

The Effect of Ambiguity Aversion on Reward Scheme Choice

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Abstract

We test the implications of ambiguity aversion in a principal-agent problem with multiple agents. Models of ambiguity aversion suggest that, under ambiguity, comparative compensation schemes may become more attractive than independent wage contracts. We test this by presenting agents with a choice between comparative reward schemes and independent contracts, which are designed such that under uncertainty about output distributions (that is, under ambiguity), ambiguity averse agents should typically prefer comparative reward schemes, independent of their degree of risk aversion. We indeed find that the share of agents who choose the comparative scheme is higher under ambiguity.

Keywords: Ambiguity aversion, comparative compensation schemes, Ellsberg urn, contract design

JEL: D01, D03, D81, M55

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1. Introduction

We compare the performance of two common types of reward schemes in a situation of ambiguity, where the output distribution faced by multiple agents is subjectively uncertain. We consider independent schemes, where the remuneration solely depends on the output of the agent, and compare them with comparative reward schemes, where only the output-rank matters. We investigate whether aversion to ambiguity influences the preference of agents between the two types of reward schemes. While experiments in the style of the Ellsberg paradox have described attitudes of ambiguity averse decision makers towards independent payment schemes, we are not aware of any experimental evidence regarding the evaluation of comparative reward schemes under ambiguity. Taking ambiguity aversion into account could in fact contribute to explaining why comparative contracts such as tournaments often play an important role in the determination of wages in firms. Tournaments may have an advantage if probabilities are subjectively uncertain and agents are ambiguity averse.

To understand why, consider an agency with two (equally skilled) agents, and assume the effort-dependent probability distribution over outcomes is unknown. Often it is nevertheless plausible to assume that, if agent exert the same effort, they face the same distributions over outcomes. Hence, a tournament is stochastically symmetric and if ties are broken at random, the two agents have equal chances of winning the tournament (of $1/2$). Equilibrium payoffs are unambiguous for such tournaments. For comparison, under, e.g., an independent bonus contract, the chance of receiving a wage bonus will typically depend on the unknown outcome distribution, resulting in ambiguous equilibrium wages.²

In many situations where outcome-dependent contracts are used, the underlying probabilities of possible outcome levels can indeed hardly be considered as objectively given. This justifies modelling these probabilities as subjectively uncertain. Theoretically, there are few further reasons why tournaments are

² See Kellner (2010) for a more detailed discussion.

in the interests of a principal (see Prendergast, 1999). Under risk neutrality, optimal contracts do not have to involve relative performance evaluations while under risk aversion, tournaments turn out to be overly risky and therefore not optimal for the principal (Mookherjee, 1984).

We offer the following types of contracts to the participants. Each of two agents draws a ball, labelled with a number, from an identical urn with unknown composition. The first payment scheme is a rank-dependent scheme (an example of a comparative reward scheme): The participant whose ball is labelled with the higher number receives a monetary prize, the other participant only a show-up fee. In the second type of payment scheme the participant receives a monetary prize if she draws a sufficiently high number, independent of the draw of the other agent. Because the participants do not know the composition of the urn, they face uncertainty about the probabilities of drawing a ball with a certain label. Hence, they are confronted with ambiguity. Such ambiguity is payoff-relevant only for the independent contract, while in the comparative scheme the prize is always received with a probability of $1/2$. While the design abstracts from effort choice, such contracts would nevertheless provide incentives to choose a high effort level (if, e.g., effort increases the number of balls with a higher number).

In many applications there could be additional aspects that influence the effect of ambiguity aversion. For instance there could be ambiguity over the relative skills of the agents or ambiguity about the behaviour of the other agent. We want to abstract from these potential confounds in order to provide a solid base for further investigation. The experimental design also ensures that potentially confounding factors are orthogonal to the treatments. Therefore we measure the pure effect of an uncertain (opposed to a certain) distribution over output levels.

We find that ambiguity in fact increases the share of subjects choosing the comparative schemes significantly. For many participants, we find that this effect is present whenever they also display ambiguity aversion in a standard Ellsberg experiment. However, about a third of participants fail to recognize

the fact that the comparative scheme eliminates ambiguity.

2. Design

We present the agents with the choice of different types of payment schemes in a simple setting: The “output” of the agents is just a random draw from an urn with balls labelled 1 to 10. Half of the agents are presented with an ambiguous environment, the other half with an unambiguous environment.

Ambiguous environment

In the ambiguous environment, agents are first presented with the following information about an urn, from which their “output” is drawn. They are given the total number of balls (100) and the fact that the balls are labelled with numbers (1 to 10), but not how they are distributed within the urn.

Purely risky environment

In the purely risky environment, agents are also presented with an urn containing 100 balls. Additionally, they know that the labels are uniformly distributed (10 balls of each label).

Schemes offered to the agents

Agents are given a choice between independent schemes, in which the payoff of the agents depends only on the ball they draw themselves, or comparative payment schemes in which an agent’s payment depends only on whether she draws a ball higher or lower than the ball of an other agent drawing from the same urn (with replacement). Participants are randomly divided into pairs with another anonymous subject. We offer two contracts of each type:

$$I_1 = \begin{cases} x_I + p_I & \text{if own ball 6 or above} \\ x_I & \text{else} \end{cases}$$

$$I_2 = \begin{cases} x_I + p_I & \text{if own ball 5 or below} \\ x_I & \text{else} \end{cases}$$

$$T_1 = \begin{cases} x_T + p_T & \text{if own ball higher than ball of other participant} \\ x_T & \text{if own ball lower than ball of other participant} \\ \text{coin flip} & \text{between the above if both balls equal} \end{cases}$$

$$T_2 = \begin{cases} x_T + p_T & \text{if own ball lower than ball of other participant} \\ x_T & \text{if own ball higher than ball of other participant} \\ \text{coin flip} & \text{between the above if both balls equal} \end{cases}$$

x_T (resp. x_I) denotes the base payment for comparative schemes (independent schemes), while p_T (resp. p_I) is the bonus payment for winning under the comparative schemes (or reaching a target in the independent schemes). The schemes T_1 and T_2 introduce an elementary form of competition: Wages depend on a comparison with the other agent, in which only the rank of the agent matters. We set x_I to ECU 5.40, x_T to ECU 4.60, and $p_I = p_T$ to ECU 19.00. The minimum payment is lower for comparative schemes so that choosing this scheme cannot occur under indifference, but in fact reflects a strict preference for this type of contract. We did not require both agents to be rewarded according to the same type of scheme.

Comprehension of Payment Options

Half of the agents in the ambiguous treatment were presented with a what-if calculator where agents could enter beliefs over the composition of the urn and were shown the resulting probabilities over possible payments over each contract. Analogously, in the risky treatment we calculated all payoff-relevant probabilities for the agents.

Ellsberg-stage

We added a standard two-colour Ellsberg experiment as a bonus-stage. Subjects were presented with two urns. Urn A contained 10 balls labelled 1 and 10 balls labelled 2, while urn B contained an unknown, but fixed distribution

of those balls. Subjects then had to choose an urn and a number: If the number was drawn from urn B, subjects received ECU 7.20 if the chosen number matched the drawn number and ECU 1.20 otherwise; if the number was drawn from urn A subjects received ECU 6.90 if the chosen number matched the drawn number and ECU 0.90 otherwise.

Implementation

When presenting these schemes to the agents, we use the neutral term “payment option” and we do not use any words or abbreviations that emphasize certain properties of the schemes. Participants never learned payoffs or choices of other participants. We also informed the agents that the process of drawing balls with replacement from the urn will be simulated by the computer. We randomized all treatments within session.

The experiment was programmed using zTree (Fischbacher, 2007). In total 206 subjects in 13 sessions (16 subjects per session, except of one where we only have 14 due to subjects not showing up) from May 2010 until June 2010 participated in the experiment at the laboratory at the University of Jena. Participants were recruited via the ORSEE recruitment system (Greiner, 2004). 52.9% of the participants were female. The currency in the experiment was labelled ECU, the exchange rate to Euro was 1ECU=0.4 €. The experiment lasted 45 minutes and the average payment was 7.11 Euro with a maximum of 12.70 Euro and a minimum of 2.20 Euro. Table 1 finally summarizes the structure of the experiment.

3. Hypothesis

Given these payment options, in the purely risky environment, everyone should choose an independent scheme, as the probability of getting the higher payment is 50% in both schemes.³ In the ambiguous environment, the higher payment is still received with a probability of 50% under the comparative

³Recall that the minimum payment is set slightly higher for the independent contract.

Treatments			
Randomly allocated within session			
<i>Risky urn</i>		<i>Ambiguous urn</i>	
Calc	No Calc	Calc	No Calc
I	Payment scheme Choice		
II	Ellsberg Urn Control Task		
III	<i>Exit Questionnaire</i>		
	Comprehension		
	Demographics		

Table 1: Summary of Experimental Design

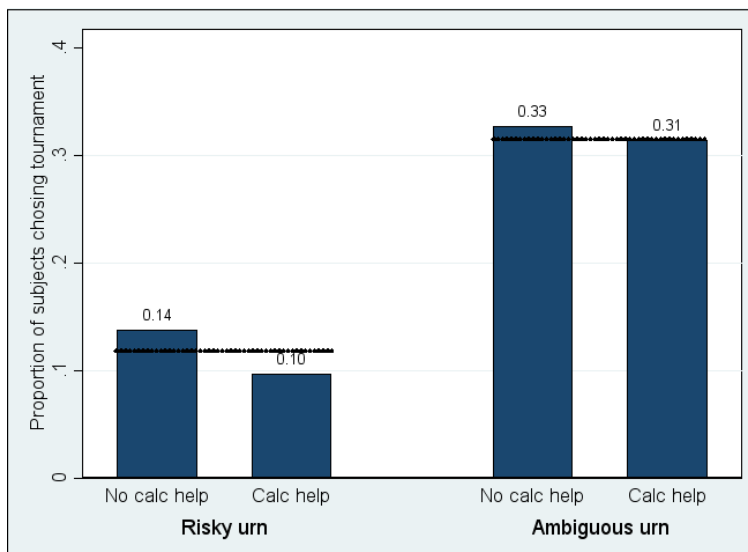
scheme, while the chance depends on the composition of the urn under the independent scheme. This should typically lead ambiguity averse participants to prefer the comparative scheme.⁴ This leads to the following Hypothesis:

Hypothesis. (a) *In the ambiguous environment, more participants will choose the comparative scheme than in the risky environment.* (b) *The share of participants choosing the comparative scheme will increase under ambiguity for ambiguity averse individuals but not for others.*

4. Results

Figure 1 summarizes the shares of participants who chose a comparative scheme in each of the four treatments in the experiment, as well as the pooled results over the ambiguous and the risky urn. As our theory predicts, comparative schemes are chosen more often under ambiguity. Among those participants who did not face ambiguity regarding the output distribution, only 14% choose a comparative scheme. Under ambiguity, the share of comparative schemes in-

⁴See Kellner (2010) for a thorough discussion of the underlying theory.



The dotted line shows the averages over the pooled risky and ambiguous treatments

Figure 1: Tournament share over treatments

creased to 31%. A mean comparison test confirms that the difference between the ambiguous and the unambiguous environment is significant at the 1 percent level according to a χ^2 -Test (and according to Fisher's distribution-free test).

Whether the agents are provided with mathematical help matters little. It has almost no effect in the presence of ambiguity (with mathematical help, the share of comparative schemes chosen dropped slightly from 33% to 31%). When agents know the output distribution, mathematical help decreases the share of participants choosing a comparative scheme (from 14% to 10%). The effect of ambiguity remains significant in both cases. Hence, our experiment strongly confirms that under ambiguity, rank-dependent schemes become more attractive than independent schemes.

The regressions in Table 2 seek to test the hypothesis, whether indeed those agents who are ambiguity averse prefer the comparative schemes. The dependent variable is a dummy variable indicating payment scheme choice in the main stage of the experiment (1 if an agent chose a rank-dependent scheme, 0 if an

agent chose an independent scheme).

The first regression includes only the effect of the key treatment variables on the share of comparative schemes chosen. Under ambiguity the share of subjects choosing the comparative scheme significantly increases by 19.3 percentage points. The effect of offering mathematical help (Calculation help) is small and insignificant. The second regression controls for the behaviour of the participants in the Ellsberg stage, where 41.7% of the subjects appeared ambiguity averse. For the group of ambiguity averse subjects the effect of ambiguity increases the choice of the comparative scheme by 25.2 percentage points and remains significant. The effect of the ambiguous urn on the group that did not show ambiguity aversion is 14.9 percentage points and is insignificant. However, also the difference of these two groups (9.7 percentage points, represented by the coefficient $\text{Ambiguous} \times \text{not amb.av.}$) is insignificant. Regarding the levels, around 14% choose the comparative scheme in the absence of ambiguity independent of ambiguity attitude. Under ambiguity, this share raises to 39.4% for ambiguity averse agents, but still to 29.7% for subjects who do not appear ambiguity averse in the Ellsberg stage.

A possible explanation for the weak correlation between the behaviour in the two stages is that, even if offered mathematical help, not all participants appear to perceive the comparative scheme as unambiguous. This explanation can be supported by the observation that according to our post-experimental questionnaire, even in the group which had calculation aid available, almost one third (35.4%) of the participants apparently was unaware of the fact that the distribution of balls in the urn is always irrelevant under the comparative reward scheme. Moreover, 29.1% of subjects reported that they expected that the share of numbers of six and above *strictly* exceeds numbers five and below or vice versa. We assign the dummy “probabilistic mistake” to the first group and “asymmetric beliefs” to the second group. For both groups, the arguments supporting our hypothesis do not apply. Hence, in regression 3 we only report the coefficients that apply to participants who were not of one of these two groups (about 47.6%). For those participants, ambiguity aversion indeed has

Table 2: Linear Probability Model. Dependent variable: Choice of comparative scheme

	(1)	(2)	(3)
Ambiguous	0.193** (0.083)	0.252** (0.109)	0.351** (0.162)
Calc	-0.038 (0.068)	-0.036 (0.066)	-0.149 (0.094)
Ambiguous \times calc	0.022 (0.112)	0.015 (0.112)	0.041 (0.170)
Not ambiguity averse		0.030 (0.072)	0.110 (0.105)
Ambiguous \times not amb.av.		-0.097 (0.120)	-0.390** (0.188)
Constant	0.167 (0.130)	0.142 (0.145)	0.097 (0.226)
Session dummies	Yes	Yes	Yes
Exclude probabilistic mistakes	No	No	Yes
Exclude asymmetric beliefs	No	No	Yes
Observations	206	206	98
R^2	0.122	0.126	0.165

Note: In this table we report the results of a linear probability model where the dependent variable is the choice of the comparative scheme. Column 1 reports the plain treatment effects. Column 2 controls for the subjects who did not appear ambiguity averse in the additional Ellsberg stage (*Not ambiguity averse*). These were 58% of all participants. Column 3 reports all coefficients only for participants who do not belong to two groups with non-standard beliefs as defined in the main text. Heteroskedasticity robust standard errors are reported in parentheses. Stars indicate following significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

the effect that is predicted by our main hypothesis. Ambiguity increases the share of comparative schemes significantly for ambiguity averse participants (by around 35.1 percentage points), but not for other agents (where the share decreases minimally). The effect differs significantly (by 39.0 percentage points) between these groups.

We also confirmed (not reported) that including demographic variables which are commonly associated with an intrinsic preference over competitive situations changes little about our results.

5. Discussion

In our experiment we have focused on the effects of ambiguity on the agents' preferences between certain comparative and independent schemes. We found that in principle, ambiguity makes comparative schemes more favourable. Moreover, we find evidence that for the larger part of the participants this is due to ambiguity aversion. The difference between the choice of the comparative schemes and the Ellsberg choices might be explained by mathematical difficulties.

Essentially, there are two issues which we have eliminated in our experimental design. First, we have abstracted from effort choice. Hence, a variation of this experiment could test whether uncertainty regarding the output distributions has any additional implications for ambiguity averse agents, if the agents can improve productivity by exerting effort. In this case, strategic ambiguity about the actions of other players could constitute a second source of ambiguity.

Second, we have compared examples of individual and comparative compensation schemes that can be considered equally risky. With the need to provide incentives a principal would optimally use very specific versions of such contracts. Most notably, a rank-dependent comparative scheme typically needs to be more risky than an independent scheme. An extension of this experiment could test whether the advantages of comparative schemes in eliminating ambiguity in fact outweigh their disadvantage in inducing more risk.

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