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An Experimental Investigation of the Disparity between WTA and WTP for Lotteries

by Ulrich Schmidt and Stefan Traub

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An Experimental Investigation of the Disparity between WTA and WTP for Lotteries

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Abstract: In this paper we experimentally investigate the disparity between willingness-to-accept (WTA) and willingness-to-pay (WTP) for risky lotteries. The direction of the income effect is reversed by endowing subjects with the highest price of a lottery when asking the WTP question. Our results show that the income effect is too small to be the only source of the disparity. Since the disparity concentrates on a subsample of subjects, parametric and nonparametric tests of the WTA-WTP ratio may lead to contradictory results. The disparity is significantly reduced when background risk is introduced. That is, putting subjects always into a risky position could improve the contingent valuation method which is often concerned with the assessment of risky situations such as health risks, automobile safety, etc.

Key words: WTA-WTP disparity, lotteries, background risk, contingent valuation.

JEL-classification: C91, D81.

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1 Introduction

The contingent valuation method (CVM) is a prominent tool for cost-benefit analysis, the assessment of public goods, and environmental policy. For critical surveys see the volumes edited by Cummings et al. (1986) and Bateman and Munro (1999), in particular the chapter by Sugden (1999) in the latter book. CVM studies usually consider two different questions in order to assess a respondent's valuation of a given good or service: (i) the maximum buying price or willingness-to-pay (WTP) and (ii) the minimum selling price or willingness-to-accept (WTA). In an important contribution Willig (1976) showed that it ought to be irrelevant whether one chooses the WTA or the WTP question, provided income effects are sufficiently small. However, not only CVM studies but also numerous experimental studies found a disparity between both measures seemingly too large to be explained by income effects alone. Hence, psychological explanations like the endowment effect (Thaler, 1980), that is, the underweighting of opportunity relative to out-of-pocket costs due to loss aversion, have been put forward to resolve these observations (see Traub, 1999, for a survey of experimental studies).

By many authors the disparity between WTA and WTP has been considered as an empirically proven fact that does not even vanish in non-hypothetical, market-like environments. Indeed, for example, Shogren et al. (1994, 2001) showed that using repeated auction mechanisms reduces the disparity. Likewise, Harless (1989) concluded from his experiment that, in the context of risk, the "difference between the measures of value decreases significantly" (p. 359) when both are elicited by means of an incentive-compatible preference-revelation mechanism, namely second-price sealed-bid auctions. However, their results may be attributed to *shaping*. That is, subjects' responses are adjusted in response to cues provided by the market mechanism rather than that subjects learn to act on their true preferences (Loomes et al., 2003).

In the context of riskless choice, Morrison (1997) found that the disparity remained significant even if the subjects were endowed with the average WTA stated by all subjects when asking the WTP question. She concluded from that, that the disparity was due to an endowment effect rather than an income or substitution effect since subjects stayed on the same indifference curves when asking for both measures of value. Bateman et al. (1997) too controlled for income and substitution effects[1] and reasoned from the results of their study that "it seems that the influence of loss aversion is a robust effect" (p. 503). As for other commodities, also for *risky lotteries* a substantial disparity between WTP and WTA has

[1] These authors assessed WTA and WTP both as equivalent and compensating measure of value.

been observed in many empirical studies (see the literature overview in Eisenberger and Weber, 1995). However, as far as we know, none of these studies controlled for income effects. Here lies one of the main motivations of the present paper. We will have a look at the role of the income effect more closely than it has been done before. More precisely, we will *reverse* the income effect as compared to earlier studies, that is, in our experiment subjects will have a higher wealth position when asked for WTP.

The assessment of WTA and WTP for lotteries differs from riskless commodities: while an individual is always in a safe position in the case of riskless commodities there is an asymmetry for lotteries (asymmetric certainty effect). When determining WTP the individual has to give up a certain wealth position and achieves a risky position; in contrast, the individual exchanges a risky for a certain position when determining WTA. Since this asymmetry may have an influence on the disparity we will eliminate it by introducing background risk. A possible alternative to WTA and WTP in CVM studies is the assessment of cash equivalents (CE) called certainty equivalents in the context of risk. Since the income position in the elicitation of CE and WTA is identical, their comparison excludes income effects completely. Therefore, we have also elicited CE in our experiment in order to compare with WTA.

The relevance of the WTA-WTP disparity for cost-benefit analysis as well as for the understanding of markets and individual decision making has been emphasized by a number of authors (Borges and Knetsch, 1998; Kahneman et al., 1990, 1991; Knetsch, 1989, 1990, 1992, 1995, 2000; Knetsch and Sinden, 1984, 1987).[2] In fact, many typical CVM situations such as the assessment of road and automobile safety and accident risks (see Samuelson and Zeckhauser, 1988; McDaniels, 1992; and Duborg et al., 1994), reliability of power supply (see Hartman et al., 1990, 1991), and health risks (Shogren et al., 1994) involve risk or uncertainty. Due to the disparity it is natural to ask for the best CVM measure *in the context of risk*. Under certainty, it has been argued that WTP is the better measure since WTA usually decreases with market experience while WTP remains constant (see Coursey et al., 1987). However, if preferences are shaped by the mechanism with which they are assessed as suggested by the experiments of Loomes et al. (2003), then also the WTP measure is biased (upwards). On the other hand, if substantial income effects exist, WTP is obviously too small in order to compensate people for the loss of a good. Consequently, it is an important question whether income effects cause the disparity between WTP and WTA. If income effects play only a minor role, the disparity may be due to the asymmetric certainty effect. In that case CVM studies could be improved by introducing background risk in the elicitation of WTP

[2] Yet, opinions differ widely about the relevance of the phenomenon: “As a matter of practical importance in markets it [the endowment effect] is perhaps of little concern” (Franciosi et al. 1996, p. 226).

and WTA. It may also turn out that CE is more suitable than WTP or WTA for CVM studies involving risk or uncertainty.

The paper is organized as follows: In Section 2, we introduce some notation and define our main hypotheses. Section 3 describes the experiment. In Section 4, we present the results of our experiment. Section 5 concludes the paper.

2 Hypotheses

2.1 Income Effects

Consider an individual taking an initial wealth position of Y who is offered to purchase a lottery L. According to expected utility (EU) and all alternative utility theories which are based on final wealth positions, the individual‘s WTP for purchasing the lottery is given by

$$V(Y) = V(Y - WTP(L) + L)\,. \tag{1}$$

Analogously, assuming that the individual already owns the lottery, his WTA for selling the lottery is given by

$$V(Y + L) = V(Y + WTA(L))\,. \tag{2}$$

Obviously, in (2) the individual is in a higher wealth position than in (1). Thus, if the degree of absolute risk aversion is non-increasing we get

$$WTA(L) \geq WTP(L)\,, \tag{3}$$

and the disparity, if any, is solely due to a (small) income effect.

More often than not, in the empirical and experimental literature, the case $WTA > WTP$ has been interpreted as a fundamental failure of standard utility theory rather than in terms of an income effect. In order to be on the safe side with this assertion, however, one has to control for the influence of the income effect.[3]

Let y denote the highest possible payoff of lottery L. Now, assume that the individual's initial wealth position is augmented by that amount before buying the lottery. Then, his WTP for purchasing the lottery is given by

$$V(Y + y) = V(Y + y - \overline{WTP}(L) + L) \tag{4}$$

[3] As noted in the Introduction, in the context of riskless choice, Morrison (1997) endowed subjects with the average WTA when asking for the WTP. Since, on average, subjects exhibited the same level of utility, observed disparities could not be due to income or substitution effects. Bateman et al. (1997) assessed the implicit rankings of two riskless consumption bundles from four different reference points, thus, controlling for all substitution and income effects, in order to test on loss aversion.

instead of (1). It is evident that under (4) the individual takes a higher wealth position than under (2) since she or he is endowed with the highest possible payoff of L and not with the lottery itself. Hence, the income effect ought to work into the opposite direction, that is,

$$(5) \qquad WTA(L) < \overline{WTP}(L) .$$

If subjects receive y before eliciting WTP there are, apart from the income effect, three further effects which could potentially increase WTP as compared to WTA. Since y is given by the highest possible prize of the lottery the payment of y can make this prize more salient. Hence, WTP may be biased upwards: (i) by an anchoring effect, that is, y serves as the starting point and its downward adjustments is insufficient (see Tversky and Kahneman, 1974); (ii) by a compatibility effect, that is, the fact that y has the same dimension as the response scale causes an overweighting of the highest possible prize (see Tversky et al. 1988); and (iii) y could be regarded as "house money" which leads to a lower degree of risk aversion and, thus, to a higher WTP (Thaler and Johnson, 1990). However, all these effects work in the same direction as the income effect. If it was the income effect which caused the WTA-WTP disparity in earlier studies, WTP should definitely exceed WTA in our setup. Hence, equation (5) forms the basis of the null hypothesis of our first test:

$$(6) \qquad H_0 : \frac{WTA}{\overline{\overline{WTP}}} < 1 \; vs. \; H_1 : \frac{WTA}{\overline{\overline{WTP}}} > 1 .$$

Since the income effect could have a negligible effect on WTP, we will treat the case $WTA(L) = \overline{WTP}(L)$ not as violations of the null hypothesis. When using nonparametric tests, observations of this type will be regarded as „ties" and distributed evenly among the „less than one" and „more than one" categories. If the null hypothesis is rejected and WTA still exceeds WTP significantly, the conclusion may be drawn that the income effect cannot be the only source of the disparity. Note that we test ratios rather than differences in most cases as we used a within-subjects comparison design (see Harless, 1989).

2.2 Background Risk

From Kahneman and Tversky´s (1979) certainty effect it is well-known that integrating safe options in decision making under risk can cause deviations from rational behaviour. In fact, experimentally observed violations of EU seem to be most pronounced when degenerate lotteries are contained in the choice set. This evidence has motivated the development of theories which are equivalent to EU if all alternatives are risky but allow for deviations from EU in the presence of riskless options (see Fishburn, 1980 and Bleichrodt and Schmidt, 2002). Also in the elicitation of WTA and WTP certainty is involved: when determining WTP, the individual has to give up a certain wealth position and achieves a risky position; in contrast, the individual exchanges a risky for a certain position when determining WTA. Hence, it may be possible that an asymmetric effect of the certain positions causes the disparity between WTP and WTA.

This effect can be controlled by letting subjects always start from and end up in a risky position. More specifically, we consider two lotteries, B and W, and an individual who strictly prefers B over W. The individual is endowed with the worse lottery and asked for his WTP for exchanging the worse lottery W for the better lottery B, hereafter called differential willingness-to-pay (DWTP). Additionally, we endow subjects as before with y, the highest possible payoff of the worse lottery, in order to reverse the income effect. This results in the following definition of DWTP:

$$(7) \qquad V(Y + y + B - DWTP(W,B)) = V(Y + y + W).$$

Analogously, the subject may be endowed with the better lottery and asked for his differential willingness-to-accept (DWTA) in order to exchange the better lottery for the worse lottery. DWTA is given by

$$(8) \qquad V(Y + B) = V(Y + W + DWTA(B,W)).$$

Again, under (7) the subject's utility is greater than under (8). Accordingly, we should have

$$(9) \qquad DWTP(W,B) > DWTA(B,W),$$

which forms the null hypothesis of our second test:

$$(10) \qquad H_0 : \frac{DWTA}{DWTP} < 1 \; vs. \; H_1 : \frac{DWTA}{DWTP} > 1,$$

where "ties" are again distributed evenly among the "less than one" and "more than one" categories.

If the null hypothesis is rejected, the conclusion that it cannot be the income effect alone which causes the disparity between WTA and WTP applies in the presence of background risk as well. Note that the payment of y in the case of DWTP may not only cause an income effect but also the compatibility, anchoring, and house money effects mentioned above, which tend to bias DWTP upwards. Otherwise, if the test generates different results than the first test presented in equation (6), we can draw the conclusion that background risk must have an impact on the disparity.

Suppose that EU holds and income effects are negligible as in the case of constant absolute risk aversion. Then we get

(11) $$\frac{DWTA}{DWTP} = \frac{WTA}{WTP} = 1,$$

and background risk does not play any role for the relation of WTP and WTA. Of course, if WTA / WTP ≠ 1, we may have DWTA / DWTP ≠ WTA / WTP even in the case of EU. Nevertheless, if both fractions differ very much, we may draw some further conclusions on the influence of background risk. Hence, the null hypothesis of our third test is given by:

(12) $$H_0 : \frac{DWTA}{DWTP} = \frac{WTA}{WTP} \; vs. \; H_1 : \frac{DWTA}{DWTP} \neq \frac{WTA}{WTP}.$$

2.3 Cash Equivalents

The cash equivalent (CE) or certainty equivalent of a lottery L is given by that amount of money which makes an individual indifferent between receiving this amount or receiving the lottery. Formally, we have

(13) $$V(Y + CE(L)) = V(Y + L).$$

Using (2) yields

(14) $$V(Y + CE(L)) = V(Y + WTA(L)).$$

Thus, if WTA and CE are elicited in an incentive compatible way, both measures should be identical for a given lottery. In order to analyse this question the hypothesis of our fourth test is given by

(15) $$H_0 : \frac{WTA}{CE} = 1 \; vs. \; H_1 : \frac{WTA}{CE} \neq 1.$$

In the presence of reference dependent preferences the framing with respect to gains and losses matters. According to Kahneman et al. (1990) individuals compare a potential gain of a lottery with a potential gain of money under CE while they compare a potential loss of a lottery with a potential gain of money under WTA. In the case of loss aversion the potential loss of the lottery under WTA should weigh more heavily then the potential gain under CE which would yield WTA>CE. Since the null hypothesis of our tests is always EU, we decided to choose a two-tailed test. If the null hypothesis is rejected, there are systematic differences between CE and WTA and it may turn out that, due to the avoidance of loss frames, CE is a more suitable tool in CVM studies than WTA.

3 The Experiment

The experiment was conducted at the Centre of Experimental Economics (EXEC) at the University of York with 24 subjects. Subjects were approached by the e-mail list of EXEC which contains mostly economics students interested in the participation in experiments. Each subject had to attend five separate treatments within one week, one per day. During five days of this week one of each five different treatments was offered on every single day with varying chronological order. The participants could choose on which day they attended which treatment. Since at most six students were allowed in one session the order in which treatments were completed varied sufficiently between participants.

Treatments lasted between 25 and 40 minutes. Expenditure of time varied not only between treatments but also across subjects since the subjects were explicitly encouraged to proceed at their own pace. After a subject had completed all five treatments, one question of one treatment was selected randomly and played out for real. The average payment to the subjects was £34.17 with £80 being the highest and £0 being the lowest payment.

Insert Table 1 about here

At each of the five treatments subjects were presented with the same 30 lottery pairs (see Table 1), 28 of which were risky. The remaining two (“uncertain”) pairs of lotteries were expressed as in the Ellsberg Paradox with £30 as possible prize. In each pair, the left lottery was safer than the right lottery. Lotteries were presented as cake diagrams on the computer screen. Figure 1 presents an example of a lottery involving a 50% chance of winning £10, a 20% chance of winning £30, and a 30% chance of winning £40. If a subject received a particular lottery as reward, he or she had to spin a wheel of fortune using the corresponding cake diagram in order to determine the prize.

Insert Figure 1 about here

We turn to the explanation of the single treatments now. Although the subjects completed the treatments in a varying order, we number them consecutively for reasons of exposition. At the first treatment, the WTP for all 60 lotteries was elicited in an incentive-compatible way. The lotteries appeared separately in randomised order on the computer screen and the subjects were asked for each lottery:

Submit your bid for this lottery in a second-price sealed-bid auction.

This means that subjects were asked to assume they did not have the lotteries and had to bid in order to get them. The subjects had to type in their bids and to confirm their answers by pressing the return key. At the beginning of the treatment, each subject received a three-page instruction sheet. Then an audio-tape of these instructions was played which took approximately 10 minutes. The instructions explained the rules and the incentive compatibility of second-price sealed-bid auctions in detail. As an example the instructions for treatment 1 can be found in the Appendix. The instructions to the other treatments were similar and can be obtained from the authors upon request. If a question of treatment 1 was selected for reward, the subject received a payment of £y where y is the highest possible prize of the corresponding lottery. Moreover, if the subject submitted the highest bid among all subjects in the group with whom he or she completed the treatment, he or she would additionally play out the lottery and would have to pay the second highest bid. Thus, in treatment 1 we elicited $\overline{WTP}(L)$ as defined by equation (4).[4]

Treatment 2 was identical to treatment 1 except for the fact that a different question was asked:

Submit your offer for this lottery in a second-price offer auction.

Analogously, this means that the subjects were asked to assume that they owned the lottery and had to make an offer to dispose of it. Again, subjects received handouts and had to listen to an audio-tape which explained the rules and the incentive compatibility of the second-price offer auction. If a question from this treatment was selected for reward, the subject could either play out the corresponding lottery, or - if he or she submitted the lowest offer among all subjects in the group with whom he or she completed the treatment - he or she received the second lowest offer instead of the lottery. Thus, in treatment 2, we elicited $WTA(L)$ as defined by equation (2) for each lottery in an incentive-compatible way.

[4] We are aware of the fact that, in general, second-price auctions are only incentive compatible if the independence axiom of expected utility (EU) holds (see Grimm and Schmidt, 2000, for details; see also Harless, 1989). This is unproblematic here, since EU is included in the null hypothesis.

Treatment 3 was designed to assess the certainty equivalents of the lotteries. The 30 lottery pairs were presented in random order and random left-right positioning. Under the left (right) lottery of the pair the following question appeared:

> *State the amount of money such that you do not care whether you will receive this amount or the left (right) lottery.*

For both lotteries subjects had to type in the corresponding amount and confirm their answers by pressing the return key. Incentive-compatibility was ensured by the standard BDM mechanism. If the question under one of the lotteries was chosen as reward, a number z was randomly drawn between 0 and y where y is the highest possible prize in the given lottery. If z was greater or equal to the answer, the subject received £z, otherwise she or he could play out the given lottery. In this treatment we therefore elicited $CE(L)$ as defined by equation (13) in a standard way which can be compared with the WTA and WTP measures.

In treatments 4 and 5 we elicited subjects' DWTA and DWTP. In treatment 4 both lotteries of each pair appeared as cake diagrams on the screen and the subjects were randomly endowed with either the left or the right lottery. The order of the lottery pairs and the left-right positioning of each lottery pair was randomised too. Above the lottery serving as initial endowment the message "*Your endowment*" appeared in bright colour. Suppose that the initial endowment was given by the left (right) lottery. Then, the following two questions appeared under the lottery:

> *How much are you at most willing to pay in order to receive the right (left) lottery instead of the left (right) one?*
>
> *How much has at least to be paid to you in order that you agree to exchange the left (right) lottery for the right (left) one?*

Subjects had to answer both questions by typing in the corresponding amount and confirming it by pressing the return key. Negative amounts were not permitted. Incentive-compatibility was ensured by the following variant of the BDM mechanism. If the first question was selected for the reward, the subject received a fixed payment of £y where y is the highest possible prize in the given lottery. Moreover, a number z was randomly drawn between 0 and y. If z was higher than the answer to the first question the individual could additionally play out the left (right) lottery. If z was less than or equal to the answer, the subject could additionally play out the right (left) lottery and had to pay £z. If the second question was selected for the reward again a number z was randomly drawn as explained above. If z was less than the answer to the second question, the subject could play out the left (right) lottery.

If z was greater than or equal to the answer, the subject could play out the right (left) lottery and additionally received £z.

At the beginning of treatments 4 and 5, subjects received a four-page instruction sheet and, again, an audio-tape of these instructions was played which took approximately fifteen minutes. The instructions explained the rules and the incentive compatibility of our BDM variant by analysing several examples.

Treatment 5 was completely identical to treatment 4 apart from the fact that the initial endowment was reversed, that is, if the initial endowment was the safe (risky) lottery in treatment 4, it was the risky (safe) lottery in treatment 5. The left-right positioning of the lotteries was again randomised and independent of that in treatment 4. By means of treatments 4 and 5 we have obviously elicited $DWTA(B,W)$ and $DWTP(W,B)$ as defined by equations (10) and (11). Note that in both, treatment 4 and treatment 5, at least one answer for a given lottery pair should be zero. More precisely, if the individual is endowed with the better (worse) lottery, the answer to the DWTP (DWTA) question should be zero. This was also explained in the instructions. Suppose the answer to the DWTP (DWTA) question in treatment 4 was positive. This implies that in treatment 5 the answer to the DWTA (DWTP) question should be positive. Consequently, when analysing the DWTA-DWTP ratio later in this paper, we only considered those cases in which the DWTP was positive in treatment 4 (5) and the DWTA positive in treatment 5 (4).

4 Results

4.1 Income Effects

On the left of Table 2 the results from testing on the WTA-WTP disparity (equation (6)) are given. The table lists for each lottery, except for lotteries 1 and 5, the number of valid observations, the mean (first row) and standard error (second row) of the WTA—WTP ratio, the Kolmogorov-Smirnov Z statistic, the median (first row) of the WTA—WTP ratio, and the number of observations k for which the ratio was greater than one including half of the ties, where the total number of ties is given in parentheses (second row). Lotteries 1 and 5 were excluded since they are degenerated one-outcome lotteries (30 pounds and 10 pounds, respectively). If the number of valid observations listed in the table is less than 24, this may be due to one of the following reasons: either stated WTA or WTP was larger than the highest or smaller than the lowest possible prize of a lottery, or WTP was equal to zero. According to these criteria one subject was completely excluded from the sample.[5]

Insert Table 2 about here

In the third column of the table, one leading asterisk marks a mean if it was significantly greater than 1 at the 10% level (one-tailed t test). Analogously, two leading asterisks mean that the null hypothesis had to be rejected at the 5% level. As can be taken from the table, in 50 of 58 cases the null hypothesis of the WTA-WTP ratio being smaller than one was rejected at the 5% significance level (55 at the 10% level). The probability that this observation is due to pure chance is extremely low ($P(k \geq 50) < .01$, binomial test with parameters $n = 58$ and $q = .05$). Thus, standard t tests indicate that - despite the reversed income effect - the WTA-WTP disparity is replicated for our setup. The median of the mean disparities of the single lotteries was 1.876. Taken alone, this evidence would mean that the income effect alone cannot be the main cause of the disparity.

However, the picture looks different when taking into account that the distribution of the WTA-WTP ratios was highly skewed in most cases. Performing a Kolmogorov-Smirnov test showed that we had to reject the null hypothesis of the distribution of the WTA-WTP ratios being normal in 40 cases (see column 4 of the table). Therefore, we additionally performed sign tests on the median of the WTA-WTP ratios (column 5). Now, we could reject the null hypothesis of the median being smaller than one only in 5 cases ($p \leq .05$) and 13 cases ($p \leq .10$), respectively. A binomial test does not reject that this pattern is due to pure chance ($P(k \geq 5) = .164$, binomial test with parameters $n = 58$ and $q = .05$).[6] Thus, in contrast to the t tests nonparametric tests do not confirm a positive WTA-WTP disparity for most lotteries. The overall median is close to unity (1.058).

It is interesting to see that always about half of the subjects exhibited a positive disparity, causing a mean ratio significantly larger than one. It is self suggesting to check whether these subjects were always the same across the different lotteries. We therefore counted the number of positive disparities (ratios of WTA and WTP larger than one) for

[5] Subjects were only excluded from the analysis of the task where they violated dominance and included in the analysis of all other hypotheses. This may be problematic since we cannot rule out the possibility that subjects violated dominance because they misunderstood the instructions rather than committing simple errors.

[6] Note, however, that the null hypothesis is rejected for the more generous significance level of 10% ($P(k \geq 13) < .01$, binomial test with parameters $n = 58$ and $q = .10$).

every subject. We used a standard binomial test, where it was assumed that the up to 58 observations for every subjects were independent from one another and that the events "positive disparity" and "negative disparity" were equally likely under the null hypothesis ("ties" were again distributed evenly among the null and the alternative hypothesis). In fact, we found 14 subjects (about 60% of the sample) with a significant number of positive disparities. Five subjects exhibited only positive disparities. Thus, the conclusion may be drawn that the WTA-WTP disparity does not vanish when lotteries are considered instead of riskless commodities, even if the sign of the income effect is reversed. The occurrence of the disparity concentrates among a group of subjects. It would be misleading, therefore, to consult the results of the sign test alone in order to draw conclusion about the WTA-WTP disparity.

This reasoning applies to Harless' (1989) study as well, where he could not reject the null hypothesis of the WTA-WTP ratio being not greater than (an arbitrarily chosen value of) 1.1 for all lotteries and samples considered, although the median was sometimes even 2, and always about one half of the subjects exhibited a disparity greater than 1.1. For example, he presented a lottery with prize \$4 and winning probability 3% to n=16 subjects (one outlier was deleted). The mean WTA-WTP ratio (not reported in the paper and reconstructed from his Figure 3) was 2.25 and its standard error .484. Thus, a one-tailed t test would reject the null hypothesis of 2.25 being not greater than 1.1 at the 5% level. However, since "only" 10 of 16 subjects exhibited a WTA-WTP ratio strictly greater than 1.1 the sign test used by Harless did not reject the null hypothesis (p=.227) because at least 12 (p=.038) such observations had been necessary to do so. In contrast to Harless, Eisenberger and Weber (1995) observed a significant disparity between WTA and WTP for risky lotteries. In their statistical analysis they focussed on mean ratios rather than median ratios to derive their results. Applying Harless' statistical analysis to their data, a binomial test (we chose, for example, Urn R, positive framing, see the top of Figure 1 in Eisenberger and Weber, 1995) yields no significant WTA—WTP disparity (that is, a disparity greater than 1.1): From 63 observations only 36 were strictly larger than 1.1 (p=.191), while 38 had been necessary to reject the null hypothesis at least at the 10% level. Thus, Eisenberger and Weber came to the conclusion that neither moving from risk to uncertainty nor the framing of lotteries would matter for the size of the WTA—WTP disparity. However, according to Harless' much stricter criterion there had been *no disparity at all*.

Summarizing, our data are despite the reversed income effect quite similar to those of Harless (1989) and Eisenberger and Weber (1995): the median of the WTA—WTP ratio is only slightly greater than unity. Note, however, that earlier studies observed a much higher median of this ratio, for instance 2.85 in the study of Knetsch and Sinden (1984) and between 2.64 and 3.37 in the experiments of Coursey et al. (1987), see Table 1 of Kahneman et al. (1990) for further examples. According to Harless (1989) these higher medians were caused by the following differences as compared to his and our studies: (i) a between subject design instead of a within subject design and (ii) the lack of an incentive mechanism or the adoption of a riskless environment.

Closer inspection of Table 2, reveals an interesting effect of the type of the lottery involved on the size of the mean or median disparity: There were 16 lotteries which guaranteed at least £10, for example, lotteries 4 to 6, while the other 42 non-degenerate lotteries contained the risk of getting a zero payoff. The WTA-WTP ratio was much larger for those lotteries involving zero as a possible payoff. This result was confirmed by both, standard two-tailed t tests on the mean difference ($p \leq .01$) and nonparametric Mann-Whitney U tests ($p \leq .01$). A trivial reason for this observation could be that on average the expected value of the zero-payoff lotteries was distinctly lower than for the other lotteries (17.35 as compared to 28.19). This should yield lower WTA and WTP for the zero-payoff lotteries such that identical absolute WTA-WTP differences cause larger ratios. There are, however, also behavioural reasons which could have caused this phenomenon. A very convincing hypothesis in this context is a regret effect (Bell, 1982, Loomes and Sugden, 1982; see also Bar-Hillel and Neter, 1996): WTP is smaller for zero-payoff lotteries because subjects fear to pay much for a lottery where they can end up with nothing. Our experiment was not designed to test such a hypothesis. However, computing the ratios between WTA for the 42 zero-payoff lotteries and WTA for the 16 other lotteries yields .56 while the same ratio for WTP is .48. This means that moving to zero-payoff lotteries WTP decreases more than WTA. Alternatively, subjects could have some aspiration level or target return in mind when evaluating the lotteries. Then, zero payoffs could be sensed as below-target returns, with the consequence that the valuation of zero-payoff lotteries turns out relatively low (see, for example, the experiments of Payne et al., 1980, 1981).

4.2 Background Risk

Recall that we analyse background risk in order to see whether the WTA-WTP disparity is caused by an asymmetric certainty effect. Therefore, in our test on the impact of background risk (hypothesis 2), we always start from a risky position (that is, the initial endowment is a lottery) and end up in a risky position. Some authors (for example, Jaffray, 1988, and Cohen, 1992) argued that a certainty effect may already be caused by different positive security levels among the lotteries, where the security level is the lowest possible prize of a lottery. In order to rule out these effects we restrict our attention to those 42 lotteries which involve a zero payoff.

Insert Table 3 about here

Table 3 lists the 15 pairs of lotteries eligible as candidates. Again, some observations were excluded for not being in the interval required, or in the case $DWTP = 0$ for the lottery which is better according to the DWTA question. Observations of the latter type could be prompted by the empirical observation that people are reluctant to exchange lottery tickets (see Bar-Hillel and Neter, 1996). Assuming a significance level of 5%, we have to reject the null hypotheses in 5 of 15 cases (10 for 10% significance level) when applying one-tailed t tests on the mean DWTA-DWTP ratio being smaller than one. A binomial test rejects the null hypothesis that this result is due to pure chance ($P(k \geq 5) < .01$, $n = 15$ and $q = .05$; $P(k \geq 10) < .01$, $n = 15$ and $q = .10$). Again, most of the distributions of DWTA-DWTP ratios are highly skewed and, therefore, it seems more appropriate to apply nonparametric tests. The respective test on the median being smaller than one (ties are distributed evenly) rejects the null hypothesis for only 1 of the lottery pairs considered at the 5% significance level and for 2 at the 10% significance level, respectively. A global test does not reject the null hypothesis that this pattern is due to pure chance ($P(k \geq 1) = .537$, $n = 15$ and $q = .05$; $P(k \geq 2) = .451$, $n = 15$ and $q = .10$).

Note that in eleven of 15 cases the median is exactly one. The global median is one too while it equals 1.058 for the standard WTA-WTP ratio. Accordingly, we expect the disparity to be reduced when differential measures are applied instead of the standard measures (hypothesis 3). Indeed, the Mann-Whitney U test rejects the null hypothesis of the distributions of the medians in Tables 2 (WTA-WTP ratios) and 3 (DWTA-DWTP ratios) coming from the same population: the DWTA-DWTP ratio is significantly smaller than the WTA-WTP ratio (n=73, U=263, p=.016).

4.3 Cash Equivalents

In this section we want to investigate whether WTA and CE are indeed equivalent measures as predicted by EU. The right side of Table 2 shows the results from testing equation (15). Again, n denotes the number of valid observations per lottery. An observed CE was treated as valid if it did not exceed the maximum payoff of the lottery and if it did not fall below its minimum payoff. The next columns list the means (first row) and standard errors (second row), and the Kolmogorov-Smirnov Z statistic for the test on normality. Finally, the last column gives the median, and 90% confidence intervals for the median (note that hypothesis 4 requires a two-tailed test).

As can be taken from the table, in most cases we could not reject the null hypothesis of the WTA-CE ratio being equal to one. This applies to both, the t test and the median test. If at all, there seems to be a slight tendency of the CE measure towards being slightly larger than the WTA measure (the median WTA-CE ratio over all lotteries is. 953 for the means and .996 for the medians). As to the t test, in 12 the ratio was significantly smaller than one as compared to one test only being larger than one. A similar picture arose from the nonparametric test. Thus, it seems to be irrelevant for CVM studies whether WTA or CE is employed. However, it should be mentioned that this result has to be taken with some caution since we used different incentive mechanisms in both cases (second-price auction for WTA and BDM mechanism for CE). In principle, it may be the case that WTA is indeed larger then CE but, at the same time, second-price auctions yield lower values than the BDM mechanism such that both effects cancel out each other. We are not aware of experimental studies comparing the BDM mechanism with second-price auctions directly. Yet, Harless (1989) using second-price auctions and Eisenberger and Weber (1995) using the BDM mechanism elicited rather similar data since the differences between the results of both papers were simply due to the application of different statistical tests. Consequently, it seems to be rather unlikely that the equivalence between WTA and CE in our experiment is due to the use of different incentive mechanisms.

Our result is in contrast to the results of Kahneman et al. (1990) who observed a median WTA-CE ratio exceeding two. There are, however, at least two important differences to our experimental design: a between subject design instead of a within subject design and the adoption of a riskless environment.

5 Conclusions

In this paper we investigated the disparity between WTA and WTP for risky lotteries. A central feature of our experimental design was the reversal of the income effect. More precisely, when eliciting WTP subjects were placed in a higher wealth position than in the elicitation of WTA. If the income effect had caused the disparity in previous studies, WTP should have exceeded WTA in our experiment. Since, nevertheless, our results do not substantially differ from those obtained before, for example, by Harless (1989) and Eisenberger and Weber (1995), we are inclined to conclude that the income effect is not capable of explaining the disparity. It is important to note, however, that the disparity concentrated among a subsample of 14 subjects (about 60% of the sample). This explains the contradictory results gained from parametric and nonparametric tests. Our results suggest that the income effect is small and that the WTP is sufficient to compensate losses in CVM studies.

Similar to our study, Harless (1989) and Eisenberger and Weber (1995) obtained median WTA-WTP ratios close to one while other studies like Knetsch and Sinden (1984) observed median WTA-WTP ratios exceeding two. Harless (1989) attributed this difference to three possible reasons: a riskless framework, a between subject design, and/or the lack of an incentive mechanism. Though our results on background risk seem to indicate that risk is the main reason for the reduced WTA-WTP disparity in the present study as well as in the work of Harless (1989) and Eisenberger and Weber (1995), we still cannot single out other sources. In order to answer this question a within subjects study would be needed in which every subject evaluates riskless and risky commodities in an incentive compatible way. Should our conjecture as to the role of risk for the WTA-WTP disparity become a certainty, the debate on the right measure to assess the value of commodities would become less relevant since many typical questions taken up by contingent valuation are concerned with the assessment of risky situations (health risks, automobile and nuclear plant safety, disasters, etc.). Our results on the equivalence of CE and WTA under risk reinforce this conclusion.

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Appendix

Instructions to Treatment 1

Introduction

Recall that you have to make decisions with respect to 60 lotteries in all of the five occasions. At the end of the experiment we will randomly select one question from one of the five occasions and play it out for real. In this occasion you have to answer exactly one question for every single lottery out of the 60 lotteries.

What are the questions?

In this occasion the lotteries are auctioned by a second-price sealed-bid auction. Sealed-bid means that every bidder submits her/his bid secretly, i.e. you do not know the bids of the other bidders and the other bidders do not know your bid. Second-price means that the bidder with the highest bid receives the auctioned lottery and has to pay a price which equals precisely the second highest bid. In other words, if you have the highest bid among all bidders you do not have to pay your own bid but only the second highest bid in order to receive the lottery. In this occasion a lottery appears on the screen and you are asked: ”Submit your bid for this lottery in a second-price sealed-bid auction”.

How is your reward calculated?

If a question of this occasion is selected for your reward you first receive a constant payment of £y, where y is the highest possible prize of the lottery, which is involved in this question. Moreover, if you are the subject with the highest bid among all subjects in the group you completed this occasion, you receive the corresponding lottery and have to pay the second highest bid.

How should you determine your bid?

Obviously the price you are at most willing to pay for a given lottery just depends on your own preferences, it cannot be objectively ”right” or ”wrong”. However, given the price you are personally at most willing to pay for a given lottery it is in your own interest to submit exactly this price as bid for the lottery. In the following we want to explain you why this is true.

Note that your bid has no influence on the price you pay for the lottery, it just decides whether you will receive the lottery for a given price or not. Suppose the price you are at most willing to pay for the given lottery is for example £31.04. Then you should bid, as we show you in the sequel, also £31.04. Suppose you ,would bid a lower amount, say, £23.91. If the highest bid among all other bidders is higher than £31.04, you would not receive the lottery in both cases. If the highest bid among the other bidders is lower than £23.91, for example £17.56, you would receive the lottery for a payment of £17.56 in both cases. Now suppose the highest bid among all other bidders is £25.53. If you bid £23.91, you do not receive the lottery. However, if you bid your true willingness to pay, i.e. £31.04, you will receive the lottery for the price of £25.53, which is significantly lower than the maximal price you are willing to pay. Therefore, you cannot win by bidding an amount lower than the price you are at most willing to pay. Now suppose you submit a bid higher than £31.04, for example £37.89. If the highest bid among all other bidders is higher than £37.89 or lower than £31.04, this does not change anything. But suppose the highest bid among all other bidders is £36.14. If you have submitted your true maximal buying price as bid, you would not receive the lottery in this case. If you, however, have submitted £37.89 as bid, you receive the lottery but have to pay £36.14, which is strictly higher than the price you are at most willing to pay. Consequently, you can also not win by bidding an amount higher than the price you are at most willing to pay.

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Table 1 The lottery pairs

	probability of payoff					probability of payoff			
#	£0	£10	£30	£40	#	£0	£10	£30	£40
				lotteries					
1	---	---	1.00	---	31	.20	---	---	.80
2	.75	---	.25	---	32	.80	---	---	.20
3	.30	.60	.10	---	33	.32	.60	---	.08
4	---	.60	.10	.30	34	.02	.60	---	.38
5	---	1.00	---	---	35	.70	---	---	.30
6	---	.50	.50	---	36	.35	---	.50	.15
7	.50	.50	---	---	37	.85	---	---	.15
8	---	---	.70	.30	38	.15	---	---	.85
9	.80	---	.14	.06	39	.83	---	---	.17
10	.20	---	.74	.06	40	.23	---	.60	.17
11	---	.20	.80	---	41	---	.50	---	.50
12	.50	.10	.40	---	42	.50	.25	---	.25
13	---	.20	.60	.20	43	.20	---	.40	.40
14	---	.10	.30	.60	44	.10	---	.20	.70
15	.20	.80	---	---	45	.80	---	---	.20
16	.10	.40	.50	---	46	.40	---	.50	.10
17	---	.40	.60	---	47	.40	---	---	.60
18	.50	.20	.30	---	48	.70	---	---	.30
19	---	.20	.30	.50	49	.20	---	---	.80
20	---	.20	.70	.10	50	.20	---	.40	.40
21	---	---	.50	.50	51	.10	---	---	.90
22	.50	---	.50	---	52	.60	---	---	.40
23	.25	.50	.25	---	53	.30	.50	---	.20
24	---	.50	---	.50	54	.20	.20	---	.60
25	.50	.25	---	.25	55	.60	.10	---	.30
26	---	.25	.50	.25	56	---	.35	---	.65
27	---	---	.75	.25	57	---	.10	.25	.65
28	.25	.25	.50	---	58	.25	.35	---	.40

	30 balls	60 balls		30 balls	60 balls	
#	red	black	yellow	#	red	black	yellow
			uncertain lotteries				
29	£30	£0	£0	59	£0	£30	£0
30	£30	£0	£30	60	£0	£30	£30

Table 2 Testing on income effects and the equivalence of cash equivalents (CE) with willingness-to-accept (WTA)

Lottery	Income effects				WTA vs. CE			
	n	t test *mean* *std. error*	KS-Z	binom. test *median* *k* (# ties)	*n*	t test *mean* *std. error*	KS-Z	median test 90% *CI*
2	21	**1.627	1.153	*1.077	22	.972	.890	1.000
		.294		14 (2)		.132		[.714,1.003]
3	23	**1.596	*1.285	1.014	23	**.757	.983	*.900
		.209		13.5 (3)		.065		[.636,.999]
4	18	**1.265	1.026	1.000	21	1.100	**1.895	1.000
		.129		9.5 (3)		.149		[.955,1.050]
6	19	*1.165	.948	1.000	21	.973	1.156	1.000
		.099		10 (1)		.075		[.952,1.000]
7	21	*3.470	**1.743	1.000	23	.865	.988	*.875
		1.767		12.5 (5)		.097		[.700,.998]
8	15	1.033	.917	1.000	19	.975	1.097	.994
		.027		7.5 (1)		.025		[.919,1.000]
9	22	**2.615	**1.643	1.000	23	1.024	**1.629	.750
		.782		11 (4)		.210		[.600,1.000]
10	22	**1.848	**1.632	**1.102	22	.935	*1.337	.963
		.423		16 (2)		.071		[.875,1.000]
11	19	**1.265	1.023	*1.060	21	**.912	1.018	.981
		.113		13.5 (5)		.040		[.900,1.000]
12	22	**2.960	**1.433	1.285	22	.897	1.020	.992
		.813		14 (2)		.087		[.933,1.000]
13	21	**1.414	1.171	1.056	22	.960	1.139	1.000
		.177		12 (2)		.057		[.993,1.000]
14	21	**1.274	*1.215	1.000	22	1.049	**1.661	.997
		.136		11 (2)		.105		[.938,1.000]
15	23	**2.014	**1.572	1.098	22	**.782	.961	**.866
		.579		14 (4)		.063		[.800,.975]
16	22	**1.874	**1.359	**1.370	22	.956	.689	.981
		.398		16 (2)		.057		[.900,1.000]
17	18	*1.155	.795	1.048	21	1.003	.998	.991
		.093		9.5 (1)		.066		[.909,1.000]
18	23	**2.303	**1.584	*1.091	23	.931	.789	1.000
		.613		16 (2)		.076		[.854,1.000]
19	20	**1.332	.823	1.133	22	1.091	**1.620	1.000
		.126		13 (2)		.101		[.994,1.000]
20	21	**1.376	**1.731	1.000	22	**.911	.789	*.964
		.174		10 (6)		.039		[889,.999]
21	13	.999	1.082	1.000	19	.995	1.022	1.000
		.024		6.5 (3)		.020		[.999,1.000]
22	23	**1.962	**1.532	1.000	23	**.808	.932	*.938
		.414		13 (4)		.079		[.667,.999]

table continues

continuation of Table 2

Lottery	Income effects				WTA vs. CE			
	n	t test *mean* *std. error*	KS-Z	binom. test *median* *k* (# ties)	*n*	t test *mean* *std. error*	KS-Z	median test 90% *CI*
23	23	**1.914	*1.244	1.261	23	.916	.982	1.000
		.317		14.5 (3)		.061		[.954,1.000]
24	20	**1.271	**1.387	1.000	22	.953	.983	1.000
		.136		10 (4)		.045		[.942,1.000]
25	23	**2.084	*1.205	**1.200	23	*.870	.825	.984
		.380		16 (2)		.068		[.800,1.000]
26	20	**1.369	*1.326	1.000	22	.952	1.042	1.000
		.172		10 (2)		.047		[.909,1.000]
27	13	**1.036	.705	1.022	16	1.011	.777	1.000
		.020		8.5 (3)		.016		[1.000,1.031]
28	23	**2.140	**1.381	1.059	23	.959	.874	.987
		.482		14 (2)		.082		[.944,1.000]
29	21	**1.646	*1.302	1.000	22	*.786	1.011	**.764
		.319		11.5 (3)		.120		[.533,.866]
30	22	**2.181	1.142	*1.400	22	1.154	.960	1.000
		.445		15 (2)		.132		[.975,1.205]
31	22	*1.972	**1.493	1.095	22	.932	1.129	.997
		.567		13.5 (1)		.048		[.950,1.000]
32	21	**1.627	1.153	*1.077	22	.972	.890	1.000
		.294		14 (4)		.132		[.714,1.003]
33	23	**1.721	*1.232	1.061	22	**.765	.701	**.725
		.276		15 (2)		.071		[.583,.978]
34	22	**1.518	.962	1.041	23	.918	.840	.960
		.238		12.5 (1)		.058		[.870,1.000]
35	20	**1.641	1.101	1.026	22	.919	.941	.991
		.326		12 (4)		.077		[.824,1.000]
36	22	**1.853	.988	1.168	21	.962	.820	1.000
		.311		14.5 (3)		.094		[.940,1.063]
37	21	**2.570	1.074	*1.667	22	1.001	.857	.988
		.469		14 (2)		.116		[.833,1.000]
38	22	**1.581	**1.323	1.056	23	*.883	**1.470	1.000
		.280		14.5 (3)		.058		[.994,1.000]
39	22	6.165	**2.037	1.000	22	*.824	.678	.850
		3.945		12 (4)		.089		[.500,1.000]
40	22	**1.877	**1.844	1.000	21	*.896	.984	**.893
		.459		11 (2)		.062		[.839,.992]
41	20	**1.471	1.038	1.160	21	.987	.822	1.000
		.149		12 (2)		.059		[.980,1.000]
42	22	**2.070	**1.346	1.200	23	.927	.791	.999
		.406		13.5 (1)		.114		[.833,1.000]
43	22	**1.949	**1.441	1.068	21	.929	.926	1.000
		.416		13.5 (1)		.066		[.948,1.000]

table continues

continuation of Table 2

Lottery	Income effects				WTA vs. CE			
	n	t test *mean* *std. error*	KS-Z	binom. test *median* *k* (# ties)	*n*	t test *mean* *std. error*	KS-Z	median test 90% *CI*
44	22	**2.243 .661	**1.805	1.022 11.5 (1)	21	1.131 .133	**1.530	.999 [.971,1.000]
45	22	*3.837 1.783	**1.899	1.071 13 (4)	22	.840 .095	.836	.958 [.600,1.000]
46	22	**2.026 .493	**1.363	1.156 14 (4)	22	.991 .063	.807	.995 [.926,1.000]
47	22	**2.157 .500	**1.558	1.063 13.5 (3)	23	.986 .078	.807	.999 [.940,1.000]
48	23	**2.773 .670	**1.585	*1.296 16.5 (3)	22	1.045 .145	**1.412	.999 [.750,1.000]
49	22	**2.560 .683	**1.625	**1.487 15.5 (3)	21	*1.149 .086	1.009	1.000 [.999,1.111]
50	22	**1.883 .403	**1.444	1.085 13.5 (3)	21	.984 .080	.843	1.000 [1.000,1.071]
51	22	**1.504 .214	**1.358	1.035 12 (2)	21	1.002 .070	*1.272	1.000 [.999,1.080]
52	23	**2.269 .577	**1.628	1.000 12.5 (5)	22	.864 .096	.933	.993 [.667,1.000]
53	22	**1.553 .214	1.171	1.008 11.5 (1)	22	.974 .075	.926	.932 [.833,1.000]
54	23	**1.912 .507	**1.756	*1.080 15.5 (5)	22	1.168 .155	**1.742	1.000 [.992,1.000]
55	23	**3.389 1.017	**1.532	**1.625 16 (2)	22	.937 .067	.692	.992 [.850,1.000]
56	20	**1.366 .154	**1.436	1.056 12 (2)	23	1.019 .082	*1.310	.983 [.900,1.000]
57	22	**1.319 .164	**1.506	1.000 11 (2)	22	*.913 .049	*1.338	.998 [.956,1.000]
58	23	**2.075 .478	**1.573	1.111 15 (4)	23	*.849 .076	.800	.950 [.800,1.000]
59	22	**3.813 1.351	**1.608	1.125 13.5 (5)	20	.995 .139	1.148	.999 [.855,1.000]
60	22	**3.603 1.494	**1.548	1.525 13.5 (1)	21	.877 .105	.910	*.833 [.750,.999]
Median	22	1.876	---	1.058	22	.953	---	.996

Table note. * $p \leq .10$. ** $p \leq .05$. *n* denotes the number of valid observations. t tests are one-tailed for WTA vs. WTP and two-tailed for CE vs. WTA. KS-Z is the value of the Z statistic of the Kolmogorov-Smirnov test on normality. *k* is the number of valid observations (WTA-WTP ratios) exceeding 1 (including half of the ties). CI is the 90% confidence interval for the median of the WTA-CE ratios.

Table 3 Testing on background risk

Lotteries	*n*	t test *mean* *std. error*	KS-Z	binomial test *median* *k* (# ties)
2,32	18	*4.467 2.556	**1.955	1.000 10 (11)
3,33	19	**2.505 .683	**1.418	*1.105 13 (6)
7,37	19	1.658 .506	*1.223	1.000 11 (6)
9,39	17	**3.160 1.223	**1.386	1.000 10.5 (7)
10,40	16	*1.513 .309	1.012	1.053 10 (4)
12,42	14	*1.995 .681	**1.515	1.000 9 (8)
15,45	19	**1.798 .369	1.069	1.182 12 (4)
16,46	17	*1.786 .552	**1.603	1.000 10.5 (5)
18,48	18	**2.085 .377	.742	**1.550 13 (2)
22,52	15	**2.316 .663	**1.393	1.000 9.5 (7)
23,53	19	.722 .111	*1.289	1.000 7 (8)
25,55	17	*1.867 .582	*1.242	1.000 10.5 (7)
28,58	20	.960 .132	1.190	1.000 9.5 (9)
29,59	16	2.135 .962	**1.580	1.000 7.5 (7)
30,60	17	1.590 .449	*1.260	1.000 8 (4)
Median	17	1.867	---	1.000

Table note. $^{*}p \leq .10$. $^{**}p \leq .05$. *n* denotes the number of valid observations. t test: two-tailed. KS-Z is the value of the Z statistic of the Kolmogorov-Smirnov test on normality. *k* is the number of valid observations (DWTA-DWTP ratios) exceeding 1 (including half of the ties).

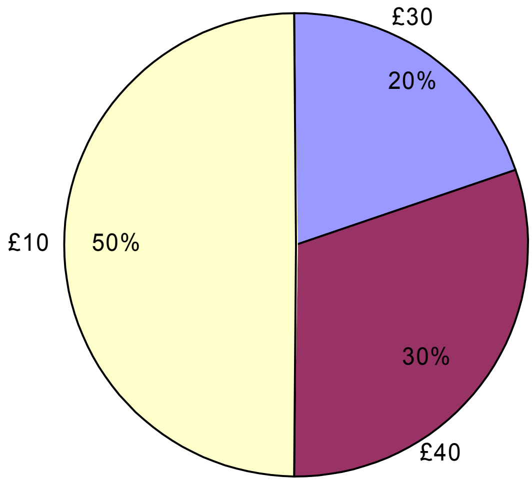

Figure 1 The Presentation of Lotteries