Appendix for
The Risk of Caution: Evidence from an R&D Experiment

A. Experiment Details

A.1. Experimental Instructions

The exact text of the instructions given to research subjects at the start of the experiment, framing the choices in the context of R&D and describing the incentives is

> Welcome to the survey and thank you for agreeing to participate in our study. Over the course of the next hour you will be asked to assume the role of the manager of a research division of an organization in the biomedical/health sector. You will be presented data on a series of potential research projects that you could fund. Some questions will ask you to rank individual projects to fund; other questions will ask you to construct a portfolio of projects from a selected list. We will also ask you some additional demographic and preference questions to better understand your decision-making processes.
>
> Research project outcomes always involve some uncertainty, which is partly reflected in the diversity of evaluation scores that can be assigned to any given proposal. After you complete the survey, the computer will draw a number from a random number generator that is consistent with the characteristics of the research projects you selected for each of the R&D investment questions you completed. Better ranked proposals will tend to have better outcomes and proposals where there is more disagreement in the ranking will tend to have more variable, both good and bad, outcomes. When proposals have different costs, expected payoffs are proportionate to proposal cost.
>
> The random numbers generated for each question will then be added to provide an aggregate score for each participant in the survey. While all participants will receive $15 for participation, bonus payments will be offered for top performers. Those that score within the top 25 percent of this survey round will receive an additional $25 bonus, with that bonus increasing to $100 for those within the top 10 percent.

Exact text of the instructions introducing the first experiment:

> For the next ten questions, assume that you are the head of the research division of an organization and are considering funding four research project proposals (A, B, C, D).
>
> - Each project proposal has received a rating on a scale from 1 to 5 (with 5 being the top rating) by seven scientific experts unaffiliated with the

projects under consideration (1, 2, 3, 4, 5, 6, 7) on your advisory board.

- All the proposals have the same cost.

- The matrix below displays how the four proposals (columns) you should use for this question were rated by the seven reviewers (rows).

- The average of the reviewers' scores for each proposal is shown at the bottom of the proposal's column.

- The order in which proposals appear is randomized.

- Proposal rankings should be treated as an indication of potential financial return. Negative returns (financial losses) are possible. Remember that your final compensation for participating in this study will depend on the choices you make here.

Prior to the second experiment, where we explicitly showed the variance, we added the following note to the above instructions:

> In addition to the average of the reviewers' scores for each proposal, we also report the <u>**variance**</u> of scores, a measure of the variability of the reviewers' assessments.

Exact text of the instructions introducing the portfolio selection questions (experiment 3):

> The next ten questions are similar in spirit to the to the earlier ones concerning the project that you would most/least like to fund. In this case, however, you will be asked to put together a portfolio of research project proposals to fund. As before, assume that you are the head of the research division of an organization conducting R&D.
>
> - There are proposals for 10 possible research projects (denoted A through J).
> - Each proposal has received a rating on a scale from 1 to 5 (with 5 being the top rating) by seven scientific experts unaffiliated with the projects under consideration (reviewer 1 through 7) on your advisory board.
> - The average of the reviewers' scores for each proposal and the variance are also displayed in each proposal's column.
> - The order in which proposals appear is randomized.
> - Proposal rankings should be treated as an indication of potential financial return. Negative returns (financial losses) are possible.

In contrast to our earlier questions, each proposal now has a **<u>different cost</u>**, which is displayed in the last row of the table. The cost of specific proposals will now influence what research projects you are able to fund. The portfolio you choose must cost the same or less than your budget constraint. Any leftover funds from each question will be returned to your organization's headquarters and will be unavailable for future R&D investments by your Division. Remember that your final compensation for participating in this study will depend on the choices you make here.

A.2. Experimental Instrument

Please repeat the exercise from the previous question for this **<u>new</u>** set of research projects with a **<u>different</u>** set of scores from your science advisory panel.

Round (2 of 10)

Reviewer	Proposal A	Proposal B	Proposal C	Proposal D
1	2	4	5	2
2	5	4	2	2
3	3	4	3	5
4	2	4	4	2
5	5	1	1	4
6	5	3	1	5
7	2	4	2	5
Average score	3.43	3.43	2.57	3.57
Variance	1.96	1.10	1.96	1.96
Which proposal you would **most** like to fund.	☐	☐	☐	☐
Which proposal you would **least** like to fund.	☐	☐	☐	☐

Fig. S1. Example of Project Selection Question from Experiment 2

The screen shows a real project selection question shown to a subject in the experiment. The screen comes from experiment 2, which showed both the mean score for each proposed project as well as the variance of scores. The screens for experiment 1 were identical except that they did not explicitly show the variance.

Your R&D budget to fund this portfolio of proposals is $14 million dollars.

Check the boxes of the projects you would like to fund located below each proposal. As you enter proposals, the costs of each one will be subtracted from your R&D budget and your remaining funds will be displayed. Depending on the cost of the individual proposals you fund you may not be able to fill in all of the boxes and you may not fully exhaust your R&D budget. You can swap proposals in and out by selecting and unselecting boxes until you are satisfied with your choices. Then click on the arrow to advance to the next question.

Remaining Budget: $14 million

Reviewer	Proposal A	Proposal B	Proposal C	Proposal D	Proposal E	Proposal F	Proposal G	Proposal H	Proposal I	Proposal J
1	4	3	5	5	5	1	4	5	2	4
2	1	2	5	5	3	4	5	2	3	1
3	1	1	5	5	5	1	5	4	1	5
4	1	1	5	4	5	1	3	2	3	4
5	1	1	2	3	3	2	5	2	4	4
6	2	1	5	5	5	1	5	5	2	4
7	1	2	5	5	5	1	5	5	3	3
Average Score	1.57	1.57	4.57	4.57	4.43	1.57	4.57	3.57	2.57	3.57
Variance	1.29	0.62	1.29	0.62	0.95	1.29	0.62	2.29	0.95	1.62
Cost	$10 M	$10 M	$10 M	$10 M	$7 M	$1 M	$1 M	$4 M	$4 M	$1 M
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Fig. S2. Example Portfolio Selection Question from Experiment 3

The screen shows a real portfolio selection question (experiment 3) given to one of the subjects as part of the experiment. The subject could choose projects for the portfolio using the checkboxes below the project proposals. The subject could add and remove projects, seeing their effect on “Remaining Budget”, until they were satisfied.

A.3. Illustration of Incentives to Choose Riskier Projects

Consider a simplified version of the experiment where 10 participants each choose one project, and the subject with the highest score wins a prize. Assume that all projects have a mean of zero and that nine of the participants choose projects $Y_1, \dots, Y_9 \sim i.i.d.\, N(0,1)$. Should the tenth participant choose a project, X, with a variance higher than 1? If the participant chooses a project with a variance of 1, all subjects will be symmetric, so the probability of any one of them receiving the max score will be 1/10. The participant can do better by choosing a higher variance project. If the participant chooses a project with variance approaching infinity, the probability of winning will approach 1/2 because the probability of a draw from a normal distribution with arbitrarily high variance exceeding any given positive value goes to 1/2.

Intermediate values can be approximated using order statistics. Consider the case with n participants and let $Y_{(n)} = \max\{Y_1, \dots, Y_n\}$ be the n^th^ order statistic of the choices from all other participants. By Blom (1961), the expected value of this order statistic, denoted $E(n{:}\,n)$, can be well approximated by

$$E(n{:}\,n) \approx \Phi^{-1}\left(\frac{n-\alpha}{n-2\alpha+1}\right)$$

where $\alpha=0.375$. For $n=9$, this expected value evaluates to 1.494, so to derive the probability of the tenth participant winning given a particular choice of variance, one can evaluate the probability that a normal random variable with mean zero and that variance exceeds 1.494. For instance, the probability of X exceeding this value if $X \sim N(0,2)$ is 0.23. If the participant instead chose a project with a variance of 4, then the probability would rise to 0.35. The probability of exceeding $E(9{:}\,9)$ for a range of possible values for the variance of X is given in Figure S3. Winning the prize in this case is a Bernoulli random variable, so an increasing probability of winning, as depicted in the figure, indicates that a higher variance choice first-order stochastically dominates a lower variance choice, and a participant should therefore choose higher variance projects regardless of their risk preferences.

The simple payment structure shown above encourages higher variance choices no matter the risk preferences of the subjects. The incentives are similar to those in the R&D model of Cabral (2003). Cabral noted that because of the winner-take-all nature of research (for instance, due to patents), a firm that is lagging behind the research frontier should engage in higher risk R&D activity. If the firm's investments pay off, they will capture the market, but if the investments do not pay off, they will not lose relative to the status quo (conditional on equal funding requirements for higher and lower risk R&D investments).

The actual incentive structure in the experiment has two payment thresholds—one for a score in the top 25% and one for a score in the top 10% of participants. With a generic two-threshold payment system, individual risk preferences could matter for optimal behavior. If a risk averse subject believed they were likely to score above the first threshold, a marginal increase in variance would raise their expected monetary payment by increasing the probability of a score above the second threshold, but it could also increase the likelihood that the subject scores in the bottom group. With sufficient risk aversion, the subject might prefer not to take this trade-off. By setting the first threshold above the 50th percentile of scores, we avoid this concern. If all participants made the same choices, then there would be a 75% chance of getting the low prize, a 15% chance of winning the middle prize, and a 10% chance of winning the high prize. If one agent deviates to reduce the variance of their choice, then they simply increase the probability of receiving the lowest prize while reducing the probability of receiving either of the higher prizes. The opposite holds for an increase in variance. Again, the distribution of earnings from higher variance choices first-order stochastically dominates the distribution from lower variance choices. All other things equal, subjects should choose higher variance projects regardless of risk preferences.

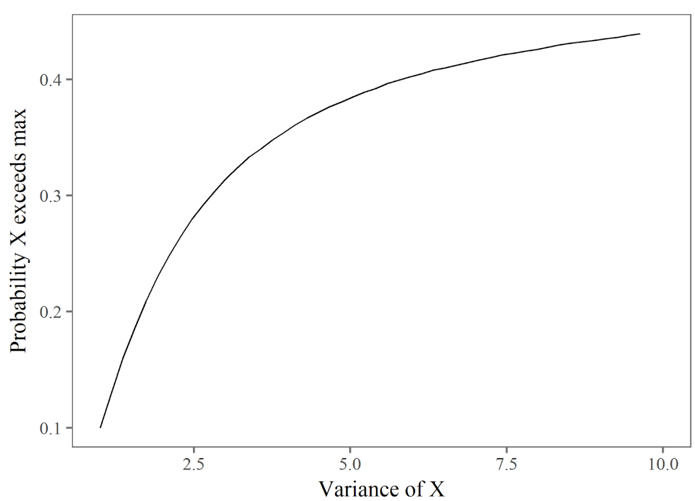


Fig. S3. Probability of Winning Prize Rises with Variance

Approximations of $E(9{:}9)$ for variance from 1 to 10 illustrating the incentive for choosing projects with higher variance.

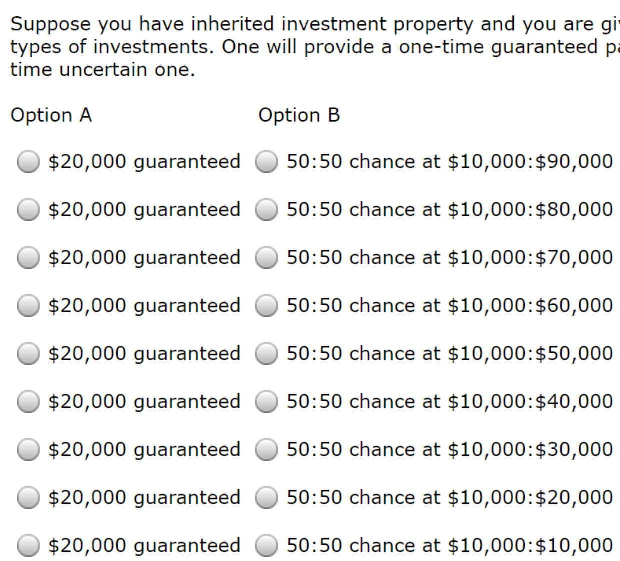
A.4. Calculation of the Coefficient of Relative Risk Aversion

Subjects were shown the list of choices in Figure S4 between guaranteed payments and gambles. We calculated a coefficient of relative risk aversion from the choices by solving for x in the equation

$$20{,}000^{x} = 0.5 * 10{,}000^{x} + 0.5 * G^{x}$$

Where G is the simple average of high value of the two gambles from the first time that the subject switched from choosing Option B to choosing Option A. For instance, if the subject chose Option B until the offered gamble was for $10,000 or $30,000, then we set I equal to $35,000. For this subject, the elicited degree of risk aversion would be 1.21. We chose the average value because we ideally want to find the point of indifference between the guaranteed payment and the gamble.

We classified subjects as risk averse if they switched to the guaranteed payment prior to the $10,000:$30,000 choice. Subjects who switched at the $10,000:$30,000 choice were classified as risk neutral, and subjects who switched at the $10,000:$20,000 choice were classified as risk loving. Four subjects always chose Option B and could not be classified. In the estimation sample, 52% of subjects were risk averse, 36% were risk neutral, and 12% were risk loving.


Suppose you have inherited investment property and you are given a choice between two different types of investments. One will provide a one-time guaranteed payout and the other will pay a one-time uncertain one.

Option A	Option B
$20,000 guaranteed	50:50 chance at $10,000:$90,000
$20,000 guaranteed	50:50 chance at $10,000:$80,000
$20,000 guaranteed	50:50 chance at $10,000:$70,000
$20,000 guaranteed	50:50 chance at $10,000:$60,000
$20,000 guaranteed	50:50 chance at $10,000:$50,000
$20,000 guaranteed	50:50 chance at $10,000:$40,000
$20,000 guaranteed	50:50 chance at $10,000:$30,000
$20,000 guaranteed	50:50 chance at $10,000:$20,000
$20,000 guaranteed	50:50 chance at $10,000:$10,000

Fig. S4. Risk Preference Elicitation Method
The screen shows the question used to elicit risk preferences from study participants.

B. Additional Results and Robustness

	(1) Experiment 1 Project choice	(2) Experiment 2 Project choice, Variance emphasized
Mean		
Average Project Score	5.25^{***}	5.27^{***}
	(0.50)	(0.42)
Project Score Variance	-0.66^{***}	-1.56^{***}
	(0.081)	(0.18)
Standard Deviation		
Average Project Score	2.09^{***}	2.86^{***}
	(0.24)	(0.34)
Project Score Variance	0.79^{***}	1.67^{***}
	(0.075)	(0.17)
Tau	0.38^{***}	-0.17^{***}
	(0.073)	(0.029)
Observations	14,040	14,040

Table S1. Experiment 1 and 2 Results Excluding Subjects from First Experimental Session

Standard errors in parentheses, * p < 0.10, ** p < 0.05, *** p < 0.01. All models contain subject and choice scenario controls. The estimating equation is given in Equation (1). The estimating equation is identical to that presented in Figure 2 except that the data in this table excludes subjects from the first experimental session (about 18% of the total sample). The results are both qualitatively and quantitatively similar to the results reported in the body of the document.

	(1) Experiment 1 Project choice	(2) Experiment 2 Project choice, Variance emphasized
Mean		
Average Project Score	5.62***	5.08***
	(0.39)	(0.51)
Project Score Variance	-0.59***	-1.42***
	(0.063)	(0.13)
Standard Deviation		
Average Project Score	2.92***	2.59***
	(0.26)	(0.52)
Project Score Variance	0.76***	1.54***
	(0.073)	(0.13)
Tau	0.436***	0.065***
	(0.020)	(0.021)
Observations	16,560	16,560

Table S2. Experiment 1 and 2 Results Excluding Subjects Who Were Multiple Switchers on Risk Elicitation

Standard errors in parentheses, * p < 0.10, ** p < 0.05, *** p < 0.01. All models contain subject and choice scenario controls. The estimating equation is given in Equation (1). The estimating equation is identical to that presented in Figure 2 except that the data in this table exclude subjects who exhibited multiple switching on the risk elicitation. The results are both qualitatively and quantitatively similar to the results reported in the body of the document.

	(1) Experiment 1 Project choice	(2) Experiment 2 Project choice, Variance emphasized
Mean		
Average Project Score	5.68***	5.31***
	(0.81)	(0.47)
Project Score Variance	-0.33***	-1.04***
	(0.080)	(0.17)
Variance x Finance	-0.58***	-0.99***
	(0.13)	(0.26)
Standard Deviation		
Average Project Score	3.92***	2.16***
	(1.14)	(0.23)
Project Score Variance	0.56***	1.29***
	(0.083)	(0.088)
Variance x Finance	-0.54***	-0.91***
	(0.12)	(0.19)
Tau	0.20***	-0.22***
	(0.05)	(0.04)
Observations	17,190	17,190

Table S3. Project Choice by Finance Degree

Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. "Finance" is an indicator variable equal to 1 if the subject is getting their degree in finance. All models contain subject and choice scenario controls. The estimating equation is given in Equation (1). The results show that individuals with finance experience were more variance averse, on average, than the subjects who did not have finance experience.

	(1) Experiment 1 Project choice	(2) Experiment 2 Project choice, Variance emphasized
Mean		
Average Project Score	5.76***	5.34***
	(0.60)	(0.43)
Project Score Variance	-0.40**	-1.15***
	(0.17)	(0.35)
Variance x Math classes	-0.041	-0.089
	(0.041)	(0.067)
Standard Deviation		
Average Project Score	2.56***	1.72***
	(0.30)	(0.19)
Project Score Variance	0.46***	1.42***
	(0.069)	(0.11)
Variance x Math classes	0.12***	0.19***
	(0.018)	(0.017)
Tau	0.10***	-0.62***
	(0.037)	(0.047)
Observations	17,190	17,190

Table S4. Project Choice by Mathematics Courses Taken

Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. "Math classes" equals the number of undergraduate mathematics courses taken by the individual. All models contain subject and choice scenario controls. The estimating equation is given in Equation (1). The results show that having taken more mathematics courses did not have a strong effect on preferences over project variance.

	(1) Experiment 1 Project choice	(2) Experiment 2 Project choice, Variance emphasized
Mean		
Average Project Score	6.14***	5.10***
	(0.76)	(0.39)
Project Score Variance	-0.64***	-1.46***
	(0.063)	(0.12)
Variance x Single choice	0.37**	-0.32
	(0.18)	(0.31)
Standard Deviation		
Average Project Score	2.66***	2.87***
	(0.34)	(0.26)
Project Score Variance	0.73***	1.64***
	(0.059)	(0.14)
Variance x Single choice	0.16***	0.29
	(0.052)	(0.21)
Tau	0.37***	-0.003
	(0.028)	(0.025)
Observations	17,190	17,190

Table S5. Project Choice by Whether the Subject Chose Only One Project for Portfolio

Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. "Single choice" is an indicator variable equal to 1 if the subject chose only one project for their portfolio choice questions. All models contain subject and choice scenario controls. The estimating equation is given in Equation (1). Choosing only one project in the portfolio selection questions had a mixed effect on project choice in the first two decision experiments.