Economics Bulletin

Volume 33, Issue 2

Debiasing the Becker – DeGroot – Marschak valuation mechanism

David de Meza
London School of Economics

Diane Reyniers
London School of Economics

Abstract

This experiment finds that the Becker-DeGroot-Marschak (BDM) (1964) valuation mechanism under-predicts the proportion of subjects choosing cash over an item. The extent of the divergence is increasing in risk aversion, which is consistent with reference dependent preferences. This suggests a reframing of the BDM to improve its performance. The modified BDM mechanism is found to better match choices at a single offer price (SOP).

We are grateful to Vedran Hurem for conducting the experiment. Dan Ariely, an anonymous referee and an associate editor provided very helpful comments.
Citation: David de Meza and Diane Reyniers, (2013) "Debiasing the Becker – DeGroot – Marschak valuation mechanism", *Economics Bulletin*, Vol. 33 No. 2 pp. 1446-1456.
Contact: David de Meza - d.de-meza@lse.ac.uk, Diane Reyniers - d.j.reyniers@lse.ac.uk.
Submitted: October 09, 2012.   **Published:** June 14, 2013.

1.Introduction

Market and economic researchers sometimes need to find the value that buyers and/or sellers place on items, especially new or unpriced goods. Economists are reluctant to just ask. Expressed values can diverge considerably from revealed preference measures of what people actually value. For example, Todd, Penke and Fasolo (2007) compare the results of a survey of what men say they look for in a date with their very different actual speed dating choices. Similarly, Noussair, Robin, and Ruffieux (2004b) find that when surveyed, people express strong aversion to buying GM food but when faced with the opportunity to buy GM, actually do so at low discounts relative to non-GM produce.

Rather than presenting subjects with hypothetical choices, it is obviously better to use market data. There are two drawbacks. First, market price is endogenous, giving rise to a classic identification problem. Even if potential instruments are available, it is impossible to know their adequacy. Second, for many items there is no market, or else price may not have varied sufficiently over the relevant period. Experiments are an alternative way of proceeding. Suppose the question is by how much demand for an item will fall if price rises by 10%. Half the subjects could be chosen at random to be charged the lower price, half the higher. The proportion buying at the two prices is then compared. A less obvious but more common approach to estimating demand experimentally is to use the Becker-DeGroot-Marshak (1964) (BDM) mechanism, a version of the Vickrey (1961) auction, to elicit valuations. Subjects express a point willingness to accept (WTA) or to pay (WTP) according to rules that penalise misrepresentation. If subjects behave according to expected utility theory, then for every subject it is revealed whether they would buy at any specified price.

The lure of the BDM is that relative to directly observing binary choice, far more demand information is potentially obtained. The possible drawback back is that it is an indirect method of estimating the choices that are actually of interest and its validity rests on a number of assumptions. In particular, the BDM mechanism is vulnerable to at least three problems:

a) Reference dependent preferences. Following Karni and Safra (1987), Horowitz (2006b) shows that unless expected utility theory applies, BDM may not be incentive compatible. For example, naming a high WTA ensures the subject ends up with the item, eliminating the possibility of disappointment when the draw is made. So the lottery aspect of BDM may distort the elicited valuations.

More explicitly, the BDM mechanism asks the agent to name a valuation,v^*, of the item. A price, p, is then drawn from a distribution with support $\left[\underline{p}\,,\overline{p}\right]$, pdf $f(p)$ and cdf $F(p)$. If $p < v^*$, the agent gets the item and if $p \geq v^*$ the agent gets payment p. Suppose the individual actually values the item at v in the sense that if offered a choice between a payment of v or the item, the agent would be indifferent.

Assume a simple but commonly used representation of a loss-averse utility function

$$U = \begin{cases} Y(1+\gamma) - \gamma R & if\ Y < R \\ Y & if\ \ Y \geq R \end{cases}$$

where R is the reference income and $\gamma > 0$, which captures the magnitude of the kink between the gain space and the loss space, has been found to be about unity (Tversky and Kahneman, 1991). The usual criticism of loss aversion is that it does not provide a theory of the reference point. Here we follow Koszegi and Rabin (2006) and adopt an endogenous reference point formulation. Decision makers feel they are in the loss space if their realisation is worse than expected. This is implemented as in de Meza and Webb (2007) by assigning an outcome to the loss space if the chance of something better occurring is more than 50%.

The payoff to two strategies will be compared. Either v^* is set equal to v or alternatively it is set equal to $\widehat{p} > v$ where $F(\hat{p}) = 0.5$. Under "truthful" reporting, the median outcome involves taking a cash payment of $\widehat{p} = R$. The payoff to a truthful report is therefore

$$EU^v = \int_v^{\overline{p}} f(p)pdp + \int_{\underline{p}}^{v} f(p)vdp - \gamma \int_{\underline{p}}^{v} (\hat{p} - v) f(p)dp - \gamma \int_v^{\hat{p}} (\hat{p} - p)\, f(p)dp \quad (1)$$

which is decreasing in γ. Now suppose that the valuation is “misreported” as $v^* = \widehat{p}$. Then, whenever the price drawn is $p \leq \widehat{p}$, the agent obtains the item. The reference payoff is therefore v and the payoff is never in the loss space. The payoff to this strategy is

$$EU^{\hat{p}} = \int_{\underline{p}}^{\hat{p}} f(p)vdp + \int_{\hat{p}}^{\overline{p}} pf(p)dp \quad (2)$$

It is not possible to rule out $EU^v < EU^{\hat{p}}$. Here is an example. The price distribution is uniform with support [9,11]. $v = 9.5$ and γ =1. Then $EU^v = 9.875 < 10 = EU^{\hat{p}}$. This shows that Prospect Theory preferences imply that it may not be optimal to report v under the BDM mechanism. The extent to which the elicited WTA diverges from v depends on γ. So if loss aversion is present, WTA and γ will be correlated. Of course γ is not directly observed but it has implications for preferences over lotteries. Consider a lottery that pays an amount equal to the price draw. The expected payoff is therefore

$$L = \int_{\hat{p}}^{\overline{p}} f(p)pdp + \int_{\underline{p}}^{\hat{p}} f(p)pdp - \gamma \int_{\underline{p}}^{\hat{p}} f(p)(\hat{p} - p)dp \quad (3)$$

which is decreasing in γ. Whether the lottery is preferred to a fixed payment of F (which has expected payoff of F) is therefore dependent on γ, just as is the WTA elicited by the BDM.

Under expected utility (or any representation that preserves independence) the WTA elicited by a BDM is uncorrelated with choices over lotteries, but with reference-dependent preferences, as in Prospect Theory, WTA under BDM will be higher for more loss-averse types and they will also be more inclined to choose the safe option over a risky lottery.

b) Price anchors. Subjects may not have well-articulated preferences over unfamiliar products and focus on some salient but incidental feature in evaluating it (Lichtenstein and Slovic, 1971). In Ariely, Loewenstein and Prelec (2003), subjects write down the last two digits of their social security number and WTP is increasing in the magnitude. When shopping, the obvious valuation anchor is price itself. Perhaps there is an underlying assumption that you get what you pay for, or it may be a matter of anchoring on whatever is focal. In either case, valuation is endogenous to the market process. If the aim is to predict demand, a BDM mechanism that eliminates the anchor of an asking price may generate misleading results. Bohm, Linden and Sonnegard (1997) find valuations depend on the announced distribution from which the BDM prices are drawn suggesting this serves as an anchor. Mazar, Koszegi and Ariely (2009) replicate this finding and present further tests indicating prices influence preferences, but BDM valuations are not compared to choices at a single offered price, SOP.

c) Mechanism Misconception. Subjects may not understand that stating their true valuation in BDM is a dominant strategy. In the WTA (WTP) setting, they may wrongly think there is strategic value in reporting a higher (lower) valuation. These possibilities are explored in Cason and Plott (2012) using an induced-value specification. They assemble persuasive evidence that the BDM tends to elicit excessive WTAs. This overvaluation reduces with repetition, suggesting that learning is involved. Nevertheless, even after the second round, fewer than a third of subjects bid close to the induced value. It is not obvious why misunderstanding is consistent with risk preferences being correlated with the BDM WTAs. Possibly, subjects have some awareness that they might not have fully understood the mechanism, then playing safe by choosing a high WTA may be best, as then you know whatever happens you will get the item.

This paper reports a between-subject experiment that finds that the valuations elicited by a BDM mechanism tend to exceed the valuations implied by the choices made when subjects face a fixed price for an item.[1] This casts doubt on the usefulness of BDM as a method of estimating demand. The finding that BDM generates WTAs that depend on risk preferences is consistent with non-expected utility theory and with mechanism incomprehension. Moreover, stated valuations depend on the SOP offer that subjects are presented with, indicating anchoring on the offer price. These results suggest that a simplified version of

[1] In a field experiment Berry, Fischer and Guiteras (2011) find that BDM elicited willingness to pay understates demand at a single offer price, which is consistent with reference dependent preferences. Horowitz (2006a) surveys other tests of BDM. None compare "home grown "values" (that is valuation of non cash items) with SOP choices or examine the role of risk preferences.

BDM that deemphasises the lottery aspect and more closely resembles market offers may better predict SOP choices. The reframed BDM (RBDM) used by Loewenstein and Adler (1995) is a plausible candidate. Subjects make a series of choices of the form, "would you prefer £x or the item?" with x increasing in successive rounds. Prior to making these choices, the subjects are told that one of the questions will be drawn at random and they will get what they chose in that question.

Although RBDM is itself a lottery and picking the item in more choices reduces risk, so as in BDM, the subject can guarantee they walk away with the good, it does not follow that the two mechanisms are perceived in the same way. The RBDM framing may encourage subjects to regard each question as a self-contained choice.[2]

The RBDM does indeed track SOP choices better than the BDM. Whatever the reason for this, our results suggest that it may be a more effective method of estimating demand curves than BDM.

The next section explains the method. Then results are discussed. Finally, brief conclusions are drawn.

2. Methodology

The experiment was conducted over a two-week period in 2008. Students were approached on an LSE walkway and told that subjects were being recruited for a research project.[3] Those willing to participate immediately undertook one of the procedures. Interaction with subjects was standardised, and scripts were used for each treatment. Subjects were shown a candle, told it was handmade from beeswax and were allowed to touch and smell it if they wished. The subject was presented with written instructions and could ask for clarification. After valuation choices were written down, demographic information was collected.

The relatively risk tolerant subjects were identified by answers to a hypothetical choice between £1,000 or a fifty-fifty chance of £4,000 or £0. Although Holt and Laury (2002) report evidence that hypothetical choices underestimate risk aversion relative to paying a randomly selected choice, bias does not affect the tendency of those selecting the safe option to be more than averagely risk averse. Irlenbusch, de Meza and Reyniers (2010) do indeed find that a similar hypothetical question significantly predicts the purchase of experimental and real insurance.

In all treatments, subjects chose between cash or a candle. This framing is objectively identical to giving a subject a candle then asking what they would accept for it, but there may

[2] Starmer and Sugden (1991), Beattie and Loomes (1997), and Cubitt, Starmer and Sugden (1998) provide mixed evidence on whether embedding binary choices in a random lottery design (which resembles the RBDM formulation), affects outcomes. Even if there is an effect, it may be smaller than is created by the BDM framing.

[3] The investigator had discretion over whom to approach, so selection will not have been random. For example, those appearing to be in a hurry were not stopped. This does not invalidate the identification of treatment effects since any bias in recruitment would have been the same for all treatments.

be psychological differences. The latter formulation seems more likely to engender an endowment effect, so we are minimising the opportunity for non-standard preferences to play a role. Moreover, in presenting the subjects with cash or item, WTA is more advantageous for subjects than a WTP opportunity, so encourages participation whilst avoiding the house money effect of a participation fee.

There were three treatments:

***a)* BDM**

Subjects were asked to write down the monetary payment they regard as equally preferred to receiving the candle. It was explained that they would then draw a chip out of a bag with a monetary value on it. If the valuation they had stated was higher than the value on the chip, the subjects would receive the candle. If it were lower, they would be paid the amount on the chip. They were told that it was in their best interest to state their true valuation for the candle. This reminder was printed in capitalized, bold and underlined letters so that participants would pay extra attention when reading it. Subjects then wrote their valuation, completed the questionnaire and finally drew one of the chips and were paid off. The chips increased in 30 pence increments from zero to £ 4.20. Subjects were not given information on the range of prices beforehand in order to avoid anchoring. None of the participants asked about the range from which price would be drawn.

***b)* RBDM**

Subjects were presented with a table comprising a series of binary choices. Each row asks which would be preferred, the candle or a cash payment. The monetary payment ascends in value from top to bottom.[4] A letter marks every row. The participant is told that following their choices, they will draw a chip from a bag. Every chip is marked with a letter, which indicates a question on the form. The subject receives the choice he has made in the question drawn.

The monetary amounts in treatment RBDM*l* had a range of £0.00 to £3.00, ascending in £0.30 steps from top to bottom. In treatment RBDM*h* the amounts also ascended in £0.30 steps, but from £1.00 to £4.00. In both treatments there was an underlined and boldly printed sentence that only one alternative in each line should be chosen. As in all other treatments, the subject is instructed orally as well.

***c)* SOP**

SOP asks the participant “Do you want to receive the candle or £X?” In SOP*l*, subjects were offered £1.00 and in SOP*h* the alternative to receiving the candle is £3.00. After each of the SOP treatments, participants were asked for a hypothetical valuation of the candle. The wording is the same as the first part of the BDM instruction simply asking the subject how much money would be as good as being given the candle. This hypothetical question was asked after the SOP question in order not to bias participants when they answer the SOP question. Of course answers to the hypothetical question may themselves be influenced by

[4] Starting low may anchor WTA to low values. Reversing the sequence might affect the results.

the SOP offer. According to standard theory there is no reason that the two hypothetical valuations, H*l* and H*h* would differ. If they do, this is some evidence that even in the SOP case preferences are constructed.

3. Results

Table 1 provides descriptive statistics. The distribution of characteristics across the treatments is well balanced. BDM valuations are highest. RBDM demands and valuations are always greater for the treatment when the range of price alternatives is shifted up. Likewise, stated valuations (H) are higher following a SOP of £3 than of £1. These results suggest that subjects may judge worth by price.

Table 1: Subject characteristics and valuations by treatment

Treatment Type	RBDM*l* (£0 to £3)	RBDM*h* (£1 to £4)	BDM	SOP (£1)	SOP (£3)	TOTAL
Number of participants	51	50	50	50	51	252
Average age	24	23	24.1	23.8	22.5	23.5
Male (%)	47.1	52	52	52	52.9	51.2
Risk taker	32	28	38	38	33	35
Median valuation (£) [5]	0.98	1.57	2.10	0.58	1.18	1.11
Mean valuation (£)	1.05	1.56	2.64	0.99	1.64	1.57
% buying at £1	55	66	78	22		
% buying at £3	2	4	38		12	

[5]Median and mean prices for SOP treatments are computed from the hypothetical WTA questions.

To conduct formal tests of how the treatments compare to SOP, Table 2 reports OLS regressions of whether subjects buy at £3/£1. In the case of BDM and RBDM, a purchase is assigned as occurring if the elicited valuation exceeds the specified SOP price. The excluded category is the SOP decision, so the treatment dummies indicate the difference relative to actual behavior. In column (1), at £3, only BDM is significantly different (at the 1% level) with demand over three times the SOP level. BDM demand is also significantly above that in the RDBM treatments. Column (2) shows that the picture is somewhat different at £1. BDM demand is significantly above SOP demand, RBDM*h* demand comes next, then RDBM*l* , but all significantly exceed SOP demand and are not significantly different to each other. In the case of RBDM*h* the first choice is whether a candle is preferred to £1. It seems likely there is a strong framing effect here. Subjects do not feel inclined to take the cash when it is the lowest value option but believe that something intermediate must be an appropriate choice. When the range starts at zero, as in RBDM*l*, a price of £1 is closer to the middle of the range so demand is lower. Subjects avoid what are presented as the extreme alternatives (see Parducci, 1965).

Table 2: Mechanism effects

	(1) Buy at £3	(2) Buy at £1	(3) Valuation
BDM	0.26*** (3.16)	0.56*** (6.69)	
RBDMh	-0.08 (-1.98)	0.44*** (4.9)	
RBDMl	-0.1 (-1.45)	0.33*** (3.58)	
Hl			-0.65** (-2.44)
	R^2=0.17 N=202	R^2=0.17 N=201	R^2=0.06 N=101

Robust t-values in brackets, *** = significant at 1%, ** = significant at 5%, * = significant at 10%

Price dependent preference is also indicated by Column 3 of Table 2. Hypothetical valuation is regressed on a dummy for whether the subject was first offered SOP*l* or SOP*h*. Valuations are greater following the £3 SOP offer than after the £1 offer.

Table 3 reports demand at each price on the risk-taking dummy. Risk attitude is significant in BDM but in no other treatment. This provides some support for a reference dependent explanation of BDM behavior.

Table 3: Risk effects

	BDM		RBDMh		RBDMl		SOP	
	£1	£3	£1	£3	£1	£3	£1	£3
RiskTaker	-0.32*** (-2.54)	-0.44*** (-3.82)	-0.05 (-0.35)	0.48 (0.1)	0.11 (0.74)	0.03 (-0.1)	0.14 (1.18)	-0.11 (-1.33)
	n=50 r^2=0.14	n=50 r^2=0.14	n=50 r^2=0.002	n=50 r^2=0.003	n=50 r^2=0.01	n=50 r^2=0.01	n=51 r^2=0.02	n=51 r^2=0.02

Robust t-values in brackets, *** = significant at 1%, ** = significant at 5%, * = significant at 10%

4. Discussion

Estimating demand for a new product is most directly accomplished by running a series of between subject SOP treatments, each with a different price. The drawback is that, relative to BDM, this is an expensive procedure. By identifying a threshold price, BDM elicits demand at all prices in a single take. This is an advantage if the BDM valuations are consistent with SOP choices. Our evidence is that they are not. The BDM overvaluation of WTA, the correlation of BDM valuations with risk preference and the better performance of the RBDM is consistent with *i)* non-expected-utility theory applying to the lotteries implicit in BDM, *ii)* price itself being an ingredient in value formation, and *iii)* lack of comprehension of the BDM mechanism. Perhaps BDM may catch up with RBDM with paid training, but it is preferable to have a mechanism that does not require learning.[6] The standard selling context of a single take-it-or-leave-it price embodies its own price anchor which the BDM can never replicate. Whether the BDM fails for preference or understanding reasons remains an open question. It seems likely that both explanations are relevant. Demand at a particular price can only really be judged by offering the good at that price, but we find that the RBDM does a better job than the BDM in generating agreement with SOP choices.

References

Ariely, D., Loewenstein, G., & Prelec, D. (2003). "Coherent Arbitrariness": Stable Demand Curves Without Stable Preferences. *The Quarterly Journal of Economics* , 118, 73-105.

Becker, G. M., DeGroot, M. H., & Marschak, J. (1964). Measuring Utility by a Single-Response Sequential Method. *Behavioral Science* , 306 - 311.

[6]Plott and Zeiler (2005) find that after 14 repetitions the gap between willingness to accept and pay is eliminated but this is disputed by Isoni, Loomes and Sugden (2011). In an induced value setting (that is the item to be valued is cash) Noussair, Ruffieux, and Robin (2004a) find that WTP approaches the true value from below with repetition. Whether such "trained" individuals' BDM homegrown valuations would then coincide with their SOP choices is an open question.

Beattie, J. and Loomes, G. (1997). "The Impact of Incentives Upon Risky Choice Experiments?' *Journal of Risk and Uncertainty.* 14, 149-162.

Berry, James, Greg Fischer and Raymond Guiteras (2011) Incentive Compatibility in the Field: A Test of the Becker-Degroot-Marschak Mechanism, *mimeo*

Bohm, P., Lindén, J., & Sonnegård, J. (1997). Eliciting Reservation Prices: Becker-DeGroot-Marschak Mechanisms vs. Markets. *The Economic Journal* , 107, 1079-1089.

Cason, Timothy N. and Charles R. Plott, (2012). Misconceptions and Game Form Recognition of the BDM Method: Challenges to Theories of Revealed Preference and Framing, *Social Science Working Paper 1364, California Institute of Technology.*

Cubitt, R.P., Starmer, C. and Sugden, R. (1998) 'On the validity of the random lottery incentive system', *Experimental Economics* 1: 115–31.

de Meza, David, Irlenbusch, Bernd and Reyniers, Diane, (2010) Disclosure, Trust and Persuasion in Insurance Markets. *IZA Discussion Paper No. 5060*. Available at SSRN: http://ssrn.com/abstract=1648345

de Meza, David, and David C. Webb, (2007), Incentive design under loss aversion, *Journal of the European Economic Association* 5, 66–92.

Horowitz, J.K., (2006a). What do we know about the performance of the Becker-DeGroot-Marschak mechanism? *University of Maryland Department of Agricultural and Resource Economics Working Paper*.

Holt, C. A., & Laury, S. K. (2002). Risk Aversion and Incentive Effects. *American Economic Review* 92(5), 1644-1655.

Horowitz, J.K. (2006b) The Becker – DeGroot – Marschak mechanism is not necessarily incentive compatible, even for non-random goods. *Economics Letters*, 93, 1, 6-11.

Isoni, A., Loomes, G. & Sugden R. (2011) The willingness to pay–willingness to accept gap, the "endowment effect", subject misconceptions, and experimental procedures for eliciting valuations: a reassessment. *American Economic Review* 101, 2, pp. 991-1011(21)

Karni, E. & Z. Safra (1987) Preference Reversal and the Observability of Preferences by Experimental Methods. *Econometrica*, 55, 675-685.

Koszegi, Botond, and Matthew Rabin (2006) A Model of Reference-Dependent Preferences *Quarterly Journal of Economics*, 121(4): 1133-1166.

Lichtenstein, Sarah, and Paul Slovic (1971) "Reversals of Preference between Bids and Choices in Gambling Decisions." *Journal of Experimental Psychology* 89: 46-55

Loewenstein, G. and D. Adler (1995) A bias in the prediction of tastes, *Economic Journal* **105**, 929–937.

Mazar, N.; B. Koszegi & D. Ariely (2009) Price-Sensitive Preferences. *Mimeo UC Berkeley.*

Noussair, C.N., Ruffieux, B., & Robin, S. (2004a) Revealing consumers' willingness to pay: A comparison of the BDM mechanism and the Vickrey auction. *Journal of economic psychology, 25*(6), 725-741.

Noussair, C., Robin, S., & Ruffieux, B. (2004b). Do consumers really refuse to buy genetically modified food? *Economic Journal,* **114**, 102–120.

Parducci, A. (1965): "Category Judgment: A Range-Frequency Model", *Psychological Review*, 72 (6), 407-418.

Plott, C.R. & K. Zeiler (2005) The willingness to pay- willingness to accept gap, the "endowment effect", subject misconceptions, and experimental procedures for eliciting valuations. *American Economic Review*, 95, 3, 530-545.

Starmer, C. & R. Sugden (1991) Does the Random-Lottery Incentive System Elicit True Preferences? An Experimental Investigation. *American Economic Review*, 81, 971-978.

Tversky, Amos and Daniel Kahneman. (1991). "Loss Aversion in Riskless Choice: A Reference Dependent Model," *Quarterly Journal of Economics* 107(4), 1039-1061.

Todd P. M., Penke L., Fasolo B., Lenton A. P. (2007). Different cognitive processes underlie human mate choices and mate preferences. *Proc. Natl Acad. Sci.* 104, 15011–15 016.

Vickrey, W. (1961). Counterspeculation, Auctions, and Competitive Sealed Tenders. *Journal of Finance* , 16 (1), 8-37.