show (cf. Proposition 3), the impact of differences in risk preferences depends on their interplay with other individual (e.g. abilities) and institutional (e.g. the rent) characteristics. However, only very few experimental papers have addressed the interaction between risk preferences and further characteristics so far. One exemption is the interaction between risk aversion and gender. Though empirical studies usually find that women are more risk averse than men (Croson and Gneezy, 2009), the experimental evidence on the impact of gender on effort in contests is mixed. While Anderson and Freeborn (2010) find that women exert less effort than men, even if controlling for risk aversion, Price and Sheremeta (2015) and Mago et al. (2013) report the opposite.

Our paper contributes to the experimental literature on contests in several ways: First, we consider contests with two-dimensional heterogeneity.[4] Second, we analyse the impact of varying the prize money. Third, we explicitly inform subjects about their opponent's degree of risk aversion. Finally, we rather focus on winning probabilities than effort provision.

3 Theory

In this section, we first introduce the basic contest game with (potentially) asymmetric abilities. We then analyse the influence of contestants' characteristics (abilities and risk preferences) and the size of the rent (prize money) on the competitive balance for contestants with CARA-preferences. Finally, we numerically confirm these comparative statics for contestants with CRRA-preferences.

3.1 The Basic Contest with Heterogeneous Abilities

Two participants $i \in \{1,2\}$ compete in a winner-take-all contest for a rent of size $R > 0$. Each participant $i \in \{1,2\}$ has an initial wealth endowment $e_i \in \mathbb{R}_+$ and can invest some *effort* $x_i \in [0, e_i]$ in order to improve his probability of winning p_i. Given effort levels x_i and x_j for

[3] Recent theoretical contributions emphasize the important role of prudence for aggregate effort in symmetric contests (Treich, 2010, Cornes and Hartley, 2012). Schindler and Stracke (2016) are the first to lend support to this prediction.

[4] Though Anderson and Freeborn (2010) consider contests with heterogeneous abilities and elicit risk preferences, they do not discuss the relation between the two.

$j \neq i$, this probability will equal $p_i := 1/2$ if $x_i = x_j = 0$, and

$$p_i := \frac{\theta_i \, x_i}{\theta_i \, x_i \, + \, \theta_j \, x_j}, \tag{1}$$

if $x_i + x_j > 0$, where $\theta_i > 0$ is a parameter expressing participant i's *ability*. Note that this formulation reflects, reasonably enough, a complementarity between ability and effort, which is standard in the related literature (e.g. Leininger, 1993, Baik, 1994).[5] Without loss of generality, let participant 1 be at least as talented as participant 2, i.e. $\theta_1 \geqslant \theta_2$.

Participants are assumed to maximise their expected utility. The utility $u_i(z)$ participant $i \in \{1, 2\}$ derives from a certain wealth level z can be expressed by means of some three times continuously differentiable function $u_i : \mathbb{R} \to \mathbb{R}$ with $u_i'' \leqslant 0 < u_i'$.

The contest is organised as a simultaneous move game with complete information. Each participant knows his own as well as his opponent's characteristics. Given effort x_i, participant i's wealth equals $W_i := e_i - x_i + R$ if he wins the contest and $L_i := e_i - x_i$ otherwise. Hence, for $i, j \in \{1, 2\}, i \neq j$,

$$\begin{aligned} Eu_i &= p_i u_i(W_i) + (1 - p_i) u_i(L_i) \\ &= \frac{\theta_i \, x_i}{\theta_i \, x_i \, + \, \theta_j \, x_j} u_i \left(e_i - x_i + R\right) + \frac{\theta_j \, x_j}{\theta_i \, x_i \, + \, \theta_j \, x_j} u_i \left(e_i - x_i\right). \end{aligned}$$

Cornes and Hartley (2012, Theorem 3.1) show that under these assumptions a Nash equilibrium in pure strategies always exists. Moreover, they derive some regularity condition on the curvature of the utility functions u_i under which the Nash equilibrium is unique (Cornes and Hartley, 2012, Theorem 4.2). Yamazaki (2009) shows that, under the assumptions made, the Nash equilibrium in pure strategies will be unique if the Arrow-Pratt measure of absolute risk aversion $RA(u_i, z) = -\frac{u_i''(z)}{u_i'(z)}$ is non-increasing in the wealth level z for all participants i. All these results hold even for the more general case of a contest between an arbitrary number $n \in \mathbb{N}$ of participants and includes the possibility that some of them might be inactive in equilibrium, i.e. exert zero effort. However, in any equilibrium of a two-player contest, both players will obviously exert positive effort. The corresponding effort levels will hence be fully characterised by the two first order conditions (FOC) for maximum expected utilities:

$$\frac{\partial p_i}{\partial x_i} = \frac{p_i u_i'(W_i) + (1 - p_i) u_i'(L_i)}{u_i(W_i) - u_i(L_i)}. \tag{2}$$

3.2 Comparative Statics for Contestants with CARA-Preferences

Similar to Skaperdas and Gan (1995) and Cornes and Hartley (2003), respectively, we first assume that the preferences of participant i can be expressed by the following utility function which exhibits CARA:

$$u_i(z_i) := \frac{1 - e^{-\alpha_i z_i}}{\alpha_i}. \tag{3}$$

[5] The resulting type of asymmetric contest success function was given an axiomatic foundation by Clark and Riis (1998), following an earlier axiomatisation of the symmetric form with $\theta_1 = \theta_2$ by Skaperdas (1996).

α_i is participant i's constant degree of absolute risk aversion. We restrict the theoretical analysis to risk averse participants, i.e. $\alpha_i > 0$. Asymptotically, this includes risk neutrality since $u_i(z_i) \to z_i$ as $\alpha_i \to 0$.

Under these assumptions, the rent seeking game has a unique Nash equilibrium in pure strategies (see Cornes and Hartley, 2003, Proposition 3.3 and Yamazaki, 2008). For ease of notation, define

$$\beta_i \equiv \beta(\alpha_i) := \frac{\alpha_i}{1 - e^{-\alpha_i R}} > \alpha_i > 0, \tag{4}$$

$$\delta_i \equiv \delta(\alpha_i) := \frac{\alpha_i e^{-\alpha_i R}}{1 - e^{-\alpha_i R}} = e^{-\alpha_i R}\beta_i = \beta_i - \alpha_i > 0. \tag{5}$$

Using the identity $e^X = \sum_{k=0}^{\infty} \frac{X^k}{k!}$ for any real X, it is easily verified that β_i (δ_i) is increasing (decreasing) in α_i (Skaperdas and Gan, 1995, supplementary appendix to Proposition 2). Given the uniqueness of the equilibrium, the necessary FOC for an interior solution of participant i's maximisation problem is also sufficient and yields

$$p_i' = \beta_i \left(p_i e^{-\alpha_i R} + 1 - p_i\right), \tag{6}$$

where $p_i' := \partial p_i / \partial x_i \geqslant 0$. Equation (6) implicitly defines the reaction function of participant i, i.e. his optimal effort x_i as a function of the opponent's effort x_j. Dividing condition (6) of participant 1 by condition (6) of participant 2 and noting that $\frac{p_1'}{p_2'} = \frac{x_2}{x_1}$ yields

$$\frac{\theta_1}{\theta_2} q = \frac{\beta_1}{\beta_2} \cdot \frac{e^{-\alpha_1 R} + q}{q e^{-\alpha_2 R} + 1}, \tag{7}$$

where $q := \frac{p_2}{p_1} = \frac{\theta_2 x_2}{\theta_1 x_1}$ is called the *competitive balance* of the contest.[6] A value $q < 1$ indicates that participant 1's probability of winning exceeds the one of participant 2, i.e. $p_1 > p_2$, and vice versa for $q > 1$. If $q = 1$, the contest will be called *even*. Notice that the equilibrium competitive balance q is a function of both, the contestants' characteristics (abilities θ_1, θ_2, and risk aversions α_1, α_2) and the contest designer's choice of the price money R.

In Appendix A, we provide closed form solutions of the competitive balance and the individual efforts in equilibrium. For the subsequent analysis, however, it is more convenient to rewrite equation (7) as follows:

$$\frac{\theta_2}{\theta_1} = q \cdot \frac{(1+q)\beta(\alpha_2) - q\alpha_2}{(1+q)\beta(\alpha_1) - \alpha_1} =: \Phi(q, \alpha_1, \alpha_2, R). \tag{8}$$

The right hand side of equation (8) is a function Φ of q, α_1, α_2, and R but independent from abilities. It shows that q depends, ceteris paribus, only on the ratio of abilities but not on their exact values.[7]

[6] Some authors use the difference in winning probabilities as an alternative measure of *competitive balance* or *closeness* of the contest (see e.g. Runkel, 2006a,b).

[7] Hence, without loss of generality, θ_1 might be normalised to 1.

3.2.1 *The role of individual characteristics: ability and risk aversion*

As intuition suggests and comparative statics with respect to abilities show, being more able always redounds to the contestant's advantage. This follows immediately from the fact that the right hand side of equation (8) is strictly increasing in q (cf. Appendix B).

Proposition 1. *The participant's probability of winning is strictly increasing (decreasing) in the own (opponent's) ability, i.e.* $\frac{\partial q}{\partial \theta_1} < 0 < \frac{\partial q}{\partial \theta_2}$.

Skaperdas and Gan (1995, Proposition 2b), Cornes and Hartley (2003, Proposition 3.4), and Bono (2008, Proposition 1) show that of any two equally able participants, the one with the lower degree of constant absolute risk aversion invests more into the contest and thus has a higher probability of winning. These results might provoke the impression that the winning probability of a contestant always is the higher the less risk averse he is. However, in general such an impression is false. Whether an increase in the participant's degree of risk aversion is in his favour or not depends on whether the gambling effect or the effect of self protection prevails, which in turn depends on the competitive balance of the contest. Hence, the relation between the participant's degree of risk aversion and his winning probability may be non-monotonic.

Proposition 2. *The participant's probability of winning is ceteris paribus*

(a) either decreasing or inverted U-shaped in the own degree of risk aversion,

(b) either increasing or U-shaped in the opponent's degree of risk aversion.

The proof can be found in Appendix B. Note that, since abilities are fixed, any change in the competitive balance results from a corresponding change in the participants' relative effort $\xi := \frac{x_2}{x_1} = \frac{\theta_1}{\theta_2} q$ in equilibrium. To get an intuition for the possible non-monotonicity, it is helpful to disentangle the two opposing effects considering, for instance, a marginal increase of participant 2's degree of risk aversion. On the one hand, self-protection refers to the effect that increasing risk aversion intensifies the participant's incentives to invest into the contest in order to protect his inframarginal investments. As a result, his winning probability increases. On the other hand, gambling refers to the effect that increasing risk aversion lowers the participant's incentives to invest into the contest constituting a risky lottery. As a result, his winning probability decreases.

In the proof (cf. equation (B.3) in Appendix B), we show that the relative strength of these two effects is scaled by the actual competitive balance: If the participant's winning probability is high, the riskiness of the contest as perceived by the participant will be relatively low. Hence, the gambling effect will be relatively weak and the effect of self protection will dominate. Inverse reasoning applies if the participant's probability of winning is relatively low. Summing up, the participant's probability of winning is increasing in the own degree of risk aversion if and only if his own probability of winning is relatively high, i.e. if the competitive balance q exceeds some threshold q_2.

However, the threshold itself depends on the participant's risk aversion (cf. Lemma 3 in Appendix B): The more risk averse the contestant is, the higher his winning probability must be for the self-protection effect to prevail. Put differently, the threshold q_2 is an increasing function of α_2 as depicted in Figure 1. Now, increasing the participant's risk aversion starting

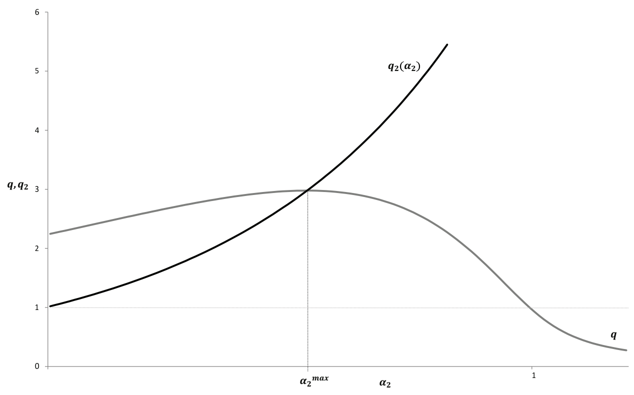


Figure 1 $q_2(\alpha_2)$ and q as functions of α_2 for $\theta_1 = \theta_2 = 1$, $\alpha_1 = 1$, $R = 3$

from $\alpha_2 = 0$, two cases may arise: If his winning probability is low even initially (e.g. due to some disadvantage in abilities), then the gambling effect will always dominate and his winning probability will be monotonically decreasing. However, if his winning probability is initially high (e.g. due to some advantage in abilities), the self-protection effect will dominate up to some level of risk aversion $\alpha_2^{\max}$ from which on the critical threshold q_2 exceeds the actual competitive balance q (cf. Figure 1). Thus, the participant's probability of winning will be inverted U-shaped in the own degree of risk aversion.

3.2.2 The role of contest design: choosing the rent

Contests are designed for various objectives. Some objectives directly tend to the odds ratio. For example, a promotion contest might want to maximise the winning probability of the most able while a sports contest might want to equalise the competitive balance. In this subsection, we investigate how the contest designer can influence the equilibrium winning probabilities by choice of the rent R. Two questions are of particular interest: First, depending on the rent, who is the *Nash winner*, i.e. who has the better odds in equilibrium (Baik, 1994)? Second, how do the odds change by a change in the rent?

Addressing these questions, we generalise the results from the existing literature to contests between participants that differ in both, ability and risk aversion. If both participants have the same degree of risk aversion, the more able participant will be the Nash winner (Baik, 1994, Lemma 2). If both players have the same ability, the less risk averse player will be the Nash winner (Cornes and Hartley, 2003, Proposition 3.4). Combining these results, it is straightforward to see that the more talented player will always be the Nash winner if he is also less risk averse.

We can thus restrict the further analysis to cases in which participant 1 has a higher ability and, at the same time, a higher degree of risk aversion than participant 2.[8] Who will be the Nash winner then depends on whether the difference in abilities or the difference in degrees of risk aversion is more pronounced. The following definitions will simplify the exposition. The contest is said to exhibit *predominance of heterogeneity in abilities* if the relative difference in abilities measured by the ratio $\frac{\theta_1}{\theta_2}$ is at least as big as the relative difference in degrees of

[8] Sometimes participant 1 will be called the *gifted* and participant 2 will be called the *venturesome* in such a case.

risk aversions measured by the ratio $\frac{\alpha_1}{\alpha_2}$. To the contrary, if $\frac{\theta_1}{\theta_2} < \frac{\alpha_1}{\alpha_2}$ the contest is said to exhibit *predominance of heterogeneity in risk aversion.* As the main result of this subsection, Proposition 3 characterises the Nash winner depending on the rent R and provides the respective comparative statics.

Proposition 3. *Suppose $\theta_1 > \theta_2 > 0$ and $\alpha_1, \alpha_2 > 0$.*

(a) Predominance of heterogeneity in abilities: *If $\frac{\theta_1}{\theta_2} \geqslant \frac{\alpha_1}{\alpha_2}$, then for all $R > 0$:*

- *(i)* $q < \frac{\theta_2}{\theta_1} < 1$,
- *(ii)* $\frac{\partial q}{\partial R} < 0$.

(b) Predominance of heterogeneity in risk aversion: *If $\frac{\theta_1}{\theta_2} < \frac{\alpha_1}{\alpha_2}$, then there exist cut-off values $0 < R_0 < R_1$ such that*

- *(i)* $q \geqslant 1 \Leftrightarrow R \geqslant R_1$ *(with equality if and only if $R = R_1$),*
- *(ii)* $\frac{\partial q}{\partial R} \geqslant 0 \Leftrightarrow R \geqslant R_0$ *(with equality if and only if $R = R_0$).*

The proof can be found in Appendix B. Part (a) of Proposition 3 states that if differences in abilities predominate differences in risk aversion, the winning probability for the gifted will always be higher than for the venturesome. Moreover, a higher prize further increases the chance of winning for the participant with the higher ability. Since abilities are fixed, any change in the competitive balance results from a corresponding change in the participants' relative effort $\xi := \frac{x_2}{x_1} = \frac{\theta_1}{\theta_2}q$. Accordingly, $\xi < 1$, i.e. the gifted will exert more effort in equilibrium. Moreover, as the rent rises, the increase in his winning probability results from an increase in his relative equilibrium effort. Intuitively, due to risk aversion, the less able participant with the worse odds expands his effort more slowly than the more able participant with the better odds.[9]

As part (b) of Proposition 3 shows, things are slightly more complicated with predominance of heterogeneity in risk aversion. In this case, again the winning probability for the gifted will be higher than for the venturesome (and increasing) if the rent is sufficiently small. However, if the rent exceeds a certain threshold, the opposite will be true: the winning probability for the venturesome will be higher than for the gifted (and increasing). Figure 2 illustrates these results.

To get an intuition, notice that for low rents, risk considerations do not play much of a role and ability differences are the predominant factor (c.f. Lemma 4 in Appendix B). However, as the rent increases, differences in risk preferences become more and more important. This has several reasons. The rising rent ceteris paribus increases both, the mean $I_i - x_i + p_i R$ and the variance $p_i(1-p_i)R^2$ of player i's lottery associated with the contest. The higher mean provides an incentive to invest more but the higher variance weakens this incentive for risk averse players. Moreover, the induced higher investment comes along with two second-order effects of a rising rent: First, the lottery takes place at a lower wealth level $I_i - x_i$ which further weakens the

[9]If players are risk neutral, their investments coincide such that the equilibrium competitive balance equals $q = \frac{\theta_2}{\theta_1}$ and does, apparently, not depend on the rent R. This neutrality result is due to Runkel (2006a, Proposition 1 (b)) and also holds for a slightly more general class of Tullock contest success functions. As Proposition 3 shows, it will break down if players are risk averse.

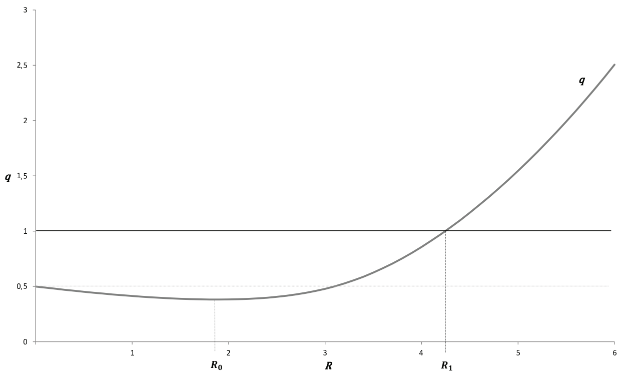


Figure 2 q as a function of R for $\theta_1 = 1$, $\theta_2 = \frac{1}{2}$, $\alpha_1 = 1$, and $\alpha_2 = \frac{1}{4}$

additional investment incentive for prudent, i.e. downside risk averse players (Treich, 2010). Second, depending on the winning probability, the higher investment will ceteris paribus either further increase the variance if $p_i < 1/2$ or decrease it if $p_i > 1/2$ (Eeckhoudt and Gollier, 2005). Summing up, the additional investment incentives for the gifted, i.e. the more risk averse and prudent player are strongest when the rent is low and he is the Nash winner but weaken as the rent rises. Consequently, from a certain threshold R_0 on, the winning probability of the venturesome starts to increase as the rent becomes higher, because – from this point on – the gifted increases his investment by relatively lees than the venturesome. This process continues such that the effort of the venturesome exceeds the effort of the gifted as the rent rises above some threshold $\bar{R} \in (R_0, R_1)$, and his winning probability exceeds the winning probability of the gifted as the rent rises above R_1.

A comparison of the positive results of Proposition 3 (a) and (b) highlights the problem of normative contest design in the presence of heterogeneous participants who may differ in more than one dimension. Depending on the contestants' characteristics, the very same design may lead to diametrically opposed outcomes. For the example at hand, a sufficiently high rent will guarantee a winning probability arbitrarily close to one either to the gifted if differences in abilities are predominant or to the venturesome if differences in risk preferences are predominant. This sensitivity turns contest design into a non-trivial task. In order to achieve a certain goal, the designer has to adapt the structure of the contest to the pool of contestants. The following two examples illustrate this necessity.

First, suppose the designer wants to maximise the winning probability of the gifted. This is a plausible goal for many selection contests such as qualifying races in sports or recruitment tests in human resource management.[10] With predominance of heterogeneity in abilities, part (a) of Proposition 3 implies that the contest designer achieves his aim the better the higher the rent he offers. However, with predominance of heterogeneity in risk aversion, he should restrict the prize money to R_0 according to part (b) of Proposition 3. Put differently, with predominance of differences in risk preferences, there is scope for the limitation of monetary incentives, but not so with predominance of heterogeneity in abilities.

Second, assume the designer wants to implement an even contest. This is a plausible as-

[10] Note that selection contests may have other goals as well, e.g. maximising the winning probability of the selected in a subsequent contest. However, selecting the most able is optimal whenever the selector is able to insure the selected against subsequent risks.

sumption whenever the closeness is a productive input or, more generally, exerts some positive externality the designer would like to internalise. For example, a well-balanced sports tournament may – besides the contestants' effort – attract more viewers and promote the organiser's sales of tickets as well as television and sponsorship contracts. Similarly, a political system that leads to close elections may involve more people into the democratic process. With predominance of heterogeneity in abilities, part (a) of Proposition 3 implies that the contest designer achieves his aim the better the lower the rent he offers. However, with predominance of heterogeneity in risk aversion, he should choose a prize money of $R_1 > 0$ according to part (b) of Proposition 3. Put differently, with predominance of heterogeneity in abilities, the trade-off between balancing the contest and incentivising the contestants' effort is much more pronounced than with predominance of differences in risk preferences.

3.3 Robustness Issues

In this section, we briefly discuss whether the qualitative results of the previous section remain valid for contests with more than two players, more general contest success functions, and different risk preferences.

3.3.1 More than two participants

The two-player-model is relevant for many real world contests like duels in sports, competition between political parties, or litigation in court. Nevertheless, other applications require to consider a contest between an arbitrary number $n \in \mathbb{N}$ of participants. The contest success function of player $i \in \{1, \dots, n\}$ is then given by $p_i := \frac{\theta_i x_i}{\sum_{j=1}^{n} \theta_j x_j}$, his degree of constant absolute risk aversion is denoted by α_i. It is straightforward to show that the participants' winning probabilities in equilibrium are, analogously to equation (8), implicitly defined by a system of equations of the following form:

$$\frac{\theta_j}{\theta_k} = \frac{(1 + q_j)\beta(\alpha_j) - q_j \alpha_j}{(1 + q_k)\beta(\alpha_k) - q_k \alpha_k},$$

where $q_i := \frac{p_i}{1-p_i}$ is player i's relative chance of winning. With more than two participants, the comparative statics become obviously more involved because an increase in q_j does not necessarily imply a decrease in q_k a priori due to possible effects on third parties. However, the equilibrium conditions have a very similar structure and the opposing effects of gambling and self protection associated with risk aversion can be identified here as well. To see this, define $\phi_i(q_i, \alpha_i) := (1 + q_i)\beta(\alpha_i) - q_i \alpha_i$. As in the proof of Lemma 2 (cf. Appendix B), the implicit function theorem yields

$$\frac{dq_j}{d\alpha_j} = -\frac{\partial \phi_j / \partial \alpha_j}{\partial \phi_j / \partial q_j} + \frac{\phi_j}{\phi_k} \frac{\partial \phi_k / \partial q_k}{\partial \phi_j / \partial q_j} \frac{dq_k}{d\alpha_j}.$$

Roughly speaking, the second term in the sum on the right hand side captures the effects that are due to the reaction of other players, and has the same sign as $\frac{dq_k}{d\alpha_j}$. Whereas the first term captures the effect that is due to a change in player j's own behaviour. This term has the opposite sign of $\partial \phi_j / \partial \alpha_j$, since $\frac{\partial \phi_j}{\partial q_j} = \delta(\alpha_j) > 0$. However, as in equation (B.3) in Appendix B, the sign of

$$\frac{\partial \phi_j}{\partial \alpha_j} = q_j \frac{\partial \delta_j}{\partial \alpha_j} + \frac{\partial \beta_j}{\partial \alpha_j}$$

depends on the relative strength of the self-protection effect represented by $\frac{\partial \delta_j}{\partial \alpha_j} < 0$ and the gambling effect represented by $\frac{\partial \beta_j}{\partial \alpha_j} > 0$.

Therefore, the basic results for a contest with an arbitrary number of participants should qualitatively be in line with those derived for two players.

3.3.2 General contest success functions

Consider the model described in Section 3.2 but with the more general contest success function

$$p_i := \frac{f_i(x_i)}{f_1(x_1) + f_2(x_2)}, \tag{9}$$

where $f_i : \mathbb{R}_0^+ \to \mathbb{R}_0^+$ is a twice continuously differentiable function of x_i satisfying $f_i'' \leqslant 0 < f'$ and $f_i(0) = 0$. Moreover, assume that the contest game has a unique Nash equilibrium in pure strategies.[11] Then it is straightforward to show that, analogously to equation (8), the competitive balance in equilibrium is implicitly defined by

$$\frac{f_2'(x_2)}{f_1'(x_1)} = q \cdot \frac{(1+q)\beta(\alpha_2) - q\alpha_2}{(1+q)\beta(\alpha_1) - \alpha_1}. \tag{10}$$

Comparing (8) and (10), observe that the right hand sides of both equations are identical and the left hand sides both express the ratio of the participants' marginal productivities. The only difference is that these marginal productivities and, hence, their ratio are constant for linear production functions, whereas in the general case the marginal productivities depend on equilibrium efforts. Consequently, though the comparative statics become more involved, the identification of the Nash winner along the lines of inequality (B.5) in Appendix B and the conclusions drawn from that carry over to a model with more general contest success functions: Whether the gifted or the venturesome has the better chance of winning depends on a comparison between relative differences in marginal productivities and degrees of risk aversion.

3.3.3 Numerical results for contestants with CRRA-preferences

The case of CARA-preferences analysed in Section 3.2 may be understood as an example for the empirically relevant class of risk preferences for which the correlation between risk aversion and prudence is positive and the less risk averse ceteris paribus has the better chance of winning. We thus conjecture that our results carry over to contests with more general risk preferences within this class. The conjecture finds support by observations from contestants with CRRA-

[11] A sufficient condition is, for example, that f_i is concave and $f_i(0) = 0$ for $i \in \{1, 2\}$ (Cornes and Hartley, 2003). Moreover, note that the model with nonlinear production functions for lotteries and linear effort costs is equivalent to a model with linear production functions for lotteries and nonlinear effort costs.

preferences. The utility of player i then equals

$$u_i(z_i) := \frac{z_i^{1-r_i}}{1-r_i},$$

where $0 < r_i < 1$ denotes his constant degree of relative risk aversion. Note that in this case the player is also prudent with a constant degree of relative prudence $1 + r_i$. Bozhinov (2006) specifies conditions under which a unique Nash equilibrium exists in the CRRA-case. Given that the conditions are met, straightforward calculations show that for equal endowments $I_1 = I_2 = I$, the first order conditions for optimal effort provision yield

$$\left(\frac{I - x_i + R}{I - x_i}\right)^{-r_i} = \frac{(I - x_i)\theta_i\theta_j x_j + \theta_j x_j[\theta_i x_i + \theta_j x_j](1 - r_i)}{(I - x_i + R)\theta_i\theta_j x_j - \theta_i x_i[\theta_i x_i + \theta_j x_j](1 - r_i)}$$

with $i, j \in \{1, 2\}, i \neq j$. Based on the equilibrium conditions, we have numerically calculated efforts and winning probabilities for a large number of parameter constellations. The results are presented in Appendix C.

The numerical results qualitatively confirm the main results for CARA-preferences: Higher abilities are always an advantage (Proposition 1). Figures C.2(c) and C.4(b) in Appendix C, respectively, illustrate that the winning probability may be non-monotonic in the own and the opponent's degree of risk aversion (Proposition 2).[12] And Figures C.5 and C.6 in Appendix C illustrate that comparative statics with respect to the rent lead to diametrical results depending on whether differences in abilities or risk preferences prevail (Proposition 3). Quantitatively, however, the impact of risk aversion with CRRA-preferences is usually less pronounced than with CARA-preferences.

4 Experimental Design and Procedures

We test the theoretical predictions derived in Section 3 with the help of an experiment. This enables us to investigate the influence of contestants' characteristics and the size of the rent under controlled ceteris paribus conditions. In this section, we describe the design and procedures of the experiment. The experimental results are presented in Section 5.

4.1 General Features

We conduct various sessions in which subjects play 30 repetitions of the basic contest game described in Section 3. In each repetition, subjects are randomly matched into pairs and each subject receives an endowment of $e_i = 600$ points. Subjects may invest this endowment to obtain lottery tickets. The lottery's prize varies across repetitions. Specifically, subjects compete for a prize of size $R = 200$ points in the first 20 repetitions and for a prize of size $R = 1,000$ points in the last 10 repetitions.

Risk preferences are measured at the beginning of the experiment.[13] We employ a multiple

[12] The observation that, as participant 2's degree of risk aversion r_2 increases from zero to some small positive value, his winning probability may either rise or fall, depending on the ability ratio θ_2/θ_1, is made also by Hughes and Woglom (1996, Lemmas 3 and 4) who consider a contest between a risk neutral participant 1 and a risk averse participant 2 with CRRA.

[13] Obviously, this design feature relies on the assumption that risk-preferences are not context-dependent.

price list format (see e.g. Holt and Laury, 2002). Each subject is presented with a table of ten ordered decisions between a safe amount of 180 points and a risky lottery which offers either 400 points or 0 points. Across the table, the likelihood of receiving the 400 points increases from 0.1 in the first row to 1.0 in the last row in steps of 0.1 (hence, the probability of receiving the 400 points in row k equals $k/10$). Subjects are required to select one of the options in each row (we did not allow for indifference). For a subject who maximizes expected utility and has a strictly increasing utility function, there exists a unique row such that the subject chooses the risky lottery in this and all subsequent rows and the safe amount in all previous rows. The subject's risk preferences may thus be summarised by the number of times he chooses the safe lottery. In the experimental instructions, probabilities are explained in terms of throws of a ten-sided dice.

In contrast to risk preferences, abilities are *induced* by assigning each subject an ability level $\theta_i \in \{1, 2\}$ where θ_i denotes the amount of lottery tickets obtained for each point invested. We implemented two treatments which differ in the assignment of abilities. In treatment *Symmetric*, each subject is assigned the ability level $\theta_i = 1$ in each repetition. Accordingly, differences in ability are absent which enables us to focus on the impact of differences in risk aversion on effort levels and probabilities of winning. In treatment *Asymmetric*, one subject in each pair is assigned the high ability level $\theta_i = 2$, while the other subject is assigned the low ability level $\theta_j = 1$ $(j \neq i)$. To provide learning opportunities, a subject is assigned the same ability level for the first half of repetitions with a given prize and switches to the other level for the second half. More precisely, we employ a median split of all participants in a given session according to the number of times subjects choose the safe amount at the beginning of the experiment. Subjects in the more (less) risk averse group are then assigned the low (high) ability in repetitions 1 to 10 and 21 to 25 and the high (low) ability in repetitions 11 to 20 and 26 to 30.

Finally, since our theoretical benchmark assumes complete knowledge of abilities and risk preferences, we aim to approximate the latter as close as possible. Therefore, before a subject chooses his effort in a given repetition, we remind him of his own and his opponent's assigned ability level, and we also inform the subject about the number of times he and his opponent selected the safe amount in the multiple price list.

4.2 The Progress of a Session

Each experimental session is partitioned into three parts. Subjects receive the instructions for a given part at the beginning of the part.[14]

In part 1, we elicit subjects risk preferences using the multiple price list format as described above. Each subject is presented with the table of ten decisions on the computer screen and asked to submit his choices via the computer. Only one out of the ten decision is paid. The payoff-relevant row as well as the payoff of the risky lottery is randomly determined at the end of the experiment.

In part 2, subjects compete in 20 repetitions of the contest for a prize of size $R = 200$ points. Efforts are submitted through the computer. To assist subjects in their decision-making, we

[14]The experimental instructions were originally given in German. An English translation is provided in Appendix E.

provided several tools. First, the instructions contain six fictitious examples. Second, the computer interface offers subjects the opportunity to enter fictitious efforts for themselves and the other investor to learn about the resulting likelihoods of winning and losing the contest and the corresponding number of points at the end of the round. Only two repetitions for the second part are paid, one repetition each from the first and the last ten repetitions. The payoff-relevant repetitions are randomly selected at the end of the experiment.

Finally, repetitions in the third part of the experiment are identical to repetitions in the second part, except that subjects compete for a prize of size $R = 1,000$ points. Only 10 repetitions are conducted in the third part and only one (randomly selected) is paid.

4.3 Procedures

Four sessions were conducted for each treatment. The sessions took place at the experimental laboratory of the Technical University of Munich ("experimenTUM") in March and November 2015. Students from TU Munich were invited using the ORSEE recruitment system (Greiner, 2015). 22 to 26 subjects participated in each session. The experiment was programmed in zTree (Fischbacher, 2007).

Upon arrival at the lab, subjects were randomly assigned to cubicles that did not allow for any visual communication between them. Subjects were immediately asked to read the computer screen, which contained some basic instructions regarding behaviour in the laboratory and informed subjects about the three parts and that instructions were going to be distributed at the beginning of each part. Once all subjects were seated, paper instructions for part 1 were distributed and subjects were given time to read them at their own pace. Instructions were then read aloud and subjects were permitted to ask questions.

Once all subjects had submitted their ten decisions in the first part, paper instructions for the second part were distributed. Subjects were again given time to read them at their own pace before the instructions were read aloud. Instructions for part 2 were followed by a short quiz to check subjects' understanding. The experimenters controlled subjects' answers and explained mistakes in private if necessary. Afterwards, the 20 repetitions of part 2 were run.

Finally, the third part of the experiment was conducted in a similar way as the second one except that only short paper instructions were distributed.

At the end of the experiment, the payoff-relevant decisions were randomly selected by means of a ten-sided dice. Points were converted into cash at the rate 1 point = €0.01 and added to a show-up fee of €4.00. Before collecting their earnings, we asked subjects to fill out a short questionnaire consisting of some demographical questions and some questions related to the experiment. Afterwards, subjects retrieved their earnings in private and left.

Session lasted 100 minutes on average. The average payment was €28.42 in treatment *Symmetric*, and €27.83 in treatment *Asymmetric*. Overall, we collected 5,760 effort choices submitted by 192 subjects.

4.4 Hypotheses

To test the theory developed in Section 3, we calculate for each match in which subjects differ in their degree of risk aversion, i.e. the number of safe choices submitted in the first part of the experiment, the winning probability of the *venturesome* implied by the chosen effort levels and the induced abilities. We then use these empirical winning probabilities to test the following hypotheses derived from Propositions 1 to 3:

Hypothesis 1. *Compared to treatment* Symmetric*, the* venturesome*'s winning probability in treatment* Asymmetric *is*

(a) higher if he has the high ability,

(b) lower if he has the low ability.

Hypothesis 2. *The* venturesome*'s winning probability is*

(a) decreasing or inverted U-shaped in his own number of safe choices,

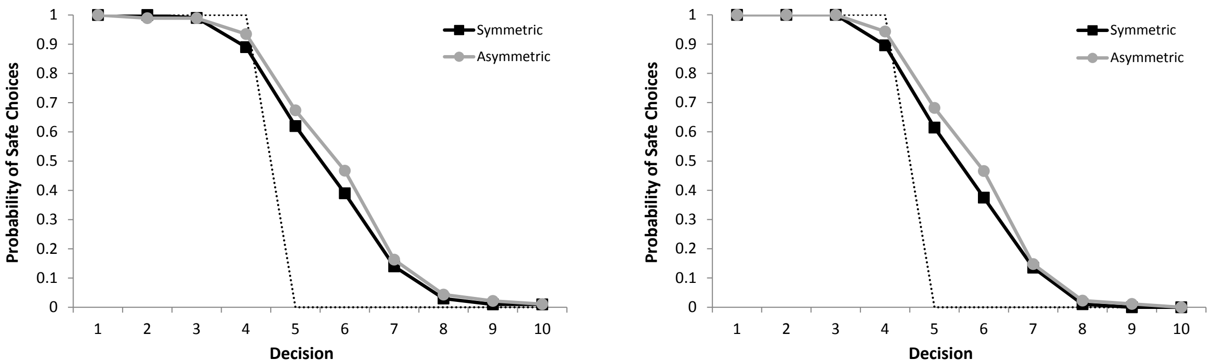
(b) increasing or U-shaped in his opponent's number of safe choices.

Hypothesis 3. *The* venturesome*'s winning probability is larger for the high than for the low prize unless the* venturesome *has the lower ability and differences in risk aversion are small.*

5 Experimental Results

We present our results in four steps: First, we report on risk preferences elicited in the first part of the experiment. Second, we analyse the dynamics of contest decisions across the course of the experiment. Third, we discuss determinants of the probability of winning. Finally, we map those findings to the chosen effort levels.

5.1 Elicited Risk Preferences



(a) All subjects **(b)** Consistent subjects

Figure 3 Proportion of safe choices in each decision

Figure 3 plots the proportion of safe choices across the ten decisions separately for each treatment. The left panel contains the choices of all subjects and the right panel restricts to choices of subjects whose decision sequence is *consistent* with maximisation of expected utility for a strictly increasing utility function. Overall, decisions in the first part of the experiment are inconsistent for 4 subjects (4 percent) in each treatment. Given the low numbers of inconsistent subjects and the fact that risk-aversion cannot be reliably measured with the multiple price list format if subjects are inconsistent, we focus on consistent subjects in our main analyses in Subsections 5.3 and 5.4.

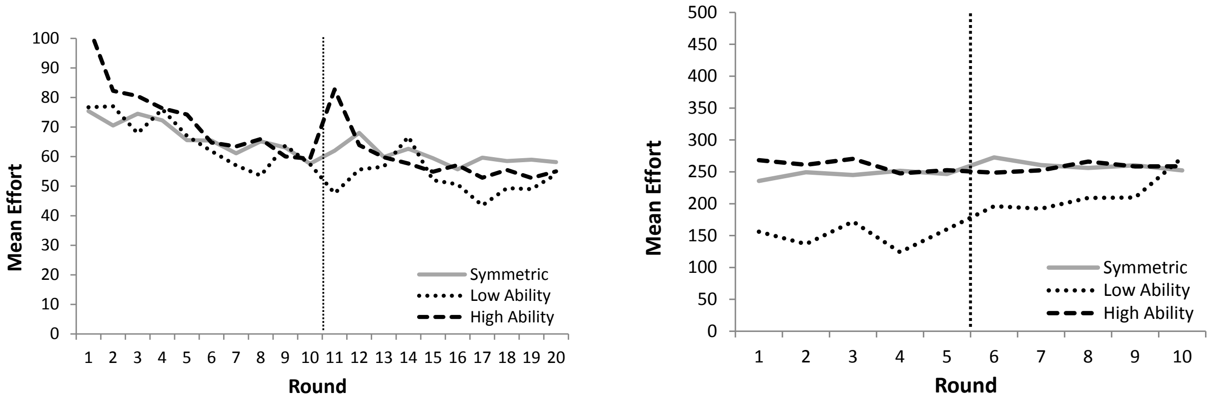
As is evident from comparison to the risk-neutral benchmark (dotted lines), a large majority of subjects is risk-averse in each treatment. The average consistent subject picks the safe amount 5.0 (5.3) times in treatment *Symmetric* (*Asymmetric*) and thus significantly more often than the risk neutral prediction ($p < 0.001$ for each treatment). The distribution of safe choices is presented in Table 1. The table also provides parameter intervals subjects would be assigned to under the assumption of CARA- or CRRA-preferences, respectively. The distributions seem very similar across treatments. Indeed, we find that differences between treatments are not significant using a Kolmogorov-Smirnov test ($p > 0.1$). Moreover, our results are very similar to the findings of Holt and Laury (2002) in the low payoff condition.

Number of Safe Choices	Range of CARA	Range of CRRA	Proportion of Subjects: Consistent *Symm.*	Consistent *Asymm.*	All Subjects *Symm.*	All Subjects *Asymm.*
0 – 2	$\alpha < -0.32$	$r < -0.51$	0.00	0.00	0.00	0.01
3	$-0.32 < \alpha < -0.10$	$-0.51 < r < -0.15$	0.10	0.06	0.10	0.05
4	$-0.10 < \alpha < 0.10$	$-0.15 < r < 0.13$	0.28	0.26	0.27	0.25
5	$0.10 < \alpha < 0.31$	$0.13 < r < 0.36$	0.24	0.22	0.26	0.22
6	$0.31 < \alpha < 0.53$	$0.36 < r < 0.55$	0.24	0.32	0.23	0.32
7	$0.53 < \alpha < 0.81$	$0.55 < r < 0.72$	0.13	0.12	0.12	0.12
8 – 9	$0.81 < \alpha$	$0.72 < r$	0.01	0.02	0.01	0.02
10	n.a.	n.a.	–	–	0.01	0.01

Table 1 Distribution of Risk Preferences

5.2 Choice Dynamics

Since we have employed the Nash equilibrium concept as our theoretical benchmark, a valid test of the theory requires that behaviour has stabilised. Figure 4 shows the evolution of average effort levels across repetitions of the game (*round* henceforth). The left (right) panel contains the results for the second (third) part of the experiment where subjects compete for prize of size $R = 200$ ($R = 1,000$).



(a) Low prize **(b)** High prize

Figure 4 Average efforts across rounds

We find a clear downward trend in efforts for subjects competing for the low prize. Averaging across the first (last) five rounds, the average effort equals 71.7 (58.2) in treatment *Symmetric*, 72.9 (49.3) for subjects of low ability in treatment *Asymmetric*, and 83.5 (54.7) for subjects of high ability in treatment *Asymmetric*. Note that the spikes in average efforts in round 11 of treatment *Asymmetric* coincide with the change in abilities.

In contrast, we find mixed evidence for changes across the third part of the experiment in which subjects compete for the high prize. In particular, efforts in treatment *Symmetric* and efforts of high ability subjects in treatment *Asymmetric* hardly change across rounds: The average effort equals 243.3 (256.2) in the first (last) three rounds of treatment *Symmetric* and 266.6 (261.1) for subjects of high ability in the first (last) three rounds of treatment *Asymmetric*. On the other hand, the average effort increases from 155.0 in the first three rounds to 230.3 in the last three rounds for subjects of low ability in treatment *Asymmetric*.

	Low Prize		High Prize	
	Coef.	SE	Coef.	SE
Constant	60.135***	(4.367)	260.605***	(5.872)
Asymmetric: Low Ability	-6.250	(6.902)	-64.285***	(8.914)
Asymmetric: High Ability	-3.846	(5.784)	2.936	(26.207)
Round Trend (= 1/Round)				
Symmetric	19.722**	(9.980)	-25.986	(20.121)
Asymmetric: Low Ability	29.364***	(10.706)	-46.094**	(20.982)
Asymmetric: High Ability	54.953***	(7.281)	-17.515	(33.072)
Observations	3,840		1,920	
R^2	0.017		0.038	

Note: Robust standard errors in parentheses, clustered at the session level.
Significance level: *** (1%), ** (5%), * (10%).

Table 2 Panel regression results for changes of efforts across rounds.

To provide statistical evidence for the reported effects, we estimate panel regression models of the chosen effort levels. The models include as explanatory variables the inverse of the round, dummies for the low and the high ability in treatment *Asymmetric*, and interactions, and they allow for subject-specific random effects. The results are presented in Table 2. We find clear evidence for a significant decrease of efforts across rounds when subjects compete for the low prize, and a significant increase of efforts for subjects with low ability competing for the high prize in treatment *Asymmetric*.

Our findings are corroborated by evidence on decision times and the frequency with which subjects made use of the decision-support tool. The corresponding figures and regression results are presented in Appendix D.1. In each case, there is a clear and significant downward trend across rounds, with spikes whenever subjects' abilities or the prize changed.

Our results lead us to conclude that subjects need time to adapt to the setting. In our main analyses, we therefore focus on *late decisions*, i.e. decisions made in rounds 11 to 20 (6 to 10) in part 2 (3) of treatment *Symmetric* and rounds 6 to 10 and 16 to 20 (3 to 5 and 8 to 10) in part 2 (3) of treatment *Asymmetric*. Exceptions will be mentioned.

5.3 Determinants of the Probability of Winning

We focus on constellations where contestants differ in their degree of risk aversion and we analyse the winning probability of the *venturesome* (i.e. the less risk averse contestant).[15] Figure 5 plots this probability against the difference in the number of safe choices of the two contestants, separated according to ability (same, low, or high) and size of the prize. For comparison, we also include cases where the two contestants have the same degree of risk aversion but differ in their ability. We make three observations: First, there is a clear effect of ability. The winning probability of the *venturesome* increases (decreases) as his own (his opponent's) ability increases. Second, the winning probability of the *venturesome* mostly increases as his advantage in risk aversion becomes stronger. The sole exception is the case where the *venturesome* also has the higher ability and the size of the prize is low. Third, a higher prize improves the chances for the *venturesome*, but the effect is small and fails to compensate the impact of ability.

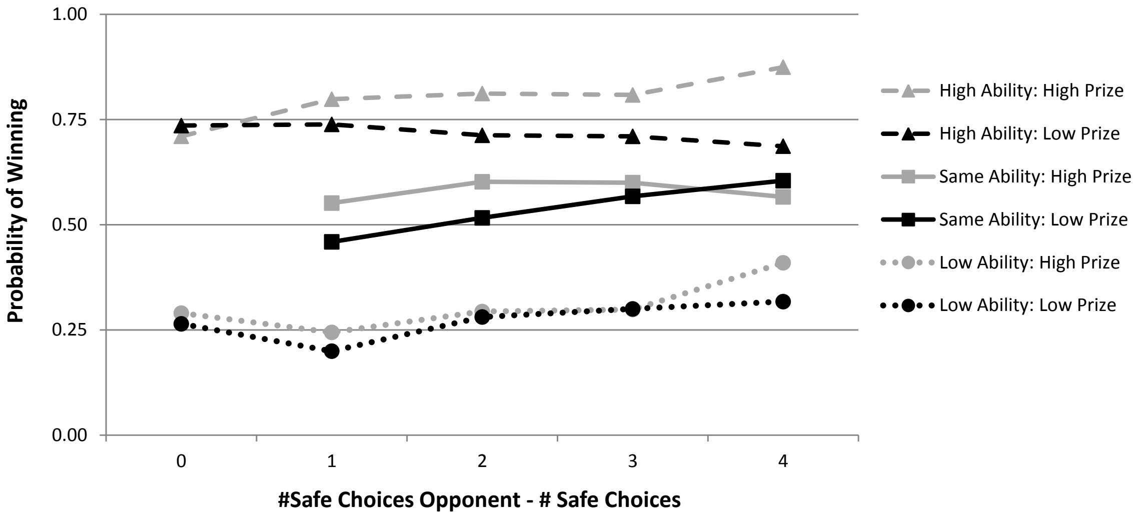


Figure 5 The *venturesome*'s probability of winning.

We formally test our hypotheses by performing OLS regressions where the dependent variable is the *venturesome*'s probability of winning, we include as explanatory variables the own and the opponent's number of safe choices fully interacted with dummies for the low and the high ability in treatment *Asymmetric* and a dummy for the high prize, and standard errors are cluster-corrected for clustering at the session level. In further specifications we also control for demographics and responses to our final questionnaire.[16] The results are presented in Table 3.

The results fully confirm Hypothesis 1. Compared to treatment *Symmetric*, the *venturesome*'s winning probability in treatment *Asymmetric* is on average about 21 percentage points lower (24 percentage points higher) if he has the low (high) ability and the prize is low. Differences are slightly larger for the high prize ($\pm$ 0.26), and highly significant for most combinations of the own and the opponent's risk preferences. Table D.3 in Appendix D.3 contains the marginal effects of the regression with full set of covariates (3) for the main combinations.

[15]See Appendix D.2 for an analysis of the remaining matches in which the two subjects in a match have a comparable degree of risk aversion.

[16]Specifically, we control for (i) age, gender, academic major, and mother tongue, and (ii) self-assessments on generosity, ambition, frequency of participation in games of chance and board games, importance of winning the contest, and importance of the final payment in the experiment.

Dependent Variable	Winning Probability of the *Venturesome*					
Specification	(1)		(2)		(3)	
	Coef.	SE	Coef.	SE	Coef.	SE
Constant	0.379***	(0.054)	0.362***	(0.057)	0.187	(0.104)
Low Ability	-0.340**	(0.116)	-0.330**	(0.110)	-0.298**	(0.097)
High Ability	0.240**	(0.073)	0.244***	(0.063)	0.248***	(0.046)
High Prize						
× Symmetric	0.152**	(0.057)	0.158**	(0.052)	0.167**	(0.064)
× Low Ability	0.027	(0.062)	0.030	(0.065)	0.013	(0.078)
× High Ability	0.101*	(0.048)	0.105*	(0.049)	0.132**	(0.056)
# Safe Choices						
× Symmetric × Low Prize	-0.029	(0.032)	-0.031	(0.029)	-0.033	(0.023)
× Symmetric × High Prize	-0.005	(0.012)	-0.009	(0.015)	-0.017	(0.020)
× Low Ability × Low Prize	-0.058**	(0.023)	-0.061**	(0.021)	-0.067**	(0.020)
× Low Ability × High Prize	-0.005	(0.038)	-0.007	(0.032)	-0.004	(0.027)
× High Ability × Low Prize	0.048**	(0.014)	0.043***	(0.009)	0.034*	(0.015)
× High Ability × High Prize	0.013	(0.014)	0.005	(0.021)	0.008	(0.034)
# Safe Choices Opponent						
× Symmetric × Low Prize	0.067*	(0.028)	0.071**	(0.026)	0.053**	(0.020)
× Symmetric × High Prize	0.024	(0.021)	0.026	(0.021)	0.004	(0.024)
× Low Ability × Low Prize	0.110**	(0.043)	0.126**	(0.048)	0.098**	(0.036)
× Low Ability × High Prize	0.099**	(0.031)	0.113***	(0.030)	0.092***	(0.015)
× High Ability × Low Prize	0.041	(0.024)	0.059*	(0.029)	0.043*	(0.019)
× High Ability × High Prize	0.038	(0.028)	0.056	(0.033)	0.025	(0.039)
Demographics Venturesome						
Female			0.028	(0.027)	0.002	(0.014)
Age			-0.001	(0.003)	-0.005	(0.004)
# Siblings			-0.003	(0.008)	-0.006	(0.008)
Non-BA Student			-0.031	(0.030)	-0.019	(0.014)
Non-German			0.028	(0.028)	0.004	(0.026)
Demographics Opponent						
Female			0.009	(0.035)	-0.001	(0.030)
Age			-0.005	(0.003)	-0.002	(0.001)
# Siblings			0.005	(0.009)	0.011	(0.009)
Non-BA Student			0.011	(0.039)	-0.022	(0.026)
Non-German			0.006	(0.028)	0.067	(0.038)
Questionnaire Responses Venturesome						
Participation Lotteries					-0.007	(0.004)
Participation Games					0.026***	(0.005)
Ambition					0.020*	(0.010)
Generosity					0.004	(0.004)
Importance Winning					0.027**	(0.009)
Importance Payment					-0.011*	(0.006)
Questionnaire Responses Opponent						
Participation Lotteries					-0.020	(0.013)
Participation Games					-0.002	(0.006)
Ambition					0.019*	(0.009)
Generosity					0.004	(0.009)
Importance Winning					-0.039**	(0.012)
Importance Payment					0.004	(0.009)
Observations	1,243		1,243		1,243	
R^2	0.360		0.371		0.457	

Note: Robust standard errors in parentheses, clustered at the session level.
Significance level: *** (1%), ** (5%), * (10%).

Table 3 Determinants of the *venturesome*'s probability of winning.

Second, the *venturesome*'s winning probability is decreasing in his own degree of risk aversion if he has the same or a lower ability than his opponent. The coefficient on the own number of safe choices is always negative in these cases, though we obtain significance only if ability and prize are low. In contrast, the winning probability increases in the *venturesome*'s degree of risk aversion if he also has a higher ability as the coefficient is positive regardless of the size of the prize (again, significance only obtains with a low prize). These results confirm part (a) of our second hypothesis. Indeed, as predicted, the winning probability is increasing in the own degree of risk aversion if the venturesome is likely to have a relatively high probability of winning since he also has the higher ability.

Third, we find a positive impact of the opponent's degree of risk aversion on the *venturesome*'s winning probability as predicted in Hypothesis 2(b). This obtains across treatments and abilities, and for both a low and a high prize, but the increase is significant only if the contest is symmetric and the prize is low, or if the venturesome has the lower ability. Contrary to the results for the own degree of risk aversion, we do not find a non-monotonic relationship between the probability of winning and the opponent's risk aversion. However, since this would require the winning probability to be relatively low, the most favourable case is a less able but more risk averse contestant and thus not included in our regression sample.

Fourth, we note that the impact of both types of risk aversion is smaller if the prize is high which suggests that the (own or opponent's) risk aversion is less important in this case.

To obtain evidence for our third hypothesis, we regress the *venturesome*'s probability of winning on dummies for the *difference* between the number of safe choices of the two contestants fully interacted with dummies for the low and the high ability in treatment *Asymmetric* and a dummy for the high prize. We also control for the *venturesome*'s number of safe choices, demographics, and responses to our final questionnaire, and we cluster-correct standard errors for clustering at the session level. Table 4 reports the marginal effects of moving from the low to the high prize on the *venturesome*'s probability of winning by ability and difference in risk aversion (regression results are presented in Table D.4 in Appendix D.3).

	$\Delta(S)$			
	1	2	3	4
Symmetric	0.082**	0.097***	0.026	-0.035
	(0.034)	(0.027)	(0.040)	(0.134)
Asymmetric: Low Ability	0.036	0.021	0.026	-0.044
	(0.057)	(0.028)	(0.034)	(0.043)
Asymmetric: High Ability	0.072**	0.100*	0.072***	0.129**
	(0.030)	(0.051)	(0.018)	(0.065)

Note: $\Delta(S)$ = # Safe Choices Opponent - # Safe Choices
Robust standard errors in parentheses, obtained using the Delta method.
Significance level: *** (1%), ** (5%), * (10%).

Table 4 Marginal effects of switching from the low to the high prize on the *venturesome*'s probability of winning.

The results partially confirm Hypothesis 3. Competing for a high instead of a low prize always increases the *venturesome*'s winning probability (i) if he has the higher ability, and (ii) if abilities are symmetric and the difference in risk aversion is not too large. The *venturesome*'s probability of winning is also higher for the high than for the low prize if he has the lower ability, but the differences are not significant and considerably smaller than in the two other cases and the average probability of the *venturesome* remains far below one-half. Our results do however suggest that lower risk aversion can compensate lower ability to some degree:[17] The coefficients of the dummies for the difference in risk aversion exhibit an increasing pattern especially if the ability of the *venturesome* is low. Indeed, treating the difference as a continuous variable yields a significantly positive coefficient in this case both for the low and the high prize (see Table D.5 in Appendix D.3).

Finally, though we do not find any influence of demographics, some of our questionnaire items impact the *venturesome*'s winning probability. For example, this probability is higher if the *venturesome* takes part in board games more often, has a higher ambition, and assigns a higher importance to winning, and it is lower if he considers the final payment less important.

5.4 Determinants of Effort Choices

Table 5 gives an overview of average effort levels and corresponding standard deviations across late rounds and matches of consistent subjects. In line with many other experimental studies on contest behaviour (Sheremeta, 2013, Dechenaux et al., 2015), we find significant heterogeneity of individual efforts and significant overbidding relative to the equilibrium predictions, which is more pronounced for the low than for the high prize. Moreover, we find an asymmetric *discouragement effect* in the sense that subjects bid less in treatment *Asymmetric* than in treatment *Symmetric*, if they have the low ability, but not if they have the high ability. March and Sahm (2017) provide a thorough discussion of these findings.

Treatment/participant Type	Low Prize: $R = 200$		High Prize: $R = 1,000$	
Symmetric	57.8	(40.2)	255.1	(148.0)
Asymmetric: Low Ability	50.8	(62.2)	193.3	(209.7)
Asymmetric: High Ability	56.0	(30.5)	266.7	(138.7)

Theoretical predictions in brackets, standard deviations in parentheses

Table 5 Average effort levels

To map our findings on the *venturesome*'s probability of winning on effort levels, we estimate panel regression models of the relative effort levels, i.e. effort divided by the size of the prize. The models include as explanatory variables the own and the opponent's number of safe choices fully interacted with dummies for the low and the high ability in treatment *Asymmetric* and a dummy for the high prize, and they allow for subject-specific random effects. In further specifications, we also incorporate demographics and responses to our final questionnaire. The estimation results for all subjects and separately for the more and the less risk averse subject in each pair are presented in Appendix D.4.

The estimation confirms, first, that subjects invest less effort than in the symmetric contest when facing a more able contestant. For the more risk averse, the reduction is the larger the higher the own and the opponents' degree of risk aversion. For the *venturesome*, the opposite holds and effects are mainly present for the high prize. In contrast, subjects barely respond to an increase in their own ability. Accordingly, the increase in the *venturesome*'s winning probability due to an increase of his ability is not driven by an increase in his (relative) effort.

[17] We are grateful to Rudi Stracke for suggesting this interpretation.

Second, the *venturesome*'s effort does not change significantly with the own and the opponent's degree of risk aversion except if he also has the higher ability. In this case, he invests the less the more risk averse his opponent is. In contrast, the more risk averse subject's effort is decreasing in his own degree of risk aversion, and the decrease is larger in an asymmetric contest. The more risk averse subject also responds to an increase in his opponent's degree of risk aversion if and only if the prize is high. However, whereas in a symmetric contest he invests the more the more risk averse his opponent is, the opposite holds true in an asymmetric contest. The results suggest that the positive relationship between the *venturesome*'s winning probability and his own degree of risk aversion if he has the high ability is mainly driven by the effort reduction of his opponent.

Third, we find that an increase of the prize leads to a (significant) reduction of relative efforts unless the contest is asymmetric and a subject has the high ability. In particular, in situations where the *venturesome* has the lower ability, neither the *venturesome* nor the gifted spends significantly less effort if the price is high. Thus, increasing the prize does not improve the chances of the *venturesome* in these situations.

Finally, we find that subjects who have more experience with board games or assign a higher importance to winning the contest invest more.

6 Applications

The results of this paper apply to many contest-like situations in various areas of everyday life. In this section, we discuss a non-exhaustive series of examples.

6.1 Personnel and labour economics

The human resource management uses contests for various purposes like recruitment, promotion, and compensation of workers. Over the last few years, two topics have received particular interest in the public debate about labour market policies: the gender gap and the compensation of executives.

The gender gap

In the labour market of most countries, gender differences persist and become manifest in a participation gap, a remuneration gap, and an advancement gap (World Economic Forum, 2013). The socio-scientific literature offers various explanations emphasising the role of both, genuine differences between women and men (see e.g. Paglin and Rufolo, 1990) as well as institutional discrimination against women (see e.g. Albrecht et al., 2003, Arulampalam et al., 2007). Yet the interplay between gender specific traits and institutions governing labour market decisions has not been fully explored. In particular, the fact that many decisions on employment, compensation, and promotion are based on *contests* has been largely neglected. Taking this institutional feature into account, our analysis offers a novel explanation for the gender gap.

Empirical and experimental studies comparing the characteristics of women and men support the following stylised facts: While there are no significant differences with respect to intellectual abilities (American Psychological Association, 2014), on average, she is significantly more risk averse (Byrnes et al., 1999, Croson and Gneezy, 2009, Noussair et al., 2014).

Accordingly, a promotion contest between the average woman and the average man exhibits predominance of heterogeneity in risk aversion. Proposition 3(b) then predicts similar winning probabilities for moderate compensation levels. For big salary gaps, however, the predicted Nash winner is male. Hence, the model explains both aspects of the gender gap: First, on average, more men than women are employed/promoted. Second, on average, promoted women earn less than promoted men.[18]

Executive compensation

Given the perception that the financial crisis of 2007-2008 might – at least partly – originate from excessive risk-taking by top managers, should the government regulate (e.g. limit) executive compensation?[19] Suppose that the promotion of top managers is governed by predominance of differences in risk aversion. If some firm does not fully internalise the risk that the decisions of its executives impose on the society as a whole (e.g. due to limited liability), it might offer promotion premiums that are too high, thereby promoting managers that are too venturesome, in the sense that regulations (limitations) may increase executive risk aversion and, hence, total welfare.

Relative performance pay

Relative performance pay is a contest-like compensation scheme which is both, widely used in practice and extensively discussed in the literature originating from the seminal paper of Lazear and Rosen (1981). Though there certainly is self-selection along both dimensions, the majority of people seem to base their occupational choice rather on abilities than on risk considerations.[20] For (mature) businesses, where this argument is valid, predominance of heterogeneity in risk aversion seems a plausible assumption. Proposition 3(b) then predicts that payments based on relative performance should be higher in industries in which risk aversion is an obstacle rather than a virtue. Comparing, for instance, the financial industry and the aircraft industry supplies some anecdotal evidence for this testable hypothesis.

6.2 Political economy

The model offers similar implications for the selection of politicians in the political process. For example, an election may be interpreted as a contest between agents competing for the rent from holding office. Given the assumption that in many (mature) democracies there is predominance of heterogeneity in risk aversion among candidates, moderate compensation for office-holders may increase the probability that the more able candidate will be elected (c.f. Proposition

[18]The predictions of the model are also in line with two more sophisticated empirical observations: First, most part of the gender wage gap vanishes if one controls for the type of occupation (Bertrand and Hallock, 2001). This observation shows that wages are not gender-specific per se but occupation-specific. Indeed, the model then predicts a lower fraction of women in highly paid jobs but no gender wage gap within a certain type of occupation. Second, gender differences in risk preferences disappear if one controls for the type of occupation (Croson and Gneezy, 2009, Section 2.3). In fact, conditional on being promoted into an occupation of a certain wage-type, the model predicts that the risk-preferences of men and women should not differ, because selection does not rest upon gender directly but upon risk-aversion.

[19]See e.g. Bebchuk and Spamann (2010).

[20]For example, Paglin and Rufolo (1990) show that comparative advantages are an important determinant of the individual choice of occupation.

3(b)). Moreover, assuming that the less risk averse candidate also chooses the riskier policies, the results entail the following hypothesis: Higher rents from office lead to riskier policies. Hence, there might be a case for the limitation of monetary incentives for politicians similar to that of executives.

6.3 Sports economics

For many mature sports, the assumption that athletes differ by less in abilities than in attitudes towards risk appears reasonable. Given this, the model may explain event-dependent differences in the prize money: It is optimal for organisers to offer a lower prize money for events that aim at the selection of talent, for example qualifying races like the Olympic Trials, than for events, like the Golden League Meetings, that aim at a balanced competition because closeness exerts a positive externality on other markets ($R_0 < R_1$, c.f. Proposition 3(b)). Similarly, the analysis gives rise to the following hypothesis: the higher the prize money of an event, the less risk averse the winners on average.

6.4 Law and economics

The considered contest may be understood as a model of litigation[21] reinterpreting the rent R as the amount in dispute and the ratio $\frac{\theta_1}{\theta_2}$ as a pre-trial head start, the so-called objective *merits* of the case (Hughes and Woglom, 1996). As the model shows, for close cases, i.e. for $\frac{\theta_1}{\theta_2}$ close to 1, the winning probability is very sensitive to the litigants' risk preferences as well as to the amount in dispute. This gives rise to the following hypothesis: Close cases are more often won by the less risk averse litigant than cases with an odds-on favourite. Moreover, even in clear cases, the favourite may have an arbitrarily small winning probability if he is risk averse and encounters an (almost) risk neutral litigant in a case in which the amount in dispute is sufficiently high (c.f. Proposition 3(b)). For example, think of litigation between a risk averse individual and a risk neutral firm or institution. This constitutes some rationale for legal insurance.

7 Concluding Remarks

In this paper, we have analysed how individual risk preferences affect the likelihood of selecting the more able contestant within a two-player Tullock contest. Our theoretical analysis and our numerical simulations have established two main predictions: First, an increase in the risk aversion of a player worsens her odds unless she already has a sufficiently large advantage. Second, if the prize money is sufficiently large, a less able but less risk averse contestant can achieve an equal or even higher probability of winning than a more able but more risk averse opponent. Moreover, we have conducted a laboratory experiment providing empirical evidence for both, the non-monotonic impact and the compensating effect of risk aversion on winning probabilities.

Our insights provide positive explanations for phenomena like the gender gap and offer suggestions for normative contest design. For example, if the contest aims at selecting the

[21]Since investments into the contest are sunk, the model represents the so-called American rule under which litigants are responsible for paying their own legal expenses, regardless of the outcome of the dispute.

most able but exhibits predominance of heterogeneity in risk aversion, then the limitation of (monetary) incentives in business (wage differentials), politics (rents from office), and sports (price money) may be optimal.

Acknowledgements

We thank Richard Cornes, Christian Feilcke, Hans Hvide, Kai Konrad, Wolfgang Leininger, Thomas Nehfischer, Marco Runkel, Rudi Stracke, and seminar audiences at Düsseldorf Institute for Competition Economics, University of Bamberg, University of Konstanz, University of Munich, Technical University of Munich, Universität der Bundeswehr München, Erasmus University Rotterdam, and Uppsala University.

Appendix

Appendix A provides closed-form solutions of individual efforts and the competitive balance in equilibrium with CARA-preferences. Appendix B contains the proofs of the theoretical results. Appendix C presents numerical results for the equilibrium with CRRA-preferences. Appendix D complements the statistical analysis reported in the main text. Finally, Appendix E contains an English translation of the experimental instructions.

A Explicit Solutions for CARA-Preferences

If participants have CARA-preferences, the equilibrium values of competitive balance and individual efforts can be computed explicitly. The closed-form solutions provided below may be useful in creating numerical examples and simulations.

A.1 Competitive Balance

Equation (7) can be transformed into a quadratic equation for the competitive balance in equilibrium; as $\frac{\theta_2\delta_1}{\theta_1\delta_2} > 0$, only the positive root yields a feasible solution $q > 0$, i.e.

$$q = \sqrt{\frac{\theta_2\delta_1}{\theta_1\delta_2} + \left(\frac{\theta_1\beta_2 - \theta_2\beta_1}{2\theta_1\delta_2}\right)^2} - \frac{\theta_1\beta_2 - \theta_2\beta_1}{2\theta_1\delta_2}. \tag{A.1}$$

A.2 Effort

With CARA-preferences, we use (3), (4), and (5) to rewrite the FOCs (2) as follows:

$$\frac{\theta_1\theta_2 x_2}{\theta_1 x_1 + \theta_2 x_2} = \delta_1\theta_1 x_1 + \beta_1\theta_2 x_2, \tag{A.2}$$

$$\frac{\theta_1\theta_2 x_1}{\theta_1 x_1 + \theta_2 x_2} = \delta_2\theta_2 x_2 + \beta_2\theta_1 x_1. \tag{A.3}$$

After division by x_2 and x_1, respectively, the left hand sides of the two FOCs coincide, and so do the right hand sides, i.e.

$$\delta_1\theta_1\frac{x_1}{x_2} + \beta_1\theta_2 = \delta_2\theta_2\frac{x_2}{x_1} + \beta_2\theta_1.$$

The resulting quadratic equation has only one positive root $x_1 = \gamma x_2$ with

$$\gamma := \frac{\sqrt{4\theta_1\delta_1\theta_2\delta_2 + (\theta_2\beta_1 - \theta_1\beta_2)^2} - (\theta_2\beta_1 - \theta_1\beta_2)}{2\theta_1\delta_1}.$$

Substituting x_1 in equation $(A.2)$ yields

$$\frac{\theta_1\theta_2}{\theta_1\gamma + \theta_2} = (\delta_1\theta_1\gamma + \beta_1\theta_2)x_2.$$

Inserting γ and rearranging terms, participant i's equilibrium effort reads as follows:

$$x_i = \frac{2\theta_i\theta_j\delta_j}{\theta_i^2\beta_j\delta_j + \theta_j^2\beta_i^2 + \theta_i\theta_j(2\delta_i\delta_j - \beta_i\beta_j + \beta_i\delta_j) + (\theta_i\delta_j + \theta_j\beta_i)\sqrt{4\theta_j\delta_j\theta_i\delta_i + (\theta_i\beta_j - \theta_j\beta_i)^2}}. \tag{A.4}$$

B Proofs

B.1 Proof of Proposition 1.

Proposition 1 follows immediately from the following

Lemma 1. Φ *is strictly increasing in* q*:* $\frac{\partial \Phi}{\partial q} > 0$.

Proof. Differentiate Φ with respect to q, use the shortcuts $\beta_i := \beta(\alpha_i)$ as well as $\delta_i := \delta(\alpha_i)$, and remember that $\delta_i = \beta_i - \alpha_i$ for $i \in \{1, 2\}$:

$$\begin{aligned}
\frac{\partial \Phi}{\partial q} &= \frac{(1+q)\beta_2 - q\alpha_2}{(1+q)\beta_1 - \alpha_1} + q \cdot \frac{(\beta_2 - \alpha_2)[(1+q)\beta_1 - \alpha_1] - [(1+q)\beta_2 - q\alpha_2]\beta_1}{[(1+q)\beta_1 - \alpha_1]^2} \\
&= \frac{[(1+q)\beta_2 - q\alpha_2] \cdot [(1+q)\beta_1 - \alpha_1] + q \cdot (\alpha_1\alpha_2 - \alpha_1\beta_2 - \alpha_2\beta_1)}{[(1+q)\beta_1 - \alpha_1]^2} \\
&= \frac{\beta_2(\beta_1 - \alpha_1) + q^2\beta_1(\beta_2 - \alpha_2) + 2q(\beta_1 - \alpha_1)(\beta_2 - \alpha_2)}{[(1+q)\beta_1 - \alpha_1]^2} \\
&= \frac{\beta_2\delta_1 + q^2\beta_1\delta_2 + 2q\delta_1\delta_2}{[(1+q)\beta_1 - \alpha_1]^2} \quad > \quad 0.
\end{aligned}$$

□

B.2 Proof of Proposition 2.

First note that Proposition 2 is equivalent to the following statement: The competitive balance q is ceteris paribus

(a) either increasing or U-shaped in α_1,

(b) either decreasing or inverted U-shaped in α_2.

The proof rests upon the following two lemmas.

Lemma 2. *The equilibrium competitive balance has the following slope*

(a) with respect to α_1*:*

$$\frac{\partial q}{\partial \alpha_1} \begin{cases} < 0 & if \quad q < q_1(\alpha_1), \\ = 0 & if \quad q = q_1(\alpha_1), \\ > 0 & if \quad q > q_1(\alpha_1), \end{cases} \tag{B.1}$$

where $q_1(\alpha_1) := -\frac{\partial \delta(\alpha_1)/\partial \alpha_1}{\partial \beta(\alpha_1)/\partial \alpha_1}$.

(b) *with respect to* α_2*:*

$$\frac{\partial q}{\partial \alpha_2}\begin{cases} < 0 & if \quad q < q_2(\alpha_2), \\ = 0 & if \quad q = q_2(\alpha_2), \\ > 0 & if \quad q > q_2(\alpha_2), \end{cases} \tag{B.2}$$

where $q_2(\alpha_2) := -\frac{\partial\beta(\alpha_2)/\partial\alpha_2}{\partial\delta(\alpha_2)/\partial\alpha_2}$.

Proof. We focus on the proof of part (a). The proof of part (b) is completely analogous and therefore omitted. We use the shortcuts $\beta_i := \beta(\alpha_i)$, $\delta_i := \delta(\alpha_i)$, and $\phi_i := \phi_i(q, \alpha_i, R)$, where

$$\begin{aligned} \phi_1(q, \alpha_1, R) &:= (1+q)\beta(\alpha_1) - \alpha_1, \\ \phi_2(q, \alpha_2, R) &:= (1+q)\beta(\alpha_2) - q\alpha_2. \end{aligned}$$

The implicit function theorem yields $\frac{dq}{d\alpha_1} = -\frac{\partial\Phi/\partial\alpha_1}{\partial\Phi/\partial q}$, where $\partial\Phi/\partial q > 0$ by Lemma 1 and $\partial\Phi/\partial\alpha_1 = q\frac{-\phi_2\cdot(\partial\phi_1/\partial\alpha_1)}{\phi_1^2}$ as $\Phi = q\frac{\phi_2}{\phi_1}$. Note that $\phi_i > 0$ since $\beta_i > \alpha_i$. Hence, $\text{sign}(dq/d\alpha_1) = -\text{sign}(\partial\Phi/\partial\alpha_1) = \text{sign}(\partial\phi_1/\partial\alpha_1)$. Now differentiate $\phi_1 = (1+q)\beta_1 - \alpha_1 = \delta_1 + q\beta_1$ with respect to α_1:

$$\frac{\partial\phi_1}{\partial\alpha_1} = \frac{\partial\delta_1}{\partial\alpha_1} + q\cdot\frac{\partial\beta_1}{\partial\alpha_1}. \tag{B.3}$$

Equation (B.3) immediately implies the properties asserted in (B.1). □

Equation (B.3) sheds light on the two opposing effects of a marginal increase of participant 1's degree of risk aversion: The self-protection effect is captured by the term $\partial\delta_1/\partial\alpha_1 < 0$ whereas the gambling effect is captured by the term $\partial\beta_1/\partial\alpha_1 > 0$. The relative strength of these two effects is scaled by the actual competitive balance q. Lemma 2 applies only locally since the cutoff values $q_i(\alpha_i)$ themselves depend on α_i. In order to attain a global picture, the following Lemma explores this dependency.

Lemma 3. *For all* $\alpha_i > 0$

(a) $\frac{\partial q_1(\alpha_1)}{\partial\alpha_1} < 0$, $\lim_{\alpha_1\to 0} q_1(\alpha_1) = 1$, $\lim_{\alpha_1\to\infty} q_1(\alpha_1) = 0$, $\lim_{\alpha_1\to\infty} q = \infty$.

(b) $\frac{\partial q_2(\alpha_2)}{\partial\alpha_2} > 0$, $\lim_{\alpha_2\to 0} q_2(\alpha_2) = 1$, $\lim_{\alpha_2\to\infty} q_2(\alpha_2) = \infty$, $\lim_{\alpha_2\to\infty} q = 0$.

Proof. We focus on the proof of part (a). The proof of part (b) is completely analogous and therefore omitted. Again, we use the shortcuts $\beta_i := \beta(\alpha_i)$ and $\delta_i := \delta(\alpha_i)$.

First, we show that $q_1(\alpha_1) := -\frac{\delta'(\alpha_1)}{\beta'(\alpha_1)}$ is decreasing in α_1, where $\delta'(\alpha_1) := \partial\delta_1/\partial\alpha_1$ and $\beta'(\alpha_1) := \partial\beta_1/\partial\alpha_1$. Remember that $\delta(\alpha) = \beta(\alpha) - \alpha$. Hence, $\delta'(\alpha) = \beta'(\alpha) - 1$ and

$$q_1(\alpha_1) = -\frac{\delta'(\alpha_1)}{\beta'(\alpha_1)} = \frac{1-\beta'(\alpha_1)}{\beta'(\alpha_1)} = \frac{1}{\beta'(\alpha_1)} - 1.$$

Differentiating $q_1(\alpha_1)$ with respect to α_1 yields $q_1'(\alpha_1) = \frac{-\beta''(\alpha_1)}{[\beta'(\alpha_1)]^2}$. Accordingly, in order to prove that $q_1(\alpha_1)$ is decreasing in α_1, it suffices to show that $\beta''(\alpha) > 0$. Compute

$$\beta'(\alpha) = \frac{\partial\beta(\alpha)}{\partial\alpha} = \frac{1-(1+\alpha R)e^{-\alpha R}}{(1-e^{-\alpha R})^2} > 0 \tag{B.4}$$

and

$$\beta''(\alpha) = \frac{\partial^2 \beta(\alpha)}{\partial \alpha^2} = \frac{Re^{-\alpha R}}{(1-e^{-\alpha R})^3} \cdot [\alpha R - 2 + (\alpha R + 2)e^{-\alpha R}].$$

However, this expression is positive since $\alpha R + 2 > (2 - \alpha R)e^{\alpha R}$ which can be easily verified using the identity $e^X = \sum_{k=0}^{\infty} \frac{X^k}{k!}$ for any real X.

Now consider the limits of $q_1(\alpha_1)$ for $\alpha_1 \to 0$ and $\alpha_1 \to \infty$. Observe from (B.4) that $\lim_{\alpha\to\infty} \beta'(\alpha) = 1$ and, hence, $\lim_{\alpha_1\to\infty} q_1(\alpha_1) = 0$. Moreover, applying l'Hospital's rule twice, compute from (B.4) that

$$\begin{aligned} \lim_{\alpha\to 0} \beta'(\alpha) &= \lim_{\alpha\to 0} \frac{-[Re^{-\alpha R} - (1+\alpha R)Re^{-\alpha R}]}{2(1-e^{-\alpha R})Re^{-\alpha R}} \\ &= \lim_{\alpha\to 0} \frac{\alpha R}{2(1-e^{-\alpha R})} \\ &= \lim_{\alpha\to 0} \frac{R}{2Re^{-\alpha R}} = \frac{1}{2} \end{aligned}$$

and, hence, $\lim_{\alpha_1\to 0} q_1(\alpha_1) = 1$.

Finally, consider the limit of q for $\alpha_i \to \infty$. Since $\beta(\alpha) = \frac{\alpha}{1-e^{-\alpha R}} \to \infty$ for $\alpha \to \infty$ and

$$\lim_{\alpha\to\infty} \delta(\alpha) = \lim_{\alpha\to\infty} \frac{\alpha e^{-\alpha R}}{1-e^{-\alpha R}} = \lim_{\alpha\to\infty} \frac{\alpha}{e^{\alpha R}-1} = \lim_{\alpha\to\infty} \frac{1}{Re^{\alpha R}} = 0$$

by l'Hospital's rule, equation (A.1) implies that $q \to \infty$ for $\alpha_1 \to \infty$. □

Applying these results and Lemma 2, two cases may arise: If $\lim_{\alpha_1\to 0} q \geqslant 1$ then q will be strictly increasing in α_1. If instead $\lim_{\alpha_1\to 0} q < 1$ then there will exist a unique $\alpha_1^{\max} > 0$ for which $q = q_1(\alpha_1^{\max})$. In this case, q is decreasing for all $\alpha_1 < \alpha_1^{\max}$ and increasing for all $\alpha_1 > \alpha_1^{\max}$. Put differently, $\alpha_1^{\max}$ is the level of risk aversion that, ceteris paribus, maximises participant 1's winning probability. Analog reasoning holds for the comparative statics with respect to α_2. This completes the proof of Proposition 2.

□

B.3 Proof of Proposition 3.

The proof of Proposition 3 is based on two propaedeutic lemmas. We start with an observation for contests with very small rents. In this case, the perceived riskiness of the contest is low and, therefore, risk considerations play a negligible role. For the most part, the participants' winning probabilities are determined by the ability ratio because their investments tend to coincide. More formally, $\lim_{R\to 0} \xi = 1$ for the participants' relative effort in equilibrium, and hence:

Lemma 4. $\lim\limits_{R\to 0} q = \frac{\theta_2}{\theta_1}$ *for all* $\theta_1, \theta_2 > 0$ *and* $\alpha_1, \alpha_2 > 0$.

Proof. Starting from equation (8) and applying l'Hospital's rule twice, compute

$$\begin{aligned}
\lim_{R\to 0}\Phi = \lim_{R\to 0} q\cdot\frac{(1+q)\beta(\alpha_2)-q\alpha_2}{(1+q)\beta(\alpha_1)-\alpha_1} &= q\cdot\lim_{R\to 0}\frac{\partial\beta(\alpha_2)/\partial\alpha_2}{\partial\beta(\alpha_1)/\partial\alpha_1}\\
&= q\cdot\lim_{R\to 0}\frac{-\alpha_2^2 e^{-\alpha_2 R}}{-\alpha_1^2 e^{-\alpha_1 R}}\cdot\frac{(1-e^{-\alpha_1 R})^2}{(1-e^{-\alpha_2 R})^2}\\
&= q\cdot\frac{\alpha_2^2}{\alpha_1^2}\cdot\left(\lim_{R\to 0}\frac{1-e^{-\alpha_1 R}}{1-e^{-\alpha_2 R}}\right)^2\\
&= q\cdot\frac{\alpha_2^2}{\alpha_1^2}\cdot\left(\lim_{R\to 0}\frac{\alpha_1 e^{-\alpha_1 R}}{\alpha_2 e^{-\alpha_2 R}}\right)^2 \quad = \quad q
\end{aligned}$$

□

Note that if players are risk neutral they will exert the same effort yielding $q = \frac{\theta_2}{\theta_1}$ for all $R > 0$ (Baik, 1994). In this sense, for very small rents, contestants behave as if they were risk neutral.

Next, we derive a general condition which is both necessary and sufficient for participant 1 to be the Nash winner, i.e. the participant with the higher winning probability in equilibrium.

Lemma 5. *In the equilibrium of the contest, $p_1 \geqslant p_2$ if and only if*

$$\frac{\theta_1}{\theta_2} \geqslant \frac{\phi(\alpha_1)}{\phi(\alpha_2)}, \tag{B.5}$$

where $\phi(\alpha) := 2\beta(\alpha) - \alpha$ for all $\alpha, R > 0$ has the following properties:

(a) $\phi(\alpha) > \alpha$,

(b) $\phi'(\alpha) := \frac{\partial\phi(\alpha)}{\partial\alpha} > 0$,

(c) $\frac{\partial\phi(\alpha)}{\partial R} < 0$,

(d) $\frac{\partial\phi'(\alpha)}{\partial R} > 0$.

The contest is even if and only if (B.5) holds with equality.

Proof. Since $\frac{\partial\Phi}{\partial q} > 0$ by Lemma 1, equation (8) implies that $q \leqslant 1$ if and only if

$$\frac{\theta_2}{\theta_1} \leqslant \frac{2\beta(\alpha_2)-\alpha_2}{2\beta(\alpha_1)-\alpha_1} = \frac{\phi(\alpha_2)}{\phi(\alpha_1)},$$

which is obviously equivalent to inequality (B.5). Note that the condition is met with equality if and only if $q = 1$. we now show the asserted properties of ϕ.

(a) $\phi(\alpha) = 2\beta(\alpha) - \alpha = \alpha\cdot\frac{e^{\alpha R}+1}{e^{\alpha R}-1} > \alpha$.

(b) Use this expression and compute

$$\phi'(\alpha) = \frac{e^{2\alpha R} - (1 + 2\alpha R e^{\alpha R})}{(e^{\alpha R}-1)^2},$$

which is positive since $e^{2\alpha R} > 1 + 2\alpha R e^{\alpha R}$. The last inequality can be easily verified using the identity $e^X = \sum_{k=0}^{\infty} \frac{X^k}{k!}$ for any real X.

(c) $\frac{\partial \phi(\alpha)}{\partial R} = -\frac{2\alpha^2 e^{\alpha R}}{(e^{\alpha R}-1)^2} < 0$.

(d) Use this expression and compute

$$\frac{\partial \phi'(\alpha)}{\partial R} = -\frac{2\alpha e^{\alpha R}}{(e^{\alpha R}-1)^3} \cdot [(2 - R\alpha)e^{\alpha R} - 2 - R\alpha],$$

which is positive since the term in brackets is negative. Again, the last statement can be easily verified using the identity $e^X = \sum_{k=0}^{\infty} \frac{X^k}{k!}$ for any real X.

□

We now apply the two lemmas in order to prove Proposition 3.

Part (a): With $\lim_{R \to 0} q = \frac{\theta_2}{\theta_1} < 1$ by Lemma 4, statement (i) follows immediately from statement (ii). It remains to show that q is strictly decreasing in R. The proof proceeds within six steps. Again, we use the shortcuts $\beta_i := \beta(\alpha_i)$ and $\delta_i := \delta(\alpha_i)$.

Step 1: The implicit function theorem yields $\frac{dq}{dR} = -\frac{\partial \Phi / \partial R}{\partial \Phi / \partial q}$, where $\partial \Phi / \partial q > 0$ by Lemma 1. Hence,

$$\text{sign}(dq/dR) = -\text{sign}(\partial \Phi / \partial R). \tag{B.6}$$

Step 2: Starting from (8) and using

$$\frac{\partial \beta(\alpha)}{\partial R} = \frac{-\alpha^2 e^{-\alpha R}}{(1 - e^{-\alpha R})^2} = -\beta(\alpha)\delta(\alpha),$$

differentiate Φ with respect to R:

$$\begin{aligned}\frac{\partial \Phi}{\partial R} &= \frac{q(1+q)}{[(1+q)\beta_1 - \alpha_1]^2} \cdot (\partial \beta_2 / \partial R \cdot [(1+q)\beta_1 - \alpha_1] - [(1+q)\beta_2 - q\alpha_2]\partial \beta_1 / \partial R) \\ &= \frac{q(1+q)}{[(1+q)\beta_1 - \alpha_1]^2} \cdot [\beta_2 \delta_1 (\beta_1 - \delta_2) - q\beta_1 \delta_2 (\beta_2 - \delta_1)]\end{aligned}$$

Thus, from equation (B.6)

$$\frac{dq}{dR} < 0 \quad \Leftrightarrow \quad \beta_2 \delta_1 (\beta_1 - \delta_2) > q\beta_1 \delta_2 (\beta_2 - \delta_1). \tag{B.7}$$

Step 3: Remember that $\beta > \alpha > 0$ is increasing in α and $\delta = \beta - \alpha$ is decreasing in α. For $\alpha_1 \leqslant \alpha_2$, this implies $\beta_2 - \delta_1 = \beta_2 - \beta_1 + \alpha_1 > 0$. For $\alpha_1 > \alpha_2$, this implies $\beta_1 - \delta_2 = \beta_1 - \beta_2 + \alpha_2 > 0$. Now consider two cases. If $\beta_2 - \delta_1 \leqslant 0$, the right hand side of inequality (B.7) will be negative and, hence, $\frac{dq}{dR} < 0$. If $\beta_2 - \delta_1 > 0$, then[22]

$$\frac{dq}{dR} < 0 \quad \Leftrightarrow \quad \Psi(R) := \frac{\beta_2 \delta_1 (\beta_1 - \delta_2)}{\beta_1 \delta_2 (\beta_2 - \delta_1)} > q. \tag{B.8}$$

[22] Note that $\beta_2 - \delta_1 > 0$ for sufficiently high R. This follows from $\lim_{R \to \infty}(\beta_2 - \delta_1) = \lim_{R \to \infty}(\beta_2 - [\beta_1 - \alpha_1]) = \alpha_2 > 0$, since $\beta(\alpha) = \frac{\alpha}{1 - e^{-\alpha R}} \to \alpha$ as $R \to \infty$.

Step 4: Now we show that

$$\lim_{R\to 0}\Psi(R)=1 \quad \text{and} \quad \frac{\partial\Psi}{\partial R}<0 \Leftrightarrow \alpha_1>\alpha_2. \tag{B.9}$$

First we compute

$$\lim_{R\to 0}\Psi(R)=\lim_{R\to 0}\frac{\beta_2}{\delta_2}\cdot\lim_{R\to 0}\frac{\delta_1}{\beta_1}\cdot\lim_{R\to 0}\frac{\beta_1-\delta_2}{\beta_2-\delta_1}.$$

Remember that $\beta(\alpha)=\frac{\alpha}{1-e^{-\alpha R}}=\frac{\alpha e^{\alpha R}}{e^{\alpha R}-1}$ and $\delta(\alpha)=e^{-\alpha R}\beta(\alpha)=\frac{\alpha}{e^{\alpha R}-1}$. Thus $\lim_{R\to 0}\frac{\beta}{\delta}=\lim_{R\to 0}e^{\alpha R}=1$ and $\lim_{R\to 0}\frac{\delta}{\beta}=\lim_{R\to 0}e^{-\alpha R}=1$. Moreover, for $i,j\in\{1,2\}$ and $i\neq j$,

$$\beta_i-\delta_j=\frac{\alpha_i e^{(\alpha_i+\alpha_j)R}-\alpha_i e^{\alpha_i R}-\alpha_j e^{\alpha_i R}+\alpha_j}{(e^{\alpha_i R}-1)(e^{\alpha_j R}-1)}.$$

Using the last equation and applying l'Hospital's rule twice, compute

$$\begin{aligned}
\lim_{R\to 0}\frac{\beta_1-\delta_2}{\beta_2-\delta_1} &= \lim_{R\to 0}\frac{\alpha_1 e^{(\alpha_1+\alpha_2)R}-\alpha_1 e^{\alpha_1 R}-\alpha_2 e^{\alpha_1 R}+\alpha_2}{\alpha_2 e^{(\alpha_1+\alpha_2)R}-\alpha_2 e^{\alpha_2 R}-\alpha_1 e^{\alpha_2 R}+\alpha_1}\\
&= \lim_{R\to 0}\frac{\alpha_1(\alpha_1+\alpha_2)e^{(\alpha_1+\alpha_2)R}-\alpha_1^2 e^{\alpha_1 R}-\alpha_1\alpha_2 e^{\alpha_1 R}}{\alpha_2(\alpha_1+\alpha_2)e^{(\alpha_1+\alpha_2)R}-\alpha_2^2 e^{\alpha_2 R}-\alpha_1\alpha_2 e^{\alpha_2 R}}\\
&= \frac{\alpha_1}{\alpha_2}\cdot\lim_{R\to 0}\frac{(\alpha_1+\alpha_2)^2 e^{(\alpha_1+\alpha_2)R}-\alpha_1^2 e^{\alpha_1 R}-\alpha_1\alpha_2 e^{\alpha_1 R}}{(\alpha_1+\alpha_2)^2 e^{(\alpha_1+\alpha_2)R}-\alpha_2^2 e^{\alpha_2 R}-\alpha_1\alpha_2 e^{\alpha_2 R}}\\
&= \frac{\alpha_1}{\alpha_2}\cdot\frac{\alpha_1^2+2\alpha_1\alpha_2+\alpha_2^2-\alpha_1^2-\alpha_1\alpha_2}{\alpha_1^2+2\alpha_1\alpha_2+\alpha_2^2-\alpha_2^2-\alpha_1\alpha_2}\\
&= \frac{\alpha_1\alpha_2(\alpha_1+\alpha_2)}{\alpha_2\alpha_1(\alpha_2+\alpha_1)} \quad = \quad 1.
\end{aligned}$$

Now, using that $\phi(\alpha)=2\beta(\alpha)-\alpha=\beta(\alpha)+\delta(\alpha)$ is positive and $\frac{\partial\beta(\alpha)}{\partial R}=\frac{\partial\delta(\alpha)}{\partial R}=-\beta(\alpha)\delta(\alpha)$, compute

$$\begin{aligned}
\frac{\partial\Psi}{\partial R} &= \frac{1}{[\beta_1\delta_2(\beta_2-\delta_1)]^2}\\
&\quad\cdot(-[\beta_2\delta_2\delta_1(\beta_1-\delta_2)+\beta_2\delta_1\beta_1(\beta_1-\delta_2)+\beta_2\delta_1(\beta_1\delta_1-\beta_2\delta_2)][\beta_1\delta_2(\beta_2-\delta_1)]\\
&\quad+[\beta_2\delta_1(\beta_1-\delta_2)][\beta_1\delta_1\delta_2(\beta_2-\delta_1)+\beta_1\delta_2\beta_2(\beta_2-\delta_1)+\beta_1\delta_2(\beta_2\delta_2-\beta_1\delta_1)])\\
&= -\frac{\beta_1\beta_2\delta_1\delta_2}{[\beta_1\delta_2(\beta_2-\delta_1)]^2}\cdot[\phi(\alpha_1)-\phi(\alpha_2)]\cdot[\beta_1\beta_2-\delta_1\delta_2]\\
&= -\frac{\beta_1\beta_2\delta_1\delta_2}{[\beta_1\delta_2(\beta_2-\delta_1)]^2}\cdot[\phi(\alpha_1)-\phi(\alpha_2)]\cdot[\beta_1\beta_2-(\beta_1-\alpha_1)(\beta_2-\alpha_2)]\\
&= -\frac{\beta_1\beta_2\delta_1\delta_2}{[\beta_1\delta_2(\beta_2-\delta_1)]^2}\cdot[\phi(\alpha_1)-\phi(\alpha_2)]\cdot[\alpha_1\beta_2+\alpha_2\beta_1-\alpha_1\alpha_2]\\
&< \frac{\beta_1\beta_2\delta_1\delta_2}{[\beta_1\delta_2(\beta_2-\delta_1)]^2}\cdot[\phi(\alpha_2)-\phi(\alpha_1)]\cdot[\alpha_1\delta_2+\alpha_2\beta_1].
\end{aligned}$$

Thus, $\frac{\partial \Psi}{\partial R} < 0 \Leftrightarrow \alpha_1 > \alpha_2$, since ϕ is strictly increasing in α by Lemma 5.

Step 5: Now we show that

$$\lim_{R\to\infty} q = 0 \quad \text{for} \quad \alpha_1 > \alpha_2. \tag{B.10}$$

In order to see this, define

$$a := a(R) := \frac{\theta_2 \delta(\alpha_1)}{\theta_1 \delta(\alpha_2)} = \frac{\theta_2 \alpha_1}{\theta_1 \alpha_2} \cdot e^{R(-\alpha_1+\alpha_2)} \cdot \frac{1-e^{-\alpha_2 R}}{1-e^{-\alpha_1 R}} > 0 \tag{B.11}$$

and

$$b := b(R) := \frac{\theta_1 \beta(\alpha_2) - \theta_2 \beta(\alpha_1)}{2\theta_1 \delta(\alpha_2)} = \frac{1}{2e^{-\alpha_2 R}} \left[1 - \frac{1-e^{-\alpha_2 R}}{1-e^{-\alpha_1 R}} \cdot \frac{\theta_2 \alpha_1}{\theta_1 \alpha_2} \right]. \tag{B.12}$$

Thus $q = \sqrt{a+b^2} - b$ by equation (A.1). Since $\alpha_1 > \alpha_2$, equation (B.11) implies that $a \to 0$ as $R \to \infty$. Moreover, since $\frac{\theta_1}{\theta_2} \geqslant \frac{\alpha_1}{\alpha_2}$ or equivalently $1 \geqslant \frac{\theta_2 \alpha_1}{\theta_1 \alpha_2}$, equation (B.12) implies that $b \to \infty$ as $R \to \infty$. Hence, for R sufficiently high, $b > 0$ and

$$0 \leqslant q = \sqrt{a+b^2} - b \leqslant \sqrt{a} + \sqrt{b^2} - b = \sqrt{a} \to 0 \quad \text{for} \quad R \to \infty.$$

Step 6: Finally we show that $\frac{\partial q}{\partial R} < 0$. Since $\lim_{R\to 0} \Psi(R) = 1 > \theta_2/\theta_1 = \lim_{R \to 0} q$ by equation (B.9) and Lemma 4, respectively, q is strictly decreasing for R small enough by equivalence (B.8). But then q must be strictly decreasing for all $R > 0$. For $\alpha_1 \leqslant \alpha_2$, this is trivial because then Ψ is non-decreasing in R. For $\alpha_1 > \alpha_2$, suppose to the contrary that there would be some $\hat{R}$ such that $\frac{\partial q}{\partial R}_{|R=\hat{R}} \geqslant 0$. Then, again by equivalence (B.8), $q \geqslant \Psi(\hat{R})$ and, since Ψ is decreasing for all $R > 0$ by (B.9), q would have to be increasing for all $R \geqslant \hat{R}$. This however would contradict the fact that $\lim_{R\to\infty} q = 0$ by equation (B.10).

Part (b): Note that $1 < \frac{\theta_1}{\theta_2} < \frac{\alpha_1}{\alpha_2}$ implies $\alpha_1 > \alpha_2$. we start with the proof of statement (ii). Again, we proceed within six steps. Steps 1 to 4 are identical to the corresponding steps in the proof of part (a). Note that – just like equivalence (B.8) – the analysis yields

$$\frac{dq}{dR} \geqslant 0 \quad \Leftrightarrow \quad \Psi(R) := \frac{\beta_2 \delta_1 (\beta_1 - \delta_2)}{\beta_1 \delta_2 (\beta_2 - \delta_1)} \leqslant q. \tag{B.13}$$

with equality on one side if and only if equality on the second side, too.

Step 5': Now we show that

$$\lim_{R\to\infty} q = \infty. \tag{B.14}$$

In order to see this, proceed exactly as in step 5 in the proof of Proposition 3. However, since now $\frac{\theta_1}{\theta_2} < \frac{\alpha_1}{\alpha_2}$ or equivalently $1 < \frac{\theta_2 \alpha_1}{\theta_1 \alpha_2}$, equation (B.12) implies that $b \to -\infty$ as $R \to \infty$. Hence, for R sufficiently high, $b < 0$ and

$$q = \sqrt{a+b^2} - b \geqslant \sqrt{b^2} - b = -2b \to \infty \quad \text{for} \quad R \to \infty.$$

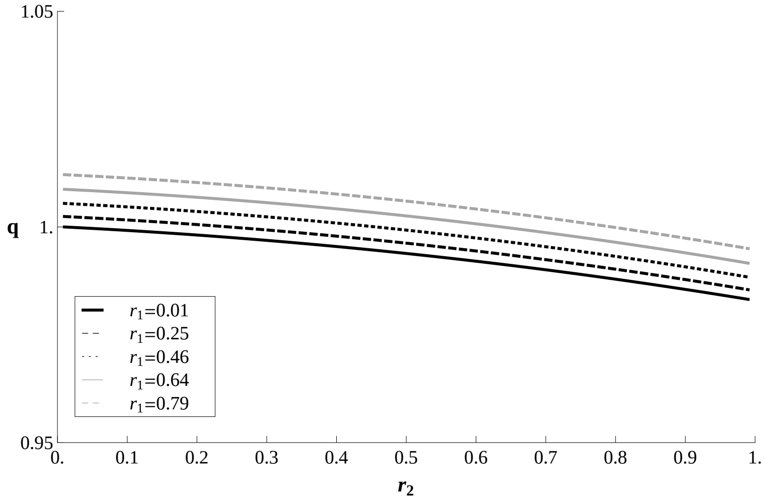
Step 6': Since $\lim_{R\to 0} \Psi(R) = 1 > \theta_2/\theta_1 = \lim_{R\to 0} q$ by (B.9) and Lemma 4, respectively, q is strictly decreasing for R small enough by equivalence (B.13). However, since Ψ is decreasing for all $R > 0$ by (B.9) but $\lim_{R\to\infty} q = \infty$ by equation (B.14), in combination with the intermediate value theorem equivalence (B.13) also implies that there must be a unique $R_0 > 0$ such that $\frac{\partial q}{\partial R} \gtrless 0 \Leftrightarrow R \gtrless R_0$ (with equality if and only if $R = R_0$).

This finishes the proof of statement (ii). Statement (i) follows immediately from (ii), again taking into account that $\lim_{R\to 0} \Psi(R) = 1 > \theta_2/\theta_1 = \lim_{R\to 0} q$ by (B.9) and Lemma 4, respectively.

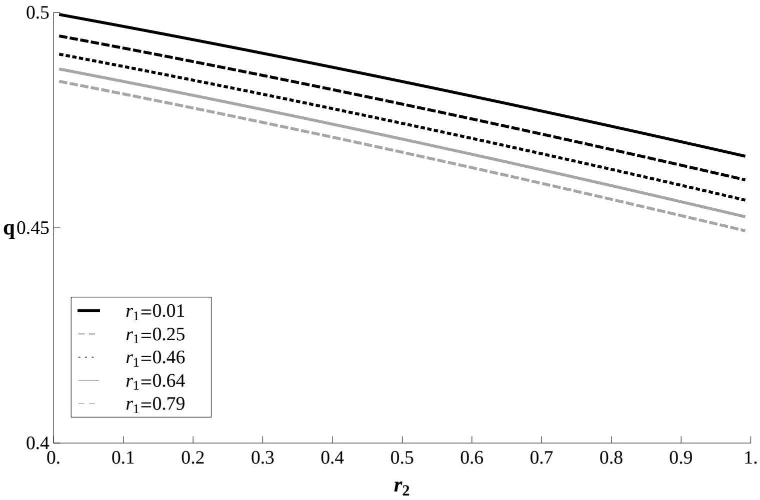
$\square$

C Numerical Results for CRRA-Preferences

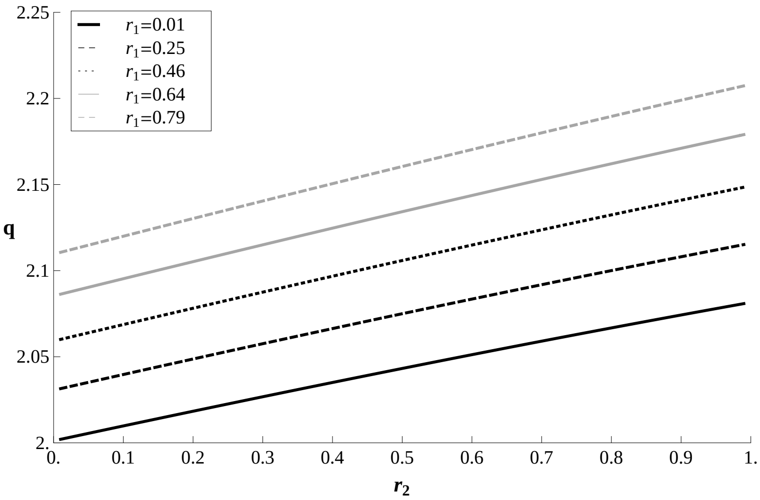
C.1 Influence of the Own Degree of Risk Aversion



(a) $\theta_1 = \theta_2 = 1$

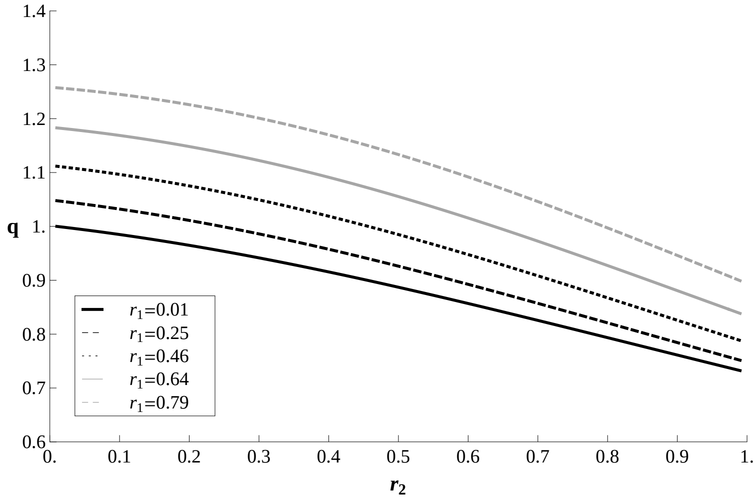


(b) $\theta_1 = 2$, $\theta_2 = 1$

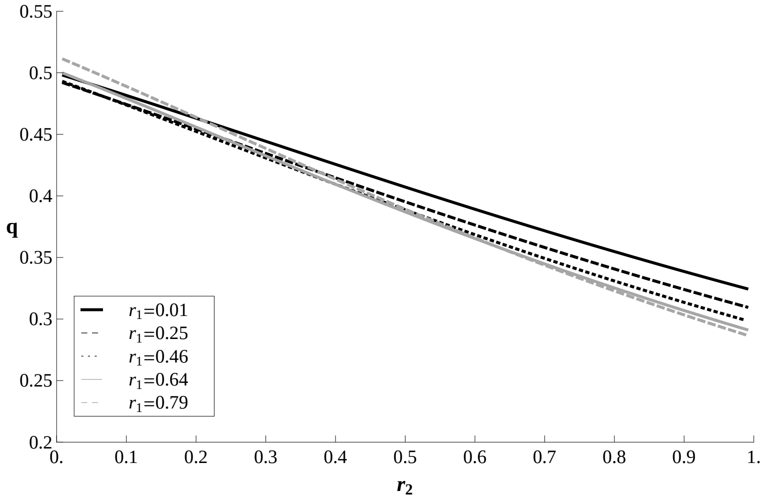


(c) $\theta_1 = 1$, $\theta_2 = 2$

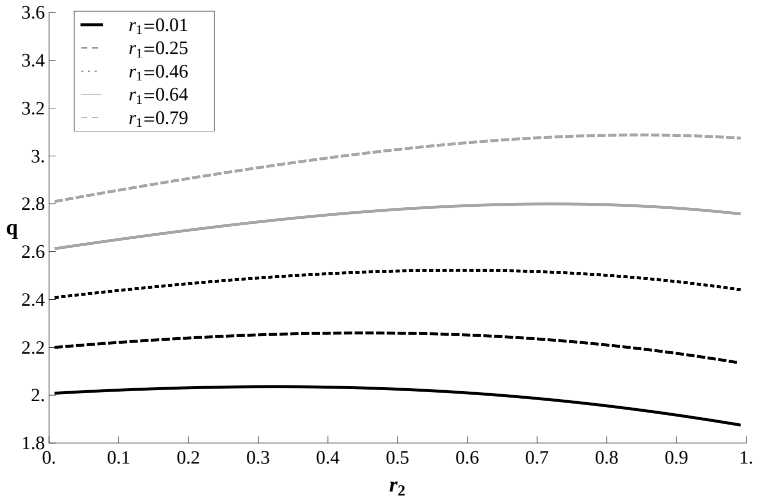
Figure C.1 q as a function of r_2 for $R = 200$



(a) $\theta_1 = \theta_2 = 1$



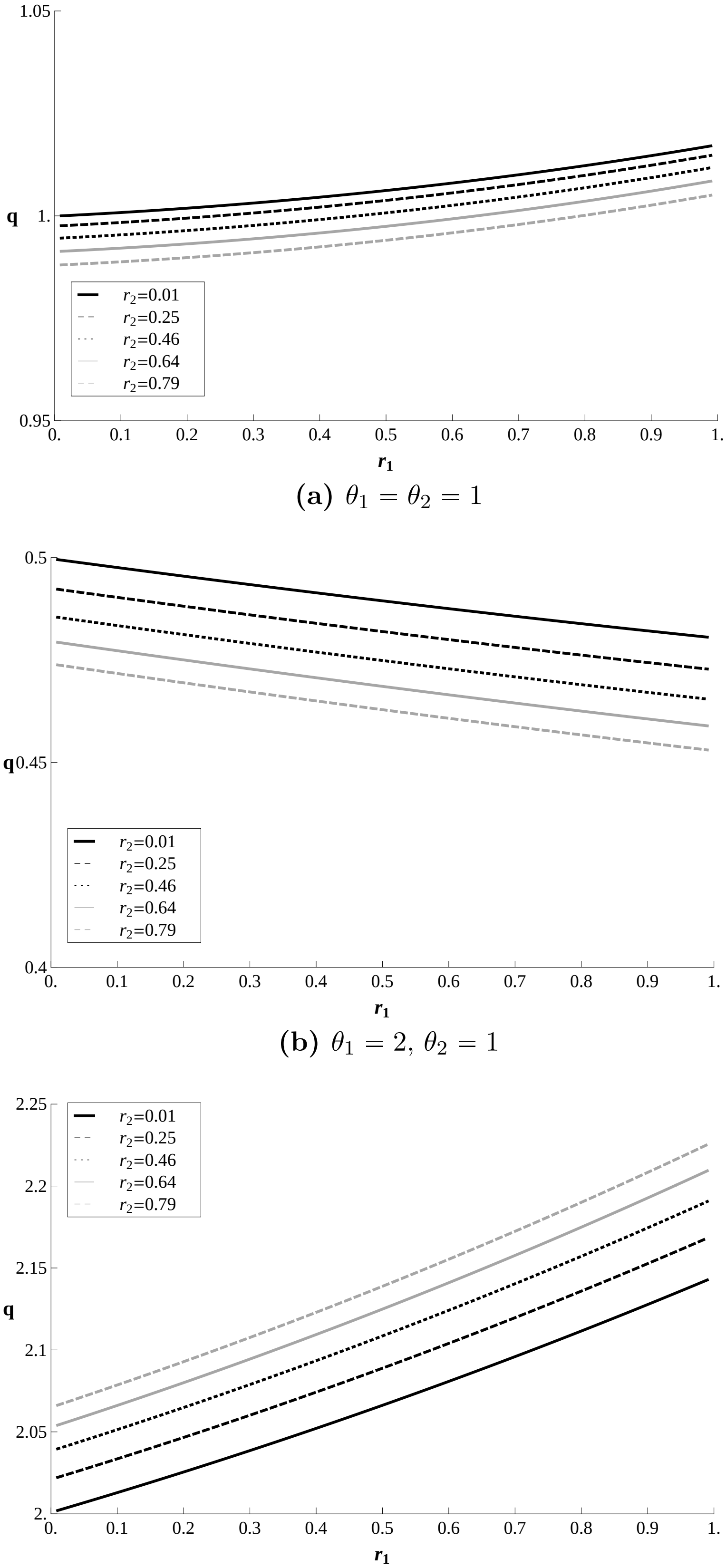
(b) $\theta_1 = 2$, $\theta_2 = 1$



(c) $\theta_1 = 1$, $\theta_2 = 2$

Figure C.2 q as a function of r_2 for $R = 1,000$

C.2 Influence of the Opponent's Degree of Risk Aversion

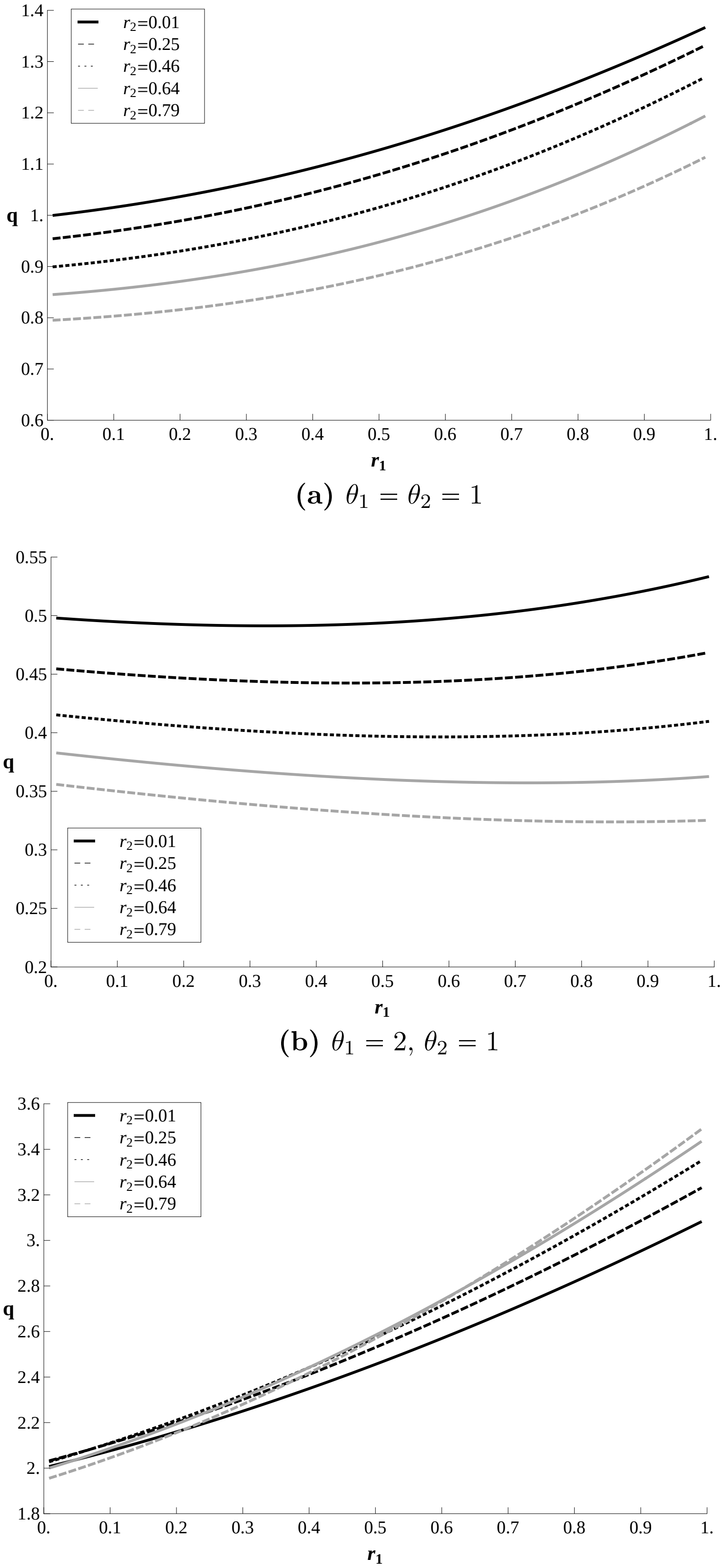


(a) $\theta_1 = \theta_2 = 1$

(b) $\theta_1 = 2$, $\theta_2 = 1$

(c) $\theta_1 = 1$, $\theta_2 = 2$

Figure C.3 q as a function of r_1 for $R = 200$



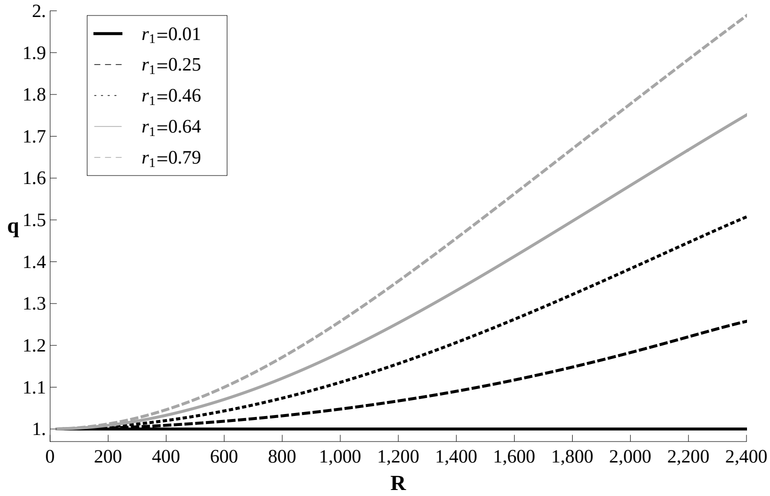
(a) $\theta_1 = \theta_2 = 1$

(b) $\theta_1 = 2$, $\theta_2 = 1$

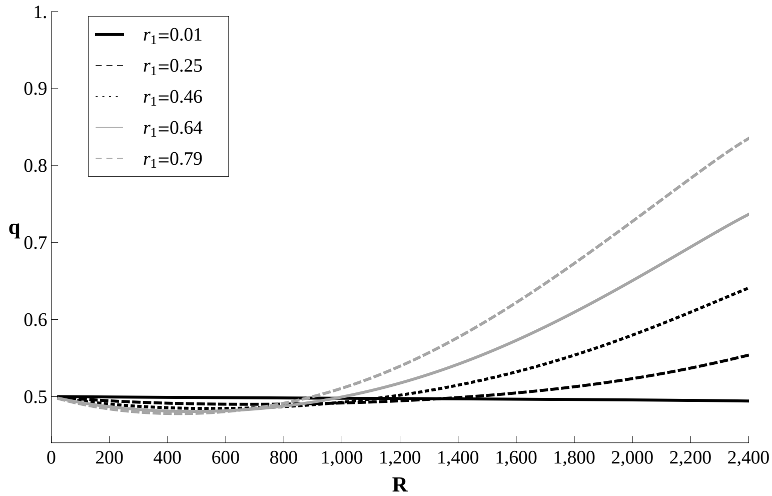
(c) $\theta_1 = 1$, $\theta_2 = 2$

Figure C.4 q as a function of r_2 for $R = 1,000$

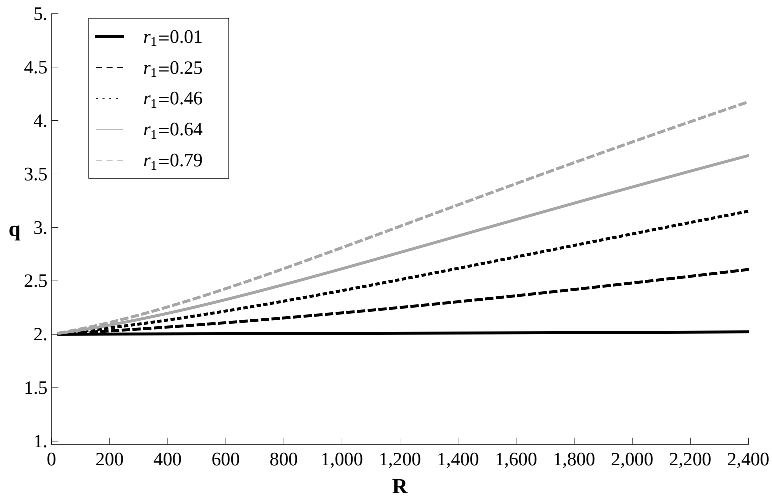
C.3 Influence of the Prize



(a) $\theta_1 = \theta_2 = 1$

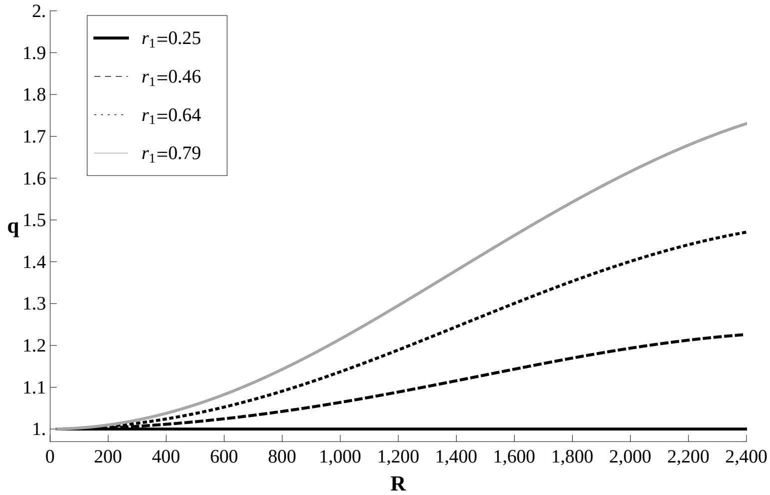


(b) $\theta_1 = 2,\ \theta_2 = 1$

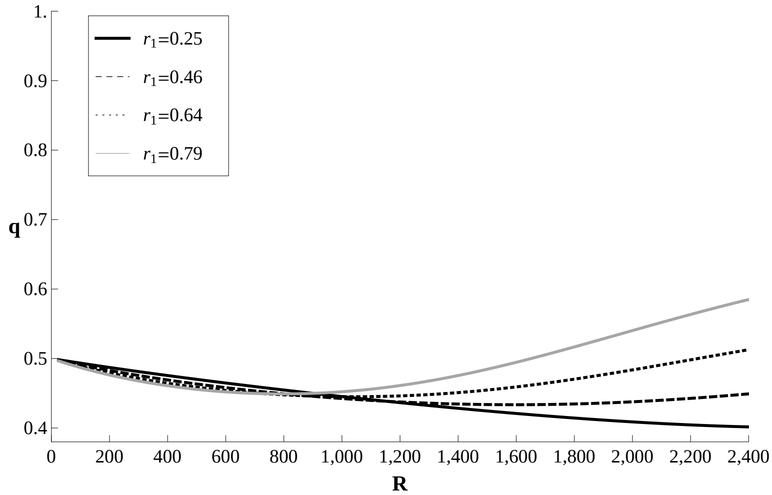


(c) $\theta_1 = 1,\ \theta_2 = 2$

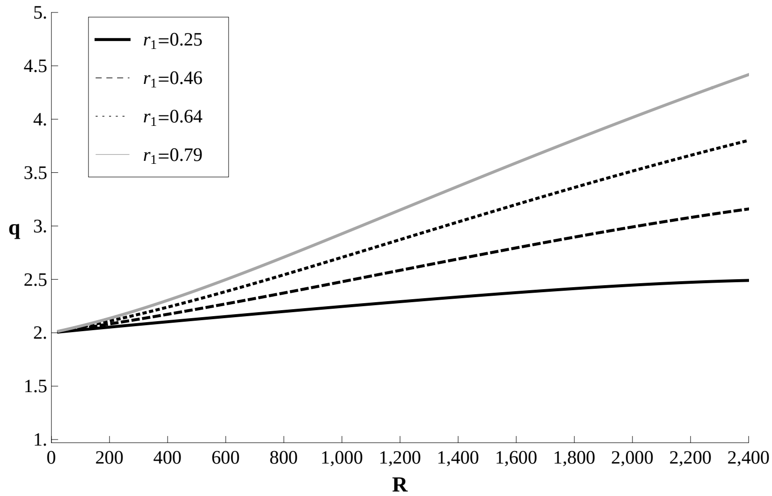
Figure C.5 q as a function of R for $r_2 = 0.01$



(a) $\theta_1 = \theta_2 = 1$



(b) $\theta_1 = 2,\ \theta_2 = 1$

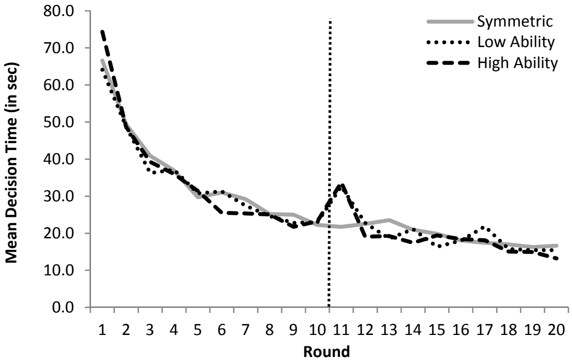


(c) $\theta_1 = 1,\ \theta_2 = 2$

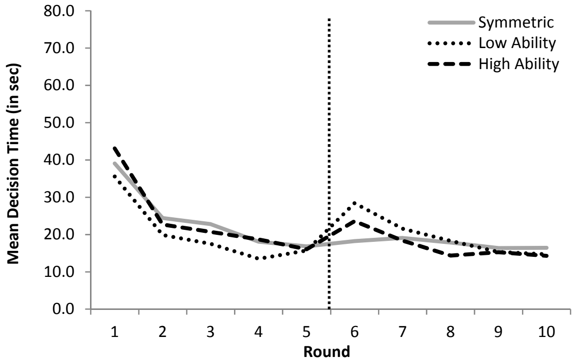
Figure C.6 q as a function of R for $r_2 = 0.25$

D Complementary Statistical Results

D.1 Additional Evidence on Learning



(a) Low prize



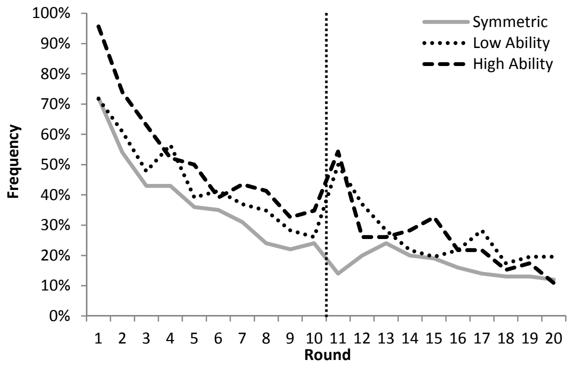
(b) High prize

Figure D.1 Average decision times across rounds

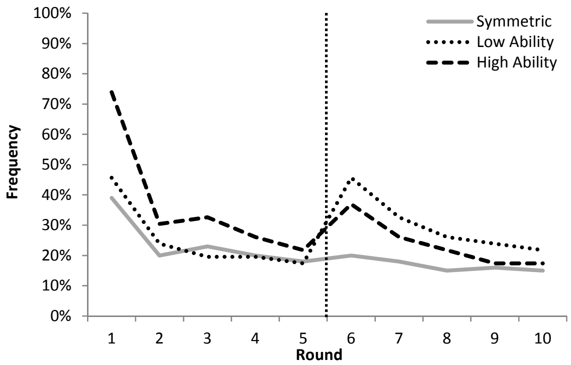
	Low Prize		High Prize	
	Coef.	SE	Coef.	SE
Constant	46.669***	(1.578)	30.257***	(1.586)
Asymmetric: Low Ability	-1.914	(3.522)	-2.198	(2.728)
Asymmetric: High Ability	1.794	(2.339)	-0.396	(5.340)
Round	-1.824***	(0.192)	-1.699***	(0.189)
Round × Low Ability	0.154	(0.249)	0.241	(0.215)
Round × High Ability	-0.223	(0.223)	0.033	(0.481)
Observations	3,840		1,920	
R^2	0.157		0.040	

Note: Robust standard errors in parentheses, clustered at the session level.
Significance level: *** (1%), ** (5%), * (10%).

Table D.6 Panel regression results for decision times.



(a) Low prize



(b) High prize

Figure D.2 Fraction of subjects using the example calculator across rounds

	Low Prize		High Prize	
	Coef.	SE	Coef.	SE
Constant	0.250	(0.214)	-0.790***	(0.054)
Asymmetric: Low Ability	0.183	(0.333)	0.016	(0.305)
Asymmetric: High Ability	0.781***	(0.229)	0.958***	(0.300)
Round	-0.128***	(0.014)	-0.109***	(0.012)
Round × Low Ability	0.024	(0.029)	0.074	(0.052)
Round × High Ability	-0.020	(0.022)	-0.082	(0.069)
Observations	3,840		1,920	
Pseudo R^2	0.092		0.030	

Note: Robust standard errors in parentheses, clustered at the session level.
Significance level: *** (1%), ** (5%), * (10%).

Table D.7 Logit regression results for use of the example calculator

D.2 Results for Matches with Homogeneous Risk Aversion

In the main text, we have focused on matches where the degree of risk aversion of the two subjects differs. To provide a complete picture of our results, we here report on the remaining matches in which subjects have chosen the safe option equally often in the first part of the experiment and thus have a comparable degree of risk aversion.

In treatment *Symmetric*, this implies that the contest is fully symmetric. Pooling all rounds, 120 (55) contests were played for the low (high) prize in this constellation. In each case, only three pairs achieved equal winning probabilities. Still, in half of those matches, winning probabilities were at most 65:35 (60:40).

In treatment *Asymmetric*, 39 (18) contests where played for the low (high) prize with contestants of similar risk aversion (pooling all rounds). In 30 (14) of those contests, the more able contestant achieved the higher probability of winning.[23] Indeed, the mean winning probability of the more able contestant equals 0.73 (0.71) with the low (high) prize and is significantly larger than 0.5 for each prize (one-sided t-test, $p < 0.001$).[24]

[23]For late decisions, the more able contestant achieved the higher probability of winning in 12 out of 21 contests for the low prize and in 8 out of 12 contests for the high prize.

[24]Using an OLS regression with standard errors clustered at the session level, we find no significant impact of the prize or the common degree of risk aversion on the more able contestant's probability of winning. The results are available from the authors upon request.

D.3 Complementary Results on the Probability of Winning

	Low Prize					High Prize				
S_p	$S=3$	$S=4$	$S=5$	$S=6$	$S=7$	$S=3$	$S=4$	$S=5$	$S=6$	$S=7$
4	-0.264***					-0.465***				
	(0.091)					(0.083)				
5	-0.219***	-0.253***				-0.377***	-0.364***			
	(0.056)	(0.056)				(0.062)	(0.054)			
6	-0.174***	-0.208***	-0.242***			-0.288***	-0.276***	-0.263***		
	(0.041)	(0.026)	(0.041)			(0.057)	(0.030)	(0.036)		
7	-0.129**	-0.163***	-0.197***	-0.231***		-0.200***	-0.188***	-0.175***	-0.162***	
	(0.063)	(0.043)	(0.043)	(0.061)		(0.072)	(0.037)	(0.019)	(0.046)	
8	-0.084	-0.118	-0.152**	-0.186**	-0.220**	-0.112	-0.100	-0.087**	-0.074	-0.061
	(0.100)	(0.082)	(0.075)	(0.081)	(0.097)	(0.098)	(0.066)	(0.044)	(0.047)	(0.073)

(a) Low Ability

	Low Prize					High Prize				
S_p	$S=3$	$S=4$	$S=5$	$S=6$	$S=7$	$S=3$	$S=4$	$S=5$	$S=6$	$S=7$
4	0.181***					0.189**				
	(0.035)					(0.083)				
5	0.171***	0.238***				0.210***	0.235***			
	(0.029)	(0.023)				(0.052)	(0.066)			
6	0.161***	0.228***	0.296***			0.231***	0.256***	0.281***		
	(0.044)	(0.019)	(0.022)			(0.051)	(0.033)	(0.054)		
7	0.151**	0.218***	0.286***	0.353***		0.252***	0.276***	0.301***	0.326***	
	(0.066)	(0.041)	(0.024)	(0.033)		(0.082)	(0.044)	(0.026)	(0.053)	
8	0.141	0.208***	0.276***	0.343***	0.410***	0.272**	0.297***	0.322***	0.347***	0.372***
	(0.092)	(0.066)	(0.045)	(0.037)	(0.049)	(0.122)	(0.083)	(0.050)	(0.038)	(0.063)

(b) High Ability

Note: *S (S_p) denotes the own (the opponent's) number of safe choices.*
Standard errors is parentheses, calculated using the delta method.
*Significance level: *** (1%), ** (5%), * (10%).*

Table D.8 Marginal Effects of Ability Compared to Treatment *Symmetric*.

Dependent Variable	Winning Probability of the *Venturesome*					
Specification	(1)		(2)		(3)	
Covariate	Coef.	SE	Coef.	SE	Coef.	SE
Constant	0.441***	(0.015)	0.425***	(0.028)	0.243**	(0.094)
Ability × *Prize* × $\Delta(S)$						
Symm. × 200 × 2	0.073**	(0.027)	0.078**	(0.025)	0.051*	(0.024)
Symm. × 200 × 3	0.141**	(0.041)	0.149***	(0.037)	0.124***	(0.026)
Symm. × 200 × 4	0.208	(0.123)	0.219	(0.117)	0.124	(0.099)
Symm. × 1000 × 1	0.083**	(0.027)	0.082**	(0.029)	0.082**	(0.034)
Symm. × 1000 × 2	0.164***	(0.014)	0.173***	(0.014)	0.148***	(0.014)
Symm. × 1000 × 3	0.173***	(0.035)	0.182***	(0.032)	0.150***	(0.042)
Symm. × 1000 × 4	0.161**	(0.050)	0.159**	(0.051)	0.089	(0.063)
Low × 200 × 1	-0.281***	(0.041)	-0.253***	(0.038)	-0.230***	(0.039)
Low × 200 × 2	-0.165***	(0.038)	-0.134***	(0.031)	-0.161***	(0.027)
Low × 200 × 3	-0.131***	(0.031)	-0.095**	(0.038)	-0.118***	(0.025)
Low × 200 × 4	-0.098***	(0.019)	-0.018	(0.045)	0.003	(0.038)
Low × 200 × 5	0.559***	(0.015)	0.623***	(0.025)	0.471***	(0.044)
Low × 1000 × 1	-0.238***	(0.052)	-0.208**	(0.061)	-0.195***	(0.047)
Low × 1000 × 2	-0.149***	(0.041)	-0.118**	(0.040)	-0.140***	(0.034)
Low × 1000 × 3	-0.135***	(0.018)	-0.096**	(0.032)	-0.093*	(0.042)
Low × 1000 × 4	-0.022	(0.065)	0.046	(0.064)	-0.041	(0.036)
Low × 1000 × 5	0.559***	(0.015)	0.570***	(0.045)	0.370***	(0.066)
High × 200 × 1	0.258***	(0.025)	0.285***	(0.029)	0.290***	(0.024)
High × 200 × 2	0.270***	(0.039)	0.299***	(0.046)	0.281***	(0.027)
High × 200 × 3	0.274***	(0.038)	0.312***	(0.054)	0.287***	(0.019)
High × 200 × 4	0.276***	(0.051)	0.348***	(0.083)	0.360***	(0.058)
High × 200 × 5	0.559***	(0.015)	0.640***	(0.032)	0.491***	(0.048)
High × 200 × 6	0.605***	(0.018)	0.689***	(0.039)	0.505***	(0.051)
High × 1000 × 1	0.319***	(0.043)	0.348***	(0.041)	0.363***	(0.051)
High × 1000 × 2	0.366***	(0.029)	0.396***	(0.030)	0.380***	(0.037)
High × 1000 × 3	0.370***	(0.020)	0.407***	(0.037)	0.358***	(0.016)
High × 1000 × 4	0.453***	(0.071)	0.540***	(0.128)	0.489***	(0.112)
S	0.046***	(0.013)	0.048***	(0.013)	0.024*	(0.010)
Demographic Controls	No		Yes		Yes	
Questionnaire Controls	No		No		Yes	
Observations	1,243		1,243		1,243	
R^2	0.371		0.381		0.462	

Note: $\Delta(S)$ = # Safe Choices Opponent - # Safe Choices
Robust standard errors in parentheses, clustered at the session level.
Significance level: *** (1%), ** (5%), * (10%).

Table D.9 Impact of difference in risk aversion (as categorical variable) on the *venturesome*'s probability of winning.

Dependent Variable	Winning Probability of the *Venturesome*			
Specification	(1)	(2)	(3)	(4)
Constant	0.410***	0.369***	0.352***	0.182
	(0.060)	(0.059)	(0.063)	(0.110)
Low Ability	-0.311**	-0.328**	-0.305***	-0.290**
	(0.090)	(0.093)	(0.084)	(0.073)
High Ability	0.312***	0.296***	0.313***	0.310***
	(0.068)	(0.066)	(0.062)	(0.048)
High Prize				
× Symmetric	0.140*	0.133*	0.133**	0.132*
	(0.060)	(0.062)	(0.055)	(0.061)
× Low Ability	0.076	0.077	0.081	0.079
	(0.081)	(0.080)	(0.078)	(0.080)
× High Ability	0.059	0.057	0.058	0.083
	(0.036)	(0.036)	(0.039)	(0.052)
# Safe Choices Opponent - # Safe Choices				
× Symmetric × Low R	0.052	0.072**	0.076**	0.056**
	(0.028)	(0.029)	(0.027)	(0.021)
× Symmetric × High R	0.015	0.038	0.042*	0.023
	(0.016)	(0.020)	(0.021)	(0.022)
× Low Ability × Low R	0.087**	0.109**	0.121**	0.098***
	(0.029)	(0.034)	(0.037)	(0.026)
× Low Ability × High R	0.057*	0.079**	0.089***	0.066***
	(0.027)	(0.029)	(0.024)	(0.016)
× High Ability × Low R	0.001	0.023	0.037	0.022
	(0.017)	(0.022)	(0.025)	(0.018)
× High Ability × High R	0.015	0.038	0.052	0.023
	(0.022)	(0.025)	(0.030)	(0.037)
# Safe Choices		0.050**	0.054**	0.030*
		(0.017)	(0.018)	(0.014)
Demographic Controls	No	No	Yes	Yes
Questionnaire Controls	No	No	No	Yes
Observations	1,243	1,243	1,243	1,243
R^2	0.346	0.357	0.367	0.453

Note: Robust standard errors in parentheses, clustered at the session level.
Significance level: *** (1%), ** (5%), * (10%).

Table D.10 Impact of difference in risk aversion (as continuous variable) on the *venturesome*'s probability of winning.

D.4 Complementary Results on Effort Choices

Specification	(1)		(2)		(3)	
Covariate	Coef.	SE	Coef.	SE	Coef.	SE
Constant	0.281***	(0.035)	0.271***	(0.049)	0.138***	(0.045)
Low Ability	0.023	(0.039)	0.019	(0.035)	0.024	(0.034)
High Ability	0.048	(0.038)	0.044	(0.036)	0.047	(0.035)
High Prize						
× Symm.	-0.001	(0.022)	-0.001	(0.022)	-0.001	(0.022)
× Low Ab.	-0.116***	(0.007)	-0.116***	(0.007)	-0.117***	(0.008)
× High Ab.	-0.040	(0.035)	-0.040	(0.035)	-0.039	(0.036)
# Safe Choices						
× Symm. × Low R	0.003	(0.015)	0.005	(0.015)	0.008	(0.013)
× Symm. × High R	-0.023***	(0.009)	-0.022***	(0.008)	-0.019**	(0.008)
× Low Ab. × Low R	-0.007	(0.012)	-0.008	(0.013)	-0.004	(0.012)
× Low Ab. × High R	-0.016*	(0.009)	-0.017	(0.011)	-0.013	(0.011)
× High Ab. × Low R	-0.024***	(0.002)	-0.024***	(0.003)	-0.020***	(0.005)
× High Ab. × High R	-0.009	(0.007)	-0.009	(0.008)	-0.006	(0.010)
# Safe Choices Opponent						
× Symm. × Low R	0.006	(0.006)	0.006	(0.006)	0.006	(0.007)
× Symm. × High R	-0.001	(0.005)	-0.001	(0.005)	0.000	(0.006)
× Low Ab. × Low R	-0.032**	(0.013)	-0.031**	(0.013)	-0.034**	(0.013)
× Low Ab. × High R	0.019**	(0.009)	0.019**	(0.009)	0.018*	(0.009)
× High Ab. × Low R	-0.014**	(0.005)	-0.014**	(0.006)	-0.016***	(0.006)
× High Ab. × High R	-0.008	(0.009)	-0.008	(0.009)	-0.010	(0.010)
Female			0.010	(0.024)	0.011	(0.026)
NAge			0.003	(0.002)	0.003	(0.003)
Siblings			-0.001	(0.010)	-0.007	(0.007)
NonBAstudent			-0.017	(0.016)	0.005	(0.014)
NonGermanMT			0.012	(0.025)	-0.023	(0.034)
ParticipationLotteries					-0.008	(0.006)
ParticipationGames					0.010***	(0.003)
Ambition					-0.002	(0.008)
Generosity					0.007	(0.008)
ImportanceWinning					0.031***	(0.006)
ImportancePayment					-0.009	(0.006)
Observations	2,728		2,728		2,728	
R^2	0.032		0.036		0.105	

Note: Robust standard errors in parentheses, clustered at the session level.
Significance level: *** (1%), ** (5%), * (10%).

Table D.11 Determinants of effort choice: All subjects.

Specification	(1)		(2)		(3)	
Covariate	Coef.	SE	Coef.	SE	Coef.	SE
Constant	0.252***	(0.068)	0.229***	(0.082)	-0.004	(0.118)
Low Ability	-0.043	(0.082)	-0.050	(0.073)	-0.040	(0.067)
High Ability	0.073	(0.069)	0.066	(0.062)	0.073	(0.057)
High Prize						
× Symm.	0.085	(0.064)	0.086	(0.062)	0.086	(0.064)
× Low Ab.	-0.005	(0.085)	-0.006	(0.087)	-0.008	(0.086)
× High Ab.	-0.003	(0.045)	-0.002	(0.045)	0.000	(0.046)
# Safe Choices						
× Symm. × Low R	0.006	(0.025)	0.008	(0.025)	0.002	(0.022)
× Symm. × High R	-0.007	(0.023)	-0.005	(0.025)	-0.011	(0.029)
× Low Ab. × Low R	0.007	(0.023)	0.015	(0.025)	0.006	(0.029)
× Low Ab. × High R	0.027	(0.037)	0.035	(0.036)	0.025	(0.031)
× High Ab. × Low R	0.010	(0.024)	0.018	(0.025)	0.007	(0.028)
× High Ab. × High R	0.034	(0.030)	0.042	(0.029)	0.033	(0.029)
# Safe Choices Opponent						
× Symm. × Low R	0.014	(0.023)	0.015	(0.023)	0.013	(0.023)
× Symm. × High R	-0.025	(0.021)	-0.026	(0.020)	-0.027	(0.022)
× Low Ab. × Low R	0.006	(0.017)	0.006	(0.017)	0.003	(0.017)
× Low Ab. × High R	0.007	(0.038)	0.008	(0.039)	0.006	(0.039)
× High Ab. × Low R	-0.017**	(0.008)	-0.016**	(0.007)	-0.018**	(0.009)
× High Ab. × High R	-0.030*	(0.017)	-0.030*	(0.017)	-0.032*	(0.019)
Female			0.035	(0.037)	0.016	(0.038)
NAge			0.005*	(0.003)	0.002	(0.004)
Siblings			-0.003	(0.012)	-0.006	(0.009)
NonBAstudent			-0.018	(0.039)	0.003	(0.026)
NonGermanMT			0.021	(0.034)	0.005	(0.040)
ParticipationLotteries					-0.009**	(0.004)
ParticipationGames					0.018***	(0.006)
Ambition					0.017	(0.016)
Generosity					0.006	(0.009)
ImportanceWinning					0.021**	(0.009)
ImportancePayment					-0.007	(0.004)
Observations	1,243		1,243		1,243	
R^2	0.021		0.032		0.090	

Note: Robust standard errors in parentheses, clustered at the session level.
Significance level: *** (1%), ** (5%), * (10%).

Table D.12 Determinants of effort choice: *Venturesome*.

Specification	(1)		(2)		(3)	
Covariate	Coef.	SE	Coef.	SE	Coef.	SE
Constant	0.356***	(0.057)	0.374***	(0.078)	0.292***	(0.081)
Low Ability	0.048	(0.079)	0.069	(0.072)	0.064	(0.080)
High Ability	0.032	(0.090)	0.053	(0.085)	0.047	(0.074)
High Prize						
× Symm.	-0.082***	(0.028)	-0.082***	(0.027)	-0.085***	(0.027)
× Low Ab.	-0.189***	(0.027)	-0.189***	(0.027)	-0.188***	(0.027)
× High Ab.	0.002	(0.071)	0.002	(0.070)	0.003	(0.070)
# Safe Choices						
× Symm. × Low R	-0.033	(0.029)	-0.035	(0.030)	-0.030	(0.031)
× Symm. × High R	-0.021	(0.016)	-0.023	(0.018)	-0.017	(0.020)
× Low Ab. × Low R	-0.047*	(0.026)	-0.064**	(0.031)	-0.054**	(0.023)
× Low Ab. × High R	-0.028	(0.029)	-0.045	(0.032)	-0.035	(0.034)
× High Ab. × Low R	-0.050**	(0.024)	-0.067**	(0.028)	-0.057***	(0.011)
× High Ab. × High R	-0.056***	(0.017)	-0.073***	(0.022)	-0.063***	(0.015)
# Safe Choices Opponent						
× Symm. × Low R	0.030***	(0.006)	0.029***	(0.006)	0.029***	(0.005)
× Symm. × High R	-0.003	(0.010)	-0.003	(0.010)	-0.003	(0.010)
× Low Ab. × Low R	-0.048***	(0.009)	-0.048***	(0.009)	-0.048***	(0.008)
× Low Ab. × High R	-0.013	(0.013)	-0.012	(0.014)	-0.011	(0.014)
× High Ab. × Low R	-0.018***	(0.005)	-0.018***	(0.005)	-0.017***	(0.005)
× High Ab. × High R	0.015	(0.027)	0.015	(0.027)	0.015	(0.027)
Female			-0.020	(0.033)	-0.017	(0.029)
NAge			0.005	(0.004)	0.004*	(0.002)
Siblings			-0.013	(0.015)	-0.017	(0.013)
NonBAstudent			-0.020	(0.040)	0.008	(0.032)
NonGermanMT			0.022	(0.049)	-0.043	(0.056)
ParticipationLotteries					-0.006	(0.009)
ParticipationGames					0.000	(0.006)
Ambition					-0.012	(0.016)
Generosity					0.005	(0.011)
ImportanceWinning					0.036***	(0.010)
ImportancePayment					-0.004	(0.012)
Observations	1,243		1,243		1,243	
R^2	0.058		0.072		0.158	

Note: Robust standard errors in parentheses, clustered at the session level.
Significance level: *** (1%), ** (5%), * (10%).

Table D.13 Determinants of effort choice: More risk averse subjects.

E Experimental Instructions

General Instructions

This is an experiment in strategic decision-making. Thank you for your participation.

To compensate you for showing up on time you will receive

4 Euros.

If you follow these instructions, you can earn additional money depending on your own decisions, the decisions of the other participants, and chance. At the end of the experiment the total amount of money that you have earned will be paid out to you privately in cash.

From now on, we ask you to remain seated quietly at your computer desk. You may use the computer only for the experiment. Please do not communicate with other participants during the experiment. If you have any questions during the experiment, please raise your hand and wait for an experimenter to come to you. Participants who intentionally violate these rules will be asked to leave the experiment without being financially compensated.

During the experiment your decisions determine a score expressed in points. At the end of the experiment, the points you have earned in some of your decisions will determine your earnings according to the following rule:

100 points = 1 Euro.

The experiment consists of 4 parts. On the next page you receive detailed instructions for the first part of the experiment. Instructions for the second and third part of the experiment will be made available before each of the respective parts begins.

Instructions for Part 1

In the first part of the experiment, your earnings only depend on your own decisions and chance. You have to submit **10 decisions** in this part. These are listed in the following table:

Choice	Option S Points	Option L Points	Option L Dice Score	Your Choice
1	180	400, if 0, if	1 2, 3, 4, 5, 6, 7, 8, 9, 10	S L
2	180	400, if 0, if	1, 2 3, 4, 5, 6, 7, 8, 9, 10	S L
3	180	400, if 0, if	1, 2, 3 4, 5, 6, 7, 8, 9, 10	S L
4	180	400, if 0, if	1, 2, 3, 4 5, 6, 7, 8, 9, 10	S L
5	180	400, if 0, if	1, 2, 3, 4, 5 6, 7, 8, 9, 10	S L
6	180	400, if 0, if	1, 2, 3, 4, 5, 6 7, 8, 9, 10	S L
7	180	400, if 0, if	1, 2, 3, 4, 5, 6, 7 8, 9, 10	S L
8	180	400, if 0, if	1, 2, 3, 4, 5, 6, 7, 8 9, 10	S L
9	180	400, if 0, if	1, 2, 3, 4, 5, 6, 7, 8, 9 10	S L
10	180	400, if 0, if	1, 2, 3, 4, 5, 6, 7, 8, 9, 10 - - -	S L

In each decision, you have a choice between two options, Option S and Option L:

- Option S yields a secure final score of 180 points.
- The final score of option L depends on the throw of a 10-sided dice. For example, in the first decision option L yields 400 points, if the dice result is 1, and it yields 0 points if the result is 2, 3, 4, 5, 6, 7, 8, 9, or 10. For the other decisions, the final score of option L is determined analogously, with the probability of receiving 400 points increasing as you move down the table. Indeed, in the last decision option L yields a secure final score of 400 points.

Only one of the 10 decisions will count towards your final earnings. To determine your earnings for the first part of the experiment, one of the participants will throw a 10-sided dice twice at the end of the experiment. The result of the first throw determines the number of the decision which counts towards your earnings. Your earnings for the first part are then determined as follows:

- If you have chosen option S in the selected decision, you earn the money equivalent of 180 points.

- If you have chosen option L in the selected decision, your earnings depend on the result of the second throw of the dice. You earn the money equivalent of the points related to the result.

Please remain quiet until all participants have finished reading the instructions. An experimenter will then read them aloud. Afterwards, the first part of the experiment will begin.

Instructions for Part 2 [Treatment ***Symmetric***]

For the second and third part of the experiment, we divide the participants into two groups, group A and group B. You will be informed about the group you have been assigned to on your computer screen at the beginning of the second part. You remain in the same group until the end of the experiment.

In the second part of the experiment, you make choices in **20 consecutive rounds**. In each of these rounds, you interact with one randomly selected participant *from the other group*. The participant you interact with is newly determined at random in each round and will henceforth be called *your counterpart*.

Your decision in each round

YOU and your COUNTERPART participate in a lottery for a prize of

$$\boxed{\text{R} = 200 \text{ points.}}$$

At the beginning of each round, each of you receives, independently of the results of previous rounds, an endowment of

$$\boxed{\text{I} = 600 \text{ points.}}$$

You may use this endowment to obtain lottery tickets for yourself. To do so, you may invest any integer amount between 0 and 600 points. You receive **1 lottery ticket** for each point invested.
Before you make your choice, you are shown on your computer screen how often YOU and your COUNTERPART have selected option L in the first part of the experiment.

The winner of the lottery

After you and your counterpart have made your choices, the winner of the lottery will be determined as follows:

If neither you nor you counterpart has obtained a lottery ticket, the computer randomly draws one of the numbers 1 and 2 where both are equally likely to be drawn. In this case you receive the prize,

- if you are a member of **Group A** and the computer draws the number 1,

- if you are a member of **Group B** and the computer draws the number 2.

Otherwise, the computer randomly draws an integer number between 1 and the total number of lottery tickets obtained by yourself and your counterpart. Each of those numbers is equally likely to be drawn. You receive the prize,

- if you are a member of **Group A** and the drawn number is at most as large as the number of lottery tickets obtained by yourself.
- if you are a member of **Group B** and the drawn number is larger than the number of lottery tickets obtained by your counterpart.

Your final score at the end of a round

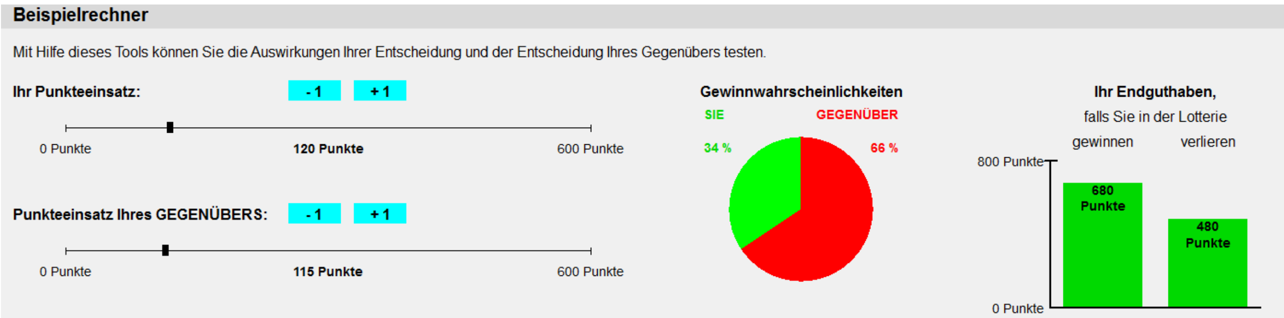
The points you invest are deducted from your endowment irrespective of the outcome of the lottery. You keep the remaining endowment. Your final score at the end of a round therefore equals

$$\boxed{finalscore = \begin{cases} I - \text{invested points} + R, & \text{if you win in the lottery.} \\ I - \text{invested points}, & \text{if your counterpart wins in the lottery.} \end{cases}}$$

At the end of each round, you are informed about (i) the number of points you and your counterpart invested, (ii) the number selected at random by the computer, (iii) the winner in the lottery in this round, (iv) your final score.

Decision support

To support you in your choice, you are provided in each round with an *example calculator* which you may use to test the impact of your decision and the decision of your counterpart.



The example calculator consists of 3 parts:

- With the help of the sliders you can select the points you and your counterpart might invest.
- The pie chart shows your winning probability (green part) and the winning probability of your counterpart (red part) depending on the points invested.
- The bar chart shows your final score in case of winning (left bar) and losing (right bar) in the lottery depending on the points invested.

In addition, the following table illustrates the choice situation in the second part of the experiment with the help of six fictitious examples for a participant in group A (and a counterpart in group B).

		Lottery		Final score	
		Invested	Winning	Drawn	
Bsp.		Points	numbers	number	Score
1	YOU	50	1, 2, ..., 50	25	600-50+200 = 750
	COUNTERPART	50	51, 52, ..., 100		
2	YOU	50	1, 2, ..., 50	75	600-50 = 550
	COUNTERPART	50	51, 52, ..., 100		
3	YOU	60	1, 2, ..., 60	25	600-60+200 = 740
	COUNTERPART	30	61, 62, ..., 90		
4	YOU	60	1, 2, ..., 60	75	600-60 = 540
	COUNTERPART	30	61, 62, ..., 90		
5	YOU	30	1, 2, ..., 30	25	600-30+200 = 770
	COUNTERPART	60	31, 32, ..., 90		
6	YOU	30	1, 2, ..., 30	75	600-30 = 570
	COUNTERPART	60	31, 32, ..., 90		

Your earnings in the second part of the experiment

At the end of the 20 rounds, two rounds will be selected. The sum of the final scores you have achieved in these two rounds determines your earnings for the second part of the experiment. To determine these two rounds, one of the participants will throw a 10-sided dice twice at the end of the experiment:

- The score of the 1st throw determines one of the rounds 1 – 10.
- The score of the 2nd throw + 10 determines one of the rounds 11 – 20.

Control questions [Treatment *Symmetric*]

The following questions are intended to ensure that you have understood the instructions. Please answer to the best of your knowledge and raise your hand once you are finished. An experimenter will then come to you and peruse the answers with you.

1. Which of the following statements is true?
   - ☐ You play in each round against the same participant drawn at random.
   - ☐ You play in each round against a participant newly drawn at random from your own group.
   - ☐ You play in each round against a participant newly drawn at random from the other group.

2. What is your likelihood of winning, if you invest exactly half as many points as your counterpart?

   ☐ 1/2.

   ☐ 1/3.

3. Who wins in the lottery, if you belong to Group B, you and your counterpart have each invested 83 points, and the computer randomly draws the number 87?

   ☐ You.

   ☐ Your counterpart.

4. Who wins in the lottery, if you invest 0 points and your counterpart invests 1 point?

   ☐ You for sure.

   ☐ Your counterpart for sure.

   ☐ Depending on the random draw of the computer, either of us may win.

5. What is your final score, if you invest your entire endowment to obtain lottery tickets and you do not win in the lottery?

   ☐ 0 points

   ☐ 600 points

Instructions for Part 3 [Treatment *Symmetric*]

The third part of the experiment will be conducted in the same way as the second part with the following exceptions:

(I) The prize equals $\boxed{\text{R = 1.000 points}}$.

(II) The third part of the experiment consists of **10 rounds**.

(III) Only one of the 10 rounds will count towards your final earnings. The number of this round will be determined at the end of the experiment by the throw of a 10-sided dice. You earn the money equivalent of the final score you achieved in this round.

Instructions for Part 2 [Treatment *Asymmetric*]

For the second and third part of the experiment, we divide the participants into two groups, group A and group B. You will be informed about the group you have been assigned to on your computer screen at the beginning of the second part. You remain in the same group until the end of the experiment.

In the second part of the experiment, you make choices in **20 consecutive rounds**. In each of these rounds, you interact with one randomly selected participant *from the other group*. The participant you interact with is newly determined at random in each round and will henceforth be called *your counterpart*.

Your decision in each round

YOU and your COUNTERPART participate in a lottery for a prize of

$$\boxed{\text{R} = 200 \text{ points.}}$$

At the beginning of each round, each of you receives, independently of the results of previous rounds, an endowment of

$$\boxed{\text{I} = 600 \text{ points.}}$$

You may use this endowment to obtain lottery tickets for yourself. To do so, you may invest any integer amount between 0 and 600 points. The number of lottery tickets you obtain is determined as follows:

in rounds 1-10:

- participants in **Group A** receive **1 lottery ticket** for each point invested.
- participants in **Group B** receive **2 lottery tickets** for each point invested.

and in rounds 11-20:

- participants in **Group A** receive **2 lottery tickets** for each point invested.
- participants in **Group B** receive **1 lottery ticket** for each point invested.

Before you make your choice, you are shown on your computer screen

(i) how many lottery tickets YOU earn with each point YOU invest,

(ii) how many lottery tickets your COUNTERPART earns with each point your COUNTERPART invests,

(iii) how often YOU have selected option L in the first part of the experiment,

(iv) how often your COUNTERPART has selected option L in the first part of the experiment.

The winner of the lottery

After you and your counterpart have made your choices, the winner of the lottery will be determined as follows:

The computer randomly draws an integer number between 1 and the total number of lottery tickets obtained by yourself and your counterpart. Each of those numbers is equally likely to be drawn.

You receive the prize,

- if you are a member of **Group A** and the drawn number is at most as large as the number of lottery tickets obtained by yourself.
- if you are a member of **Group B** and the drawn number is larger than the number of lottery tickets obtained by your counterpart.

If neither you nor you counterpart has obtained a lottery ticket, the computer randomly draws one of the numbers 1 and 2 where both are equally likely to be drawn. In this case you receive the prize,

- if you are a member of **Group A** and the computer draws the number 1,
- if you are a member of **Group B** and the computer draws the number 2.

Your final score at the end of a round

The points you invest are deducted from your endowment irrespective of the outcome of the lottery. You keep the remaining endowment. Your final score at the end of a round therefore equals

$$\boxed{finalscore = \begin{cases} I - \text{invested points} + R, & \text{if you win in the lottery.} \\ I - \text{invested points}, & \text{if your counterpart wins in the lottery.} \end{cases}}$$

At the end of each round, you are informed about

(i) the number of points you and your counterpart invested,

(ii) the number of lottery tickets you and your counterpart obtained,

(iii) the number selected at random by the computer,

(iv) the winner in the lottery in this round,

(v) your final score.

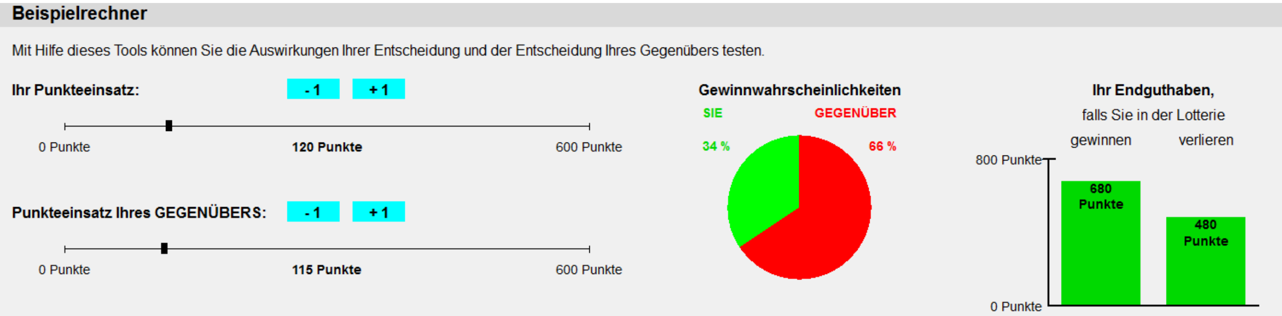
Your earnings in the second part of the experiment

At the end of the 20 rounds, two rounds will be selected. The sum of the final scores you have achieved in these two rounds determines your earnings for the second part of the experiment. To determine these two rounds, one of the participants will throw a 10-sided dice twice at the end of the experiment:

- The score of the 1st throw determines one of the rounds 1 – 10.
- The score of the 2nd throw + 10 determines one of the rounds 11 – 20.

Example calculator and examples

To support you in your choice, you are provided in each round with an *example calculator* which you may use to test the impact of your decision and the decision of your counterpart.



The example calculator consists of 3 parts:

- With the help of the sliders you can select the points you and your counterpart might invest.
- The pie chart shows your winning probability (green part) and the winning probability of your counterpart (red part) depending on the points invested.
- The bar chart shows your final score in case of winning (left bar) and losing (right bar) in the lottery depending on the points invested.

In addition, the following table illustrates the choice situation in the second part of the experiment with the help of six fictitious examples for a participant in group A (and a counterpart in group B).

Example		Lottery: Tickets per point	Lottery: Invested points	Lottery: Tickets obtained	Lottery: Winning numbers	Final score: Drawn number	Final score: Score
1	You	2	50	100	1, 2, . . . , 100	25	600-50+200 = 750
	Counterpart	1	50	50	101, 102, . . . , 150		
2	You	2	50	100	1, 2, . . . , 100	125	600-50 = 550
	Counterpart	1	50	50	101, 102, . . . , 150		
3	You	1	50	50	1, 2, . . . , 50	49	600-50+200 = 750
	Counterpart	2	50	100	51, 52, . . . , 150		
4	You	1	50	50	1, 2, . . . , 50	101	600-50 = 550
	Counterpart	2	50	100	51, 52, . . . , 150		
5	You	1	100	100	1, 2, . . . , 100	25	600-100+200 = 700
	Counterpart	2	50	100	101, 102, . . . , 200		
6	You	1	100	100	1, 2, . . . , 100	125	600-100 = 500
	Counterpart	2	50	100	101, 102, . . . , 200		

Control questions [Treatment *Asymmetric*]

The following questions are intended to ensure that you have understood the instructions. Please answer to the best of your knowledge and raise your hand once you are finished. An experimenter will then come to you and peruse the answers with you.

1. Which of the following statements is true?
   - ☐ You play in each round against the same participant drawn at random.
   - ☐ You play in each round against a participant newly drawn at random from your own group.
   - ☐ You play in each round against a participant newly drawn at random from the other group.

2. How many lottery tickets can you obtain with each point you invest?
   - ☐ Always exactly 1 lottery ticket.
   - ☐ Always exactly 2 lottery tickets.
   - ☐ Either 1 or 2 lottery tickets, depending on your group and the round number.

3. How many points does your COUNTERPART obtain with each point YOU invest?
   - ☐ No lottery ticket.
   - ☐ Either 1 or 2 lottery tickets, depending on your group and the round number.

4. What is your final score, if you invest your entire endowment to obtain lottery tickets and you do not win in the lottery?
   - ☐ 0 points
   - ☐ 600 points

5. Who wins in the lottery, if you invest 0 points and your counterpart invests 1 point?
   - ☐ You for sure.
   - ☐ Your counterpart for sure.
   - ☐ Depending on the random draw of the computer, either of us may win.

Instructions for Part 3 [Treatment *Asymmetric*]

The third part of the experiment will be conducted in the same way as the second part with the following exceptions:

(I) The prize equals $\boxed{\text{R} = 1.000 \text{ points}}$.

(II) The third part of the experiment consists of **10 rounds**.

(III) The number of lottery tickets participants obtain is determined as follows:

in rounds **1-5**:

- participants in **Group A** receive **1 lottery ticket** for each point invested.
- participants in **Group B** receive **2 lottery tickets** for each point invested.

and in rounds **6-10**:

- participants in **Group A** receive **2 lottery tickets** for each point invested.
- participants in **Group B** receive **1 lottery ticket** for each point invested.

(IV) Only one of the 10 rounds will count towards your final earnings. The number of this round will be determined at the end of the experiment by the throw of a 10-sided dice. You earn the money equivalent of the final score you achieved in this round.

References

Albrecht, J., Björklund, A., Vroman, S., 2003. Is there a glass ceiling in Sweden? Journal of Labor Economics 21 (1), 145–177.

American Psychological Association, August 2014. Think again: Men and women share cognitive skills. online at http://www.apa.org/action/resources/research-in-action/share.aspx.

Anderson, L. R., Freeborn, B. A., 2010. Varying the intensity of competition in a multiple prize rent seeking experiment. Public Choice 143 (1-2), 237–254.

Arulampalam, W., Booth, A. L., Bryan, M. L., 2007. Is there a glass ceiling over Europe? Exploring the gender pay gap across the wage distribution. ILR Review 60 (2), 163–186.

Baik, K. H., 1994. Effort levels in contests with two asymmetric players. Southern Economic Journal 61, 367–378.

Bebchuk, L. A., Spamann, H., October 2010. Regulating bankers' pay. Georgetown Law Journal 98 (2), 247–287.

Bertrand, M., Hallock, K. F., October 2001. The gender gap in top corporate jobs. Industrial and Labor Relations Review 55 (1), 3–21.

Bono, J. W., June 2008. Sales contests, promotion decisions and heterogeneous risk. Managerial and Decisions Economics 29 (4), 371–382.

Bozhinov, P., April 2006. Constant relative risk aversion and rent-seeking games. Ph.D. thesis, Keele University.

Byrnes, J. P., Miller, D. C., Schafer, W. D., May 1999. Gender differences in risk taking: A meta-analysis. Psychological Bulletin 125 (3), 367–383.

Clark, D. J., Riis, C., 1998. Contest success functions: an extension. Economic Theory 11 (1), 201–204.

Cornes, R., Hartley, R., 2003. Risk aversion, heterogeneity and contests. Public Choice 117, 1–25.

Cornes, R., Hartley, R., 2012. Risk aversion in symmetric and asymmetric contests. Economic Theory 51 (2), 247–275.

Croson, R., Gneezy, U., September 2009. Gender differences in preferences. Journal of Economic Literature 47 (2), 448–74.

Dechenaux, E., Kovenock, D., Sheremeta, R. M., 2015. A survey of experimental research on contests, all-pay auctions and tournaments. Experimental Economics 18, 609–669.

Eeckhoudt, L., Gollier, C., 2005. The impact of prudence on optimal prevention. Economic Theory 26 (4), 989–994.

Fischbacher, U., 2007. z-tree: Zurich toolbox for ready-made economic experiments. Experimental Economics 10 (2), 171–8.

Fonseca, M. A., 2009. An experimental investigation of asymmetric contests. International Journal of Industrial Organization 27 (5), 582 – 591.

Greiner, B., 2015. Subject pool recruitment procedures: Organizing experiments with orsee. Journal of the Economic Science Association 1, 114–25.

Hillman, A. L., Katz, E., 1984. Risk-averse rent seekers and the social cost of monopoly power. The Economic Journal 94, 104–110.

Holt, C., Laury, S., December 2002. Risk aversion and incentive effects. American Economic Review 92 (5), 1644–1655.

Hughes, J., Woglom, G., 1996. Risk aversion and the allocation of legal costs. In: Anderson, D. (Ed.), Dispute resolution: Bridging the settlement gap. JAI Press, Greenwich, Connecticut, p. 167–192.

Hvide, H. K., 2002. Tournament rewards and risk taking. Journal of Labor Economics 20 (4), 877–898.

Hvide, H. K., Kristiansen, E. G., January 2003. Risk taking in selection contests. Games and Economic Behavior 42 (1), 172–181.

Kimbrough, E. O., Sheremeta, R. M., Shields, T. W., 2014. When parity promotes peace: Resolving conflict between asymmetric agents. Journal of Economic Behavior & Organization 99, 96 – 108.

Konrad, K., Schlesinger, H., November 1997. Risk aversion in rent-seeking and rent-augmenting games. The Economic Journal 107, 1671–1683.

Konrad, K. A., 2009. Strategy and Dynamics in Contests. Oxford University Press, New York.

Lazear, E. P., Rosen, S., 1981. Rank order tournaments as optimum labor contracts. Journal of Political Economy 89 (5), 841–864.

Leininger, W., 1993. More efficient rent-seeking–a münchhausen solution. Public Choice 75 (1), 43–62.

Mago, S. D., Sheremeta, R. M., Yates, A., 2013. Best-of-three contest experiments: Strategic versus psychological momentum. International Journal of Industrial Organization 31 (3), 287 – 296.

March, C., Sahm, M., 2017. Asymmetric discouragement in asymmetric contests. Economics Letters 151, 23–27.

Millner, E. L., Pratt, M. D., 1991. Risk aversion and rent-seeking: An extension and some experimental evidence. Public Choice 69 (1), 81–92.

Noussair, C. N., Trautmann, S. T., van de Kuilen, G., 2014. Higher order risk attitudes, demographics, and financial decisions. The Review of Economic Studies 81, 325–355.

Paglin, M., Rufolo, A. M., 1990. Heterogeneous human capital, occupational choice, and male-female earnings differences. Journal of Labor Economics 8 (1), 123.

Price, C. R., Sheremeta, R. M., 2015. Endowment origin, demographic effects and individual preferences in contests. Journal of Economics and Management Strategy 24 (3), 597–619.

Runkel, M., 2006a. Optimal contest design, closeness and the contest success function. Public Choice 129, 217–231.

Runkel, M., 2006b. Total effort, competitive balance and the optimal contest success function. European Journal of Political Economy 22, 1009–1013.

Sahm, M., May 2017. Risk aversion and prudence in contests. Economics Bulletin 37 (2), 1122–1132.

Schindler, D., Stracke, R., 2016. The incentive effects of uncertainty in tournaments. Working Paper, University of Munich.

Sheremeta, R. M., 2011. Contest design: An experimental investigation. Economic Inquiry 49 (2), 573–590.

Sheremeta, R. M., 2013. Overbidding and heterogeneous behavior in contest experiments. Journal of Economic Surveys 27 (3).

Skaperdas, S., 1996. Contest success functions. Economic Theory 7 (2), 283–290.

Skaperdas, S., Gan, L., July 1995. Risk aversion in contests. The Economic Journal 105, 951–962.

Treich, N., 2010. Risk-aversion and prudence in rent-seeking games. Public Choice 145 (3-4), 339–349.

Tullock, G., 1980. Efficient rent-seeking. In: Buchanan, J., Tollison, G., Tullock, G. (Eds.), Toward a theory of the rent-seeking society. College Station: Texas A&M University Press, pp. 97–112.

World Economic Forum, 2013. The global gender gap report 2013. Tech. rep., World Economic Forum.

Yamazaki, T., April 2008. On the existence and uniqueness of pure-strategy Nash equilibrium in asymmetric rent-seeking contests. Journal of Public Economic Theory 10 (2), 317–327.

Yamazaki, T., 2009. The uniqueness of pure-strategy Nash equilibrium in rent-seeking games with risk-averse players. Public Choice 139 (3-4), 335–342.