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# Preference reversals: experimental review and a new idea for using arbitrage within the double bound dichotomous choice elicitation method.

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## Introduction

A problem in environmental good valuation has been the introduction of risk into the valuation process. Although humans make risky decisions every day (e.g. driving to work), experimental subjects struggle in risk experiments. One troubling problem is preference reversals. To keep things simple consider two choices with risk, A and B. The choice you prefer should give you a higher level of expected satisfaction and therefore a higher value. A preference reversal occurs if you prefer choice A but indicate a higher value for B, or if you prefer B but indicate a higher value for A.

A monetary example and experimental results are provided in Thaler and Tversky (1992). Imagine you "own" two lotteries and have the right to sell them to someone else if you choose. If they purchase either or both from you a random draw would determine how much you would have to payout to the purchaser. From the seller's perspective Lottery A has a 1/9 chance of paying out $0 and an 8/9 chance of paying out $4. Lottery B has a 8/9 chance of paying out $0 and a 1/9 chance of paying out $40. Which lottery do you prefer? What is the minimum amount you would sell lottery A for (a.k.a. willing and able to accept, WTA), and separately lottery B? About two out of every three people prefer A but indicate a higher selling price for B.

Preference reversals are challenging from both a theoretical and applied standpoint. Theoretically, preference reversals call into question fundamental behavioral assumptions including the existence and stability of preference orders (see, for example, Kahneman, Ritov, and Schkade,1999). In an applied setting, if a large number of respondents reverse preferences the wrong signal will be conveyed to policy makers leading to inefficient use of scarce resources.

Preference reversals can send mixed or opposing messages in the valuation of goods. Imagine asking survey respondents to choose between risky environmental goods. To do so, reconsider our lotteries in a different context. Lottery C is a day of guided fishing which includes a 90% chance of catching a rainbow trout, and a 10% chance of catching nothing. Lottery D is a day of guided fishing which includes a 10% chance of catching a brown trout, and a 90% chance of catching nothing (ignore the possibility that you might catch a rainbow trout while fishing for a brown trout). If I prefer C but indicate I am willing and able to pay (WTP) more for D, what can be inferred? Since stated preference valuation surveys often rely on WTP to indicate preference, the higher WTP would point to a preference toward lottery B which is the opposite of the true preference ranking. Scarce policy money could inefficiently flow to a less preferred option.

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A process known as arbitrage has been used to directly punish preference reversals in monetary lotteries (see early examples: Berg, Dickhaut, and O'Brien, 1985; Chu and Chu, 1990). In experimental settings arbitrage has been shown not only to reduce preference reversals in monetary lotteries but to have a spillover effect of reducing preference reversals in hypothetical lotteries. These hypothetical lotteries can include environmental and food safety risks (see: Cherry, Crocker, and Shogren, 2003; Settle and Shogren, 2006; Kivi and Shogren, 2011).

While the experimental results suggest preference reversals can be reduced with arbitrage it is unclear how practical and useful this method is in valuation. Its previous uses will be considered. Also uncertain is whether it can work for the double bound dichotomous choice (DBDC) method, the most popular WTP elicitation method in use today. This possibility is outlined.

## Background: Preferences, Valuations, and Arbitrage

One method of decreasing preference reversals (PRs from here on) is through a process known as arbitrage. Consider a financial market example where online transaction software asks you for your preferences between two stocks, E and F, and your bids (buy prices) and asks (sell prices) *for one share of each*. Assume that you exhibit a PR: you indicate that you prefer E to F; your bid for E is $50 and ask is $60, and; your bid for F is $100 and ask is $120. What transactions might the software automatically make based on your preferences from this information? First, it may sell you F for your bid price of $100. Next, it will trade F for E since you prefer it. (Note a third party would be happy to make this trade, if your valuations are correct, since F is worth at least $100 while E is worth at most $60). Last, it will buy E back from you for your ask price of $60. What are the results? You have no shares of stock and $40 less wealth. You may argue that you would never be so naïve as to reverse your preferences in this context. That may be true but recall the experimental results above that PRs in experiments occur at an alarming rate. More importantly, if you did make this mistake, how would you respond if forced to repeat the whole exercise?

A similar process can occur with lotteries A and B by adding a clause. The respondent must agree to either buy or sell their lottery at the given valuation. Suppose I indicate a preference for A and list minimum selling prices of $3.80 for A and $8 for B. A savvy administrator would sell me B for $8, trade me B for A (note I should trade since I prefer A), and buy back A from me for $3.80. I have no lottery and lost $4.20. Again, if I am forced to repeat the whole exercise, which changes am I likely to make?

Although making a change to avoid arbitrage may seem practically simple, which changes are made may be very important. Notice from the lottery example that I could just switch my preference from A to B to avoid arbitrage. This switch prevents arbitrage and avoids a PR but could be troubling with regard to fundamentally understanding preferences. Alternative explanations exist in attempting to explain a preference switch.

### *Preference Switching*

One possibility for explaining preference switching is that stable preference orders do not exist. Kahneman, Ritov, and Schkade (1999) provide an experimental example based on punitive jury awards for two cases; one involving business fraud and another involving a flawed child-safety cap. Respondents were informed that compensatory damages had already been awarded in the amount of $500,000 for the personal injury and $10 million for the financial harm. Respondents only considering one case assessed punitive damages of $5 million on average (median) in the financial case and $2 million in the personal injury case. However, a large majority (75%) of those that judged the cases together switched the award ranking between the two; this lead to an average award of $2.5 million in the personal injury and $0.5 million in the financial harm case. Based on the context dependence of valuations the authors suggest an observation that "the hope of measuring preference by stated willingness to pay is unrealistic" (p. 221).

An alternative to the nonexistence of stable preference orders is that preferences can be discovered. The Discovered Preference Hypothesis states that repetition of unfamiliar tasks, such as non-market valuation, can allow for convergence to rationality (Plott, 1996). Plott and Zeiler (2005) performed experimental tests with different experimental controls (e.g. paid practice rounds, experience with the elicitation method, and anonymity) to determine if the experimental environment could affect the presence of a behavioral anomaly. An obvious case was to consider the sometimes found result that a subject's willingness to accept exceeds their willingness to pay for the same good. By implementing different experimental controls they were able to "turn on and off" WTA and WTP differences. Therefore, using controls such as best experimental practices from the literature (e.g. training on the elicitation mechanism) can influence whether the results conform to rationality. Braga and Starmer (2005) outline explanations for convergence to rationality and point to institutional learning, value learning, and repeated experience and choice heuristics.

***Value Switching***

The explanations of convergence to rationality from Braga and Starmer (2005) allow for more than just discovering preferences through institutional learning and repeated experience and choice heuristics. Another possibility is value learning. Recall my PR in lotteries A (initially preferred) and B (initially higher WTP than A). Instead of changing preferences, I might change my valuations. Specifically, if I truly prefer A to B the ways to avoid arbitrage would be to either increase my valuation of A, decrease my valuation of B, or both until WTA for A is higher than WTA for B. Therefore, my PR may simply be due to my lack of experience in risky good valuation.

Recall from the seller's perspective Lottery A has a 1/9 chance of paying out $0 and an 8/9 chance of paying out $4. Lottery B has a 8/9 chance of paying out $0 and a 1/9 chance of paying out $40. Assume my preference is truly A over B. If I sell Lottery A it is likely I will pay out $4 so I may make my valuation close to but less than that amount (since the other possibility is paying out $0). However, I may be very nervous about the possibility of paying out $40 in Lottery B. My initial WTA may be higher than the amount for Lottery A. Consider the example above with WTA for Lottery A = $3.80 and WTA for Lottery B = $8. After being arbitraged in this example, I am unlikely to significantly increase my WTA for A since it may be close to the maximum I would have to payout. However, in Lottery B there is an 8/9 chance of paying out $0. Upon further consideration of the high likelihood of paying out nothing, I may considerably lower my WTA for Lottery B. Imagine I set my WTA for Lottery B = $3. These values do not create a PR and cannot be arbitraged.

Therefore, my preferences between Lottery A and B might be well established. It is the lack of experience in risky valuation that created a PR. Experimental evidence suggests that this result may occur frequently. Cherry, Crocker, and Shogren (2003) gave subjects an endowment of money and used real money lotteries with and without arbitrage to test its efficacy in reducing the rate of preference reversals. The reversal rate without arbitrage was around 33% and did not reduce over the 15 rounds. The reversal rate with arbitrage began at about 33% and fell to between 5%-10% after ten rounds. The general pattern for subjects who stop reversing preferences was that they did not change their preferences, did not change their valuation of their preferred lottery, and did change their valuation of their non-preferred lottery. This suggests that some subjects may have stable preferences but need a process such as arbitrage to assist in learning how to value lotteries.

Convergence to rationality may be due to changes in preferences and values from various forms of learning. Next consider two methods that have been used to facilitate learning in valuation research.

## Applied Experimental Valuation Methods for PR Reduction

Two ways of reducing PR in valuation will be considered; indirectly reducing and directly preventing PRs. Applied examples from the literature are summarized. Both offer applied ways to reduce PR problems by utilizing combinations of survey and experimental techniques.

### *Indirectly Reducing PRs*

One method to deal with the PR problem is to try to indirectly reduce PRs with repetition and arbitrage. Cherry, Crocker, and Shogren (2003) demonstrated that learning from monetary arbitrage can "spillover" to environmental good valuation. The "spillover" effect is crucial since subjects would be likely to strongly object to their environmental good valuation being arbitraged.

Reconsider lottery C and D above where I consent to either buy or sell at my valuations. Imagine I prefer C but list my WTP for C= $100 and WTP for D = $300. The administrator sells me D for $300, trades me D for C, and buys back C from me for $100. After explaining what occurred, I am asked to pay $200 for my PR penalty. In a real world experiment there is no way to collect this $200 from me if I choose not to pay. After all, I agreed to do this survey out of good will and now I owe $200; I could literally run away from a face-to-face interview or shut down my computer for an online one. Similarly, few researchers could afford to give each subject $500 at the start such that the penalty could be credibly enforced by reducing respondent earnings to $300. The uncertainty around the magnitude of subjects' environmental good valuations and inability for the administrator to credibly follow-through makes monetary arbitraging of environmental good valuations impractical. Besides, the goal is not to generate revenue from participants but to generate accurate environmental good valuations. Therefore, any learning from the monetary lotteries through arbitrage must "spillover" to the environmental good valuations which will not be arbitraged.

Cherry, Crocker, and Shogren (2003) presented money and environmental good lotteries side-by-side (think of valuing A and B on the left side of the screen and valuing C and D on the right side) in their experimental program to test if arbitrage in the monetary lottery setting could decrease PRs in valuing the environmental good. Their results for hypothetical environmental good lotteries were similar for monetary lotteries. The presence of an arbitraged monetary lottery decreased the rate of PRs in the side-by-side hypothetical environmental good lottery from about 30% to 12% after ten rounds. The reduction in the PR rate from arbitrage for monetary and hypothetical lotteries has been replicated under more difficult conditions including having no real monetary consequence (just description of arbitrage process) and very low probability events (see Cherry and Shogren, 2007; Kivi and Shogren, 2011).

### *Directly Preventing PRs*

Another method of reducing PRs in valuation is to force them not to occur. While a method may insure consistency between preferences and valuation bids, it need not force homogeneous preferences. Norwood and Lusk (2011) used a "paternalistic" approach to allow for wide ranging preferences regarding goods with similar attributes (e.g. eggs with price and six animal welfare attributes) while forcing rationality between preferences and bids for those goods. Their calibrated auction-conjoint method (CACM) used a preference elicitation mechanism for determining the importance of each of the good's attributes as a percentage. Once these preferences were initially determined, respondents were asked to bid on a dozen eggs from one production system (e.g. cage). Based on the initial preferences and the bid, the method automatically generated "intelligent guesses" for bids of the other production systems (e.g. free-range organic). Respondents were encouraged to change the bids if they wished and instructed that the way to do so was to change at least one measure of preferences, thereby always insuring consistency between preferences and bids. Once the subjects were comfortable with their bids for a dozen eggs from each production system, they were submitted to an auction that used a Becker-DeGroot-Marshack (BDM) mechanism.

***Open-ended Valuation***

The two methods above were effective in reducing PRs, one by force and the other indirectly. While these studies are promising for the use of experiments in valuation they do not address a common problem in valuations surveys. It has long been argued that asking people to provide an exact dollar amount in valuing an environmental good is impractical (see for example, NOAA, 1993). For example, the once popular open-ended contingent valuation method (CVM) directly asks for a specific WTP/WTA amount. Although this task may seem simple, economic theory requires the household to consider its income and think of the possible ways it could be spent with the goal of achieving the highest level of satisfaction from that limited resource. In general, the use of open-ended valuation questions is discouraged. While training and repetition may facilitate the types of learning discussed in Braga and Starmer (2005), it is unclear whether these techniques are sufficient in enabling subjects to provide precise WTP estimates.

In response to the open-ended valuation problem a common approach is to ask the respondent to provide a "yes" or "no" answer to a specific value (a.k.a. dichotomous choice CMV); would your household be willing and able to pay $20? This type of decision is thought to be much less burdensome since the respondent does not need to know their precise value only whether or not it is above/equal or below the listed amount. Note that the economist does not receive the actual value desired. In an attempt to get closer to the respondents' true value a method referred to as double-bounded dichotomous choice (DBDC) CVM was created by asking a follow-up WTP question. If the respondent answers "yes" a new question with a higher WTP is presented and vice versa. Several studies have found this advantageous in increasing statistical efficiency (see seminal study by Hanemann, Loomis, and Kanninen, 1991).

However, questions remain about whether multiple WTP questions create starting point bias and inconsistent WTP estimates (see for example; Caron and Groves, 2007). There is a growing literature that repetition of similar dichotomous choice WTP questions can reduce some bias concerns. Bjorstad, Cummings, and Osborne (1997) found that including hypothetical and real dichotomous choice questions on a similar good in advance of the final good decreased hypothetical bias of the final good estimates. Bateman et al. (2008) found that repetition reduced the inconsistency between the single and double-bounded valuation estimates and reduced starting point bias.

## Double Bounded Arbitrage

Double bounding also allows for the ability to arbitrage. This can be done through implied values based on the "yes" and "no" respondent answers. Subjects would agree to buy at the highest WTP "yes" value: note this value is at or below their maximum willingness to pay so they should agree without hesitation. Subjects would also agree to sell at their lowest WTP "no" value: note this is consistent with selling above their maximum WTP. Agreeing to sell above their maximum

WTP is even less restrictive than the typical experimental arbitrage clause that subjects will buy or sell at their maximum WTP.

Consider an illustrative example using lottery A and B. I agree to buy or sell at my maximum WTP. The lotteries are presented to me from the buyer's perspective followed by questions about my preference and WTP for each. Imagine I answer each question as follows:

| Lottery A | | Lottery B | |
|---|---|---|---|
| Chance | Outcome | Chance | Outcome |
| 1/9 | $0 | 8/9 | $0 |
| 8/9 | $4 | 1/9 | $40 |

1. Do you prefer Lottery A or Lottery B? Answer: *Lottery A.*
2. Are you WTP $2 for Lottery A? Answer: *No.*
3. Are you WTP $1 for Lottery A? Answer: *No.*
4. Are you WTP $5 for Lottery B? Answer: *Yes.*
5. Are you WTP $7.50 for Lottery B? Answer: *Yes.*

Notice I prefer Lottery A but am not willing to pay $1 for Lottery A; I do not prefer Lottery B yet I am willing pay at least $7.50 for Lottery B. This is a PR and it can be arbitraged. The administrator will sell B to me for $7.50; note this amount is at or below my maximum WTP. The administrator will switch B for A (since I prefer it). The administrator will buy A from me for $1; note this is above my maximum WTP for A (recall I agreed to sell at my maximum WTP). I have no lottery and lose $6.50 from the arbitrage process. If you work through all of the possible subject responses to the $2 and $5 starting values with Lottery A being preferred, 50% can be arbitraged (8/16 assuming starting bids are increased/decreased by half for the follow-up bids).

It might be argued that selecting a starting Lottery A value below that of Lottery B is setting the respondents up to fail. While this initially seems like a negative, it may very well be a positive. First, it does not force a preference reversal (only 50% of possible responses) but makes those who understand take notice of how high the value for Lottery B is set. Subjects will respond either by thinking it through or reversing preferences.

Second, quick failure-based learning through arbitrage may be exactly what is desired if this type of exercise is to be added into a valuation process. Without arbitrage in the money lotteries there was no decline in the rate of PRs across repetitions in Cherry, Crocker, and Shogren (2003). Therefore, delaying those who will make preference reversals from doing so only adds to the repetitions required to complete the survey with consistent preferences. Also, since subjects will need to be endowed a monetary balance at the beginning of each round to participate in the binding money lotteries, adding more rounds may increase the expected payouts to subjects and therefore reduce the sample size that can be afforded by a fixed research budget.

## Discussion and Extension

An intuitively appealing idea is to try to add the DBDC valuation elicitation method to parts of the methodologies used in Norwood and Lusk (2011) and Cherry, Crocker, and Shogren (2003). One possibility would be to start with monetary lotteries. One version could force consistent preferences similar to Norwood and Lusk (2011). Another version could use arbitrage in an attempt to indirectly reduce PRs similar to Cherry, Crocker, and Shogren (2003). Subjects could be given induced values and the "force" verses "arbitrage" versions could be tested to determine which is most accurate in obtaining preferences and values that are consistent with the induced value.

Reconsider the example above with induced values of $3 for Lottery A and $2.50 for Lottery B. Without forcing consistent preferences or including arbitrage the DBDC method could lead to many potential outcomes including relatively severe PRs. In the example above, the preferred Lottery A is valued below $1 while Lottery B is valued at or above $7.50. From a policy perspective, this is very troubling as the strong preference signal is toward Lottery B while Lottery A is preferred. The same is true of the other PR possibility where Lottery B is preferred but Lottery A valued higher. PRs are not expected to decrease with repetition without some type of intervention.

| Lottery A<br>Induced Value = $3 | | Lottery B<br>Induced Value = $2.5 | |
|---|---|---|---|
| Chance | Outcome | Chance | Outcome |
| 1/9 | $0 | 8/9 | $0 |
| 8/9 | $4 | 1/9 | $40 |

Consider the forced approach using Lottery A and Lottery B with the given induced values. Imagine I indicate preference for Lottery A, choose “no” for WTP for A = $1, and “yes” for WTP for B = $7.50. The forced approach would instruct the subject to change the preference or at least one initial answer to the WTP questions. If the subject changed one or both WTPs such that the WTP for Lottery A was higher, the preference and bids would be consistent and these would also be consistent with the induced value. If the subject changed the preference to Lottery B, the preferences and bids would be consistent but would go against the implied preference given by the induced value. Therefore, the forced approach may be consistent between the selected preference and WTPs but inconsistent with respect to the induced value.

Another potential problem with DBDC is that not all PRs will be detected. Again, imagine I indicate preference for Lottery A. I may choose “yes” to WTP for A = $2 and “no” to $4. Therefore, my indicated WTP for A is bounded by [$2, $4). I may choose “no” to WTP for B = $5 and “yes” to WTP for B = $2.5. Therefore, my indicated WTP for B is bounded by [$2.5, $5). Since these ranges overlap it is unclear whether the WTPs are consistent or whether a PR has occurred. I may have wanted to set WTP for A = $2 and WTP for B = $4, however the choice limitations have prevented my PR from being known. Therefore, the information limitation makes always forcing consistency difficult.

Now consider the arbitrage approach. Similar issues present themselves as the forced approach. Switching the WTP amounts prevents a PR and creates consistency with the induced value. Switching the preferences prevents a PR but creates inconsistency with the induced value. Also, the double bound arbitrage approach will likely not catch all PRs as in the example above.

It may be interesting to add a Likert scale to assess the degree of preference (e.g. neutral, slightly, moderately, strongly) and guide the feedback to the subject. For example, subjects that choose A to be strongly preferred to B but list higher WTP for B could receive a reminder that A was selected as strongly preferred as a type of cheap talk for either the forced or arbitrage approaches.

The DBDC forced and arbitrage ideas should undergo testing before being implemented in a CVM designed to inform policy. First, they should be tested only with money lotteries to determine their power in reducing PRs relative to the open-ended question results in Cherry, Crocker, and Shogren (2003). Second, they should be tested with side-by-side money and environmental good lotteries. These tests could help shed light on how subjects will respond to the mechanisms and their advantages and disadvantages in applied settings.

## Conclusion

Preference reversals have been on the minds of economists and psychologists for many years. Yet the reason why they occur is still unclear. Lab experiments have helped identify the PR problem and provided some measures of its extent. Also, experiments have suggested some ways to reduce PRs. Most of these include some type of learning possibilities such as training and repetition as part of the elicitation method. While some applied studies have combined experimental and survey techniques, this method is not in widespread use and has not been adapted for the most commonly used valuation method today. The popular double bound dichotomous choice format can be included in techniques designed to reduce PRs directly or indirectly. Thoroughly testing the double bound dichotomous choice format with forced preference and bid consistency and/or arbitrage could help determine the efficacy and practicality of its applied use.

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