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Value Elicitation using BDM and a Discrete Choice Mechanism

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Abstract

We compare the Becker-DeGroot-Marschak (BDM) mechanism to a discrete choice mechanism for revealing willingness to pay (WTP) in a lab experiment. Differences in WTP disappear when considering only engaged bidders with non-zero bids. Only WTP elicited with BDM are sensitive to the variation of quantity offered to participants.

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1. Introduction

Eliciting willingness to pay (WTP) for one good may be altered by the presence or the absence of available substitutes during a lab experiment. Substitution among products poses a difficulty in designing a lab experiment, as a lab experiment usually requires a reduced number of possible choices so as to control the process of price determination or information revelation. Such a reduction may introduce biases. In particular, consumers' behavior in the lab differs from their behavior in their usual environment, in which they have to choose between numerous substitutes.

In most of lab experiments, WTP for a specific product/quality is evaluated through the rate of substitution between a quality parameter and income for a given product. Auctions or BDM mechanisms (Becker-DeGroot-Marschak, 1964) abstract from substitutes. However, substitutes should be considered also in the lab, since Lusk and Fox (2003) and Marette et al. (2008) showed that field valuations were greater than lab valuation.

Our paper tackles this issue and compares in the lab a classical BDM mechanism[1] with a mechanism detailed by Binswanger and Masters & Sanogo (BMS), namely a discrete choice mechanism that evaluates WTP by measuring the propensity of substitution between two goods (see Binswanger, 1980; Masters and Sanogo, 2002). Under the BDM mechanism, participants had to indicate WTP for an enriched yogurt with cholesterol-lowering properties. Under the BMS mechanism, participants had to choose between plain yogurt and enriched yogurt. It is shown that for a given quantity offered to consumers (i.e., a given number of cups), responses under both mechanisms are statistically indistinguishable after controlling for engaged bidders (those interested by the good with non-zero bids).

While several papers have compared auction mechanisms and BDM (e.g., Lusk et al. 2004), the comparison between BDM and alternative choice mechanisms has been overlooked.[2] Frykblom and Shogren (2000) compared open ended and discrete (dichotomous) choice questions. Our paper differs from this last paper, since we compared an open ended mechanism (the BDM) and a choice mechanism (the BMS) based on the quantity substitution between two goods, without testing any anchoring effect linked to difference in posted prices.

Our paper also contributes to the quantity variation in mechanisms for eliciting WTP. List and Lucking-Reiley (2000) show that, in a multiple unit auction, consumers lower their bids for an additional unit of a commodity. In our paper, we show that, when the quantity offered to participants increases, the per-unit values significantly decrease with the BDM procedure but not with the BMS procedure.

Section 2 demonstrates the theoretical equivalence of WTP evaluated using BDM and BMS. Section 3 introduces the experimental design and section 4 discusses the results. Conclusions are drawn in section 5.

[1] We chose the BDM for comparison, because it is deemed incentive compatible, and a relatively simple mechanism. It allowed a within group test of both mechanisms. A combination with an auction mechanism would have been to demanding. In addition, enforcement of BDM and BMS mechanisms does not depend on the degree of competition within the group..

[2] Auctions fit "scarcity" situations and not situations of mass consumption in supermarkets without quantity constraints. Auctions are tailored to scarce goods where the offered quantity is limited (fixed supply), while the BDM and the BMS are tailored to real situations where offered quantities may vary a lot (variable supply). The quantity offered under BDM and BMS may easily vary, which is not the case under auction mechanism (see List and Lucking-Reiley, 2000).

2. WTP in BDM and BMS

WTP is defined as the maximum amount of money that a consumer is willing to forego in order to receive a good. The consumer with income *Y* consumes two goods (types of yoghurts) A and B in quantities q_A and q_B and an outside good Z with price normalized to unity. The per-unit price of good *A* announced during the experiment is denoted by $\overline{p}_A$.The budget constraint results as $\overline{p}_A q_A + WTP_B q_B + Z \leq Y$, where WTP_B is the unknown WTP for one unit of good B.

In the BDM procedure the consumer indicates a WTP for a given bundle $\overline{q}_B$ such that (s)he is indifferent between receiving or not the good. With the utility function *U(.)*, WTP_B solves

$$U(q_A, \overline{q}_B, Z - \overline{q}_B WTP_B) = U(q_A, 0, Z). \quad (1)$$

The idea developed by Binswanger (1980) and Masters and Sanogo (2002) is to use respondents' choices to infer their relative preference and WTP. The BMS mechanism relies on the monotonicity of preferences and identifies the switching point by offering several choice situations to consumers. The mechanism is incentive compatible by randomly selecting one choice situation that is enforced at the end of the experiment.The quantity of product *B*, $\tilde{q}_B$, at which the consumer switches from a given quantity of product *A*, $\overline{q}_A$, to the choice of product B can be interpreted as the point at which the consumer reveals indifference, so that

$$U(0, \tilde{q}_B - 1, Z) \leq U(\overline{q}_A, 0, Z) \leq U(0, \tilde{q}_B, Z).^{3} \quad (2)$$

From the budget constraint and the definition of WTP, it follows that for $\tilde{q}_B$, the inequalities $WTP_B(\tilde{q}_B - 1) < \overline{p}_A \overline{q}_A$ and $WTP_B \tilde{q}_B \geq \overline{p}_A \overline{q}_A$ are satisfied. Rewriting, the per-unit WTP is approximated by

$$WTP_B \approx \frac{\overline{p}_A \overline{q}_A}{\tilde{q}_B}.^{4} \quad (3)$$

Hence, while the BDM evaluates the compensating variation in income for an additional bundle of good B, BMS derives a monetary value by the propensity of substitution between two goods.

3. The experimental design

We conducted the experiment in Paris, France, in February 2008 using enriched yogurts reducing cholesterol. The sample consists of 101 adults regularly consuming dairy products. We selected a plain yogurt (Danone Nature) and a yogurt enriched with sterols for their cholesterol-lowering properties (Danacol by Danone). Products were chosen to be as similar as possible (same brand, same weight, same packaging and same flavour (plain)).

The subjects were randomly assigned to two different groups. Subjects in the group "BDM first" ("BMS first") indicated their choices before and after health information, according to a BDM (BMS) procedure, and ended the experiment with a choice procedure based on the BMS (BDM) procedure. The group consisted of 54 (47) subjects.

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[3] Between (1) and (2) results will differ by an income effect as in the BMS consumers are endowed with $\overline{q}_A$ units of good A, which is not the case in the BDM. Given the small value of endowment, income effects should be negligible.

[4] The quality of approximation depends on the size of the initial endowment of good A.

In the BDM procedure, participants were asked to indicate the WTP for *Q* cups of yoghurt B (sterol enriched), knowing the retail price of *Q* cups of yoghurt A (plain). At the end of the experiment, if WTP is less (more) than the randomly drawn price, the participant could not (had to) purchase *Q* cups of yogurts B.[5]

In the BMS, participants were asked to choose between an endowment of *Q* cups of yoghurt A and a number of cups of yoghurts B (sterols enriched), varying from 1 to 2*Q*. The 2*Q* choice situations were presented on a single sheet of paper with 2*Q* lines to check off. For each line, they had to choose either $\bar{q}_A = Q$ cups of yogurt A or q_B cups of yogurt B with $q_B \in \{1,..., 2Q\}$. Despite differences, the BDM offers *Q* cups and the BMS starts with an endowment equivalent in quantity of *Q* cups. The choice sheet with 12 lines for exchanging the 6 cups of yogurt A was similar to the following truncated example with 3 lines (for saving space):

Situation 1	O 6 cups of Yogurt A	**or**	O 1 cup of Yogurt B
Situation k	O 6 cups of Yogurt A	**or**	O k cups of Yogurt B
Situation 12	O 6 cups of Yogurt A	**or**	O 12 cups of Yogurt B

The session started with a trial round explaining both choice mechanisms. Participants received €15 of indemnity. For both procedures (BDM or BMS), the retail price of 6 cups of yoghurt A was revealed to control for anchoring regarding prices. The choice #1 was conducted according to the initial choice procedure assigned to the group (BDM for group "BDM first" and BMS for group "BMS first") for *Q=6*, where *Q* is the offered quantity (see the figure 1).

Product names were announced and health information on Danacol was revealed. The information detailed benefits and potential risks of consuming yogurts with added plant sterols for reducing cholesterol. Then, choice #2 for *Q=6* was conducted using the initial choice procedure in each group. Choice #3 (using the same initial mechanism in each group) was realized after changing the quantity offered in the BDM and the endowed quantity of yoghurt A in the BMS to *Q=8*. The retail price of 8 cups of yoghurt A was revealed in both groups. Choice #4 was conducted according to the alternative choice procedure assigned to the group (BMS for group "BDM first" and BDM for group "BMS first") with *Q=6*. The retail price of 6 cups of yoghurt A was recalled before each round of choices.

The experiment concluded by randomly selecting one out of the 4 choices and then determining the choice situation or the product price that would be used for enforcing the choice during the experiment. Each participant bought/received the number of yoghurts linked to their WTP/selection in the randomly drawn choice situation.

4. Results

While the BDM mechanism directly reveals WTP for $\bar{q}_B$ cups, WTP is deduced from the choice mechanism in the BMS according to equation (3). If during the experiment, every $q_B^j \in \{1,...,2Q\}$ only satisfies $WTP_B \tilde{q}_B > \bar{p}_A Q$ (only yogurt B were selected in all 2*Q* situations on the choice sheet linked to BMS), we arbitrarily determined a value $\tilde{q}_B = 1$. If during the experiment no $\tilde{q}_B \in \{1,...,2Q\}$ observed for a respondent, the value is set at $\tilde{q}_B = 2Q+1$.

[5] The upper bounds of the price distribution were not announced for avoiding an anchoring effect on WTP (Bohm et al., 1997).

One important difference between the BMS and the BDM mechanism is that BMS provides (2Q+1) discrete possible WTP defined in equation (3) while BDM elicits potential WTP on a continuum. The possible WTP under BMS follows a hyperbolic function.

Table 1 and Table 2 compare both mechanisms showing WTP for 6 cups.[6] Statistical test use the Wilcoxon signed-rank (Mann-Withney-U) test for within (across) sample comparison. The Wilcoxon test accounts for the correlation of paired observations within sample. The difference between tables 1 and 2 concerns the presence or the absence of unengaged bidders, who offered zero under BDM for product B or who never chose product B under BMS (Lusk and Fox, 2003). Their share ranges between 39% and 75% in the respective subsample. In other words, table 1 considers all participants, while table 2 only takes into account engaged bidders who are interested in product B. For the comparison across samples, we also evaluate bids under BDM (BMS) (choice #2) with bids under BMS (BDM) at the end (choice #4) in the group starting with BDM (BMS).

Tables 1 and 2 exhibit minor differences across BDM and BMS mechanisms. Several WTP differences that are statistically significant in table 1 are not statistically significant in table 2. This difference may come from a bias linked to the BMS mechanism for unengaged bidders never selecting products B (Danacol), with a value arbitrarily determined with $\tilde{q}_B$=2Q+1, leading to a small but positive WTP of 0.484, while BDM indicates zero values. Note however, that in the BMS mechanism more participants tend to become unengaged in comparison to the BDM.

Tables 3 and 4 show the quantity impact on mechanisms coming from the comparison of choices #2 and #3. As BDM mechanism directly reveals WTP for Q cups, we divided the revealed WTP by Q for having the WTP per cup.

Results show that WTP is sensitive to a variation of the reference quantity Q in the BDM mechanism. Results are robust across tables 3 and 4 capturing different types of participants (engaged or not). By showing a WTP decrease when the quantity increases, the BDM mechanism is consistent with List and Lucking-Reiley's (2000) result showing that, in a multiple-unit auction, consumers lower their bids for an additional unit of a commodity.

For BMS, WTP does not significantly decrease with the increase of quantity Q. The insignificant shift in WTP under BMS is explained by the "minor" changes in participants' choices. As Q increases, the additional lines for the choice situation appear on the choice sheet. The point $\tilde{q}_B$ at which the consumer reveals indifference (see equation 2) only increases slightly, but it does not significantly influence the WTP determined by (3).

4. Conclusion

These results give support to the BMS mechanism as an alternative mechanism to other methods for evaluating willingness to pay. More studies are necessary for understanding the differences between mechanisms taking into account substitutability and discreteness/continuity of WTP evaluations (see Lust and Schroeder, 2006). The BMS confirms that the BDM leads to realistic/robust results for WTP estimations despite the absence of substitutes that is observed in studies using this BDM in a single-good context.

[6] Per-unit WTP from the BMS was multiplied by 6 to obtain WTP for the bundle.

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Figure 1. Timeline of Experimental Procedures

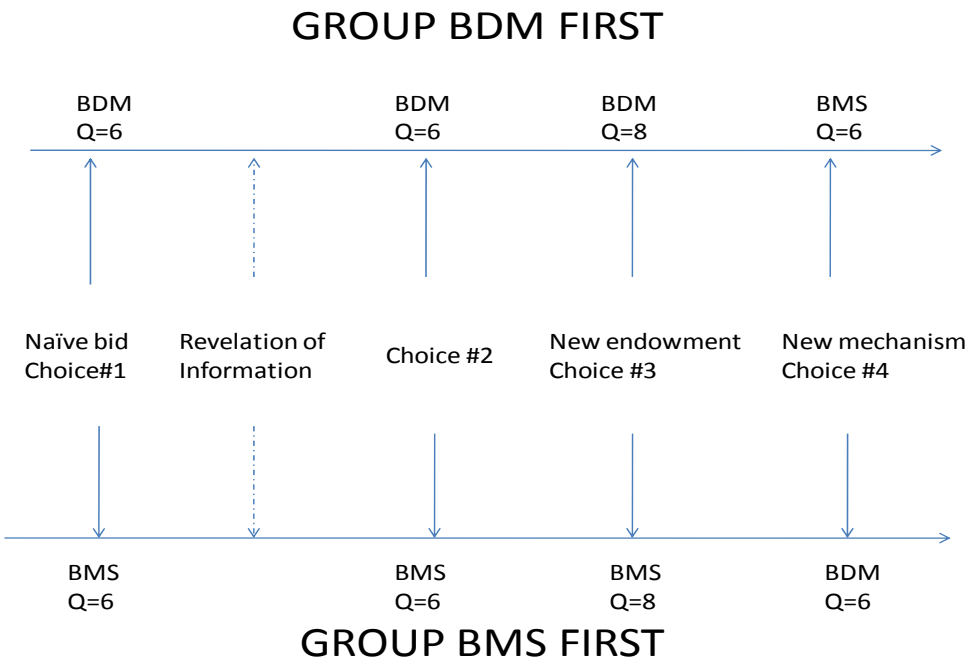

Table 1. Comparison of 6 cups WTP (€) for BDM versus BMS (all subjects) with *Q*=6

	Mean (std.dev.)			
Within Sample Comparison (Wilcoxon test)				
	Last BDM	**Last BMS**	**z-value**	**p-value**
Group Starting BMS Choices #4 and #2	0.635 (0.784) N=51	0.998 (1.172) N=49	-2.798*	0.005
Group Starting BDM Choices #2 and #4	1.116 (0.984) N=56	1.015 (0.918) N=54	-1.113	0.266
Across Sample Comparison (Mann-Witney-U test)				
	Group starting BDM	**Group starting BMS**	**z-value**	**p-value**
Choice #1	0.736 (0.691) N=56	1.451 (1.692) N=51	-2.003*	0.045
Choices #2	1.156 (0.984) N=56	0.998 (1.172) N=49	-1.800	0.072
Choices #4	1.015 (0.918) N=54	0.918 (0.784) N=51	-2.780**	0.005

Note: *N* is the number of participants taken into account. Within (Across) sample comparison by Wilcoxon (Mann-Whitney-U). H_0 : frequencies for a group = frequencies for the other group. ***** denotes rejection of H_0 at 5% significance level. ****** denotes rejection of H_0 at 1% significance level.

Table 2. Comparison of 6 cups WTP (€) for BDM versus BMS (engaged bidders) with $Q = 6$

	Mean (Std. Dev.)			
Within Sample Comparison				
	Last BDM	**Last BMS**	**z-value**	**p-value**
Group Starting BMS Choices #4 and #2	1.372 (0.621) N=20	1.668 (1.627) N=20	-0.121	0.904
Group Starting BDM Choices #2 and #4	1.610 (0.909) N=30	1.430 (1.067) N=30	-1.417	0.157
Across Sample Comparison				
	Group starting BDM	**Group starting BMS**	**z-value**	**p-value**
Choice #1	1.144 (0.518) N=36	1.816 (1.864) N=37	0.371	0.711
Choices #2	1.541 (0.831) N=42	1.491 (1.493) N=25	-0.468	0.640
Choices #4	1.380 (1.050) N=32	1.295 (0.623) N=25	-0.936	0.349

Note: The note in table 1 applies to table 2.

Table 3. Analysis of Scope, per-cup WTP (€), all subjects

	Choice #2 6 cups *Q*=6	**Choice #3 8 cups *Q*=8**	**z-value**	**p-value**
	Mean (Std. Dev.)			
BDM (N=56)	0.193 (0.164)	0.173 (0.125)	-3.304**	0.001
BMS (N=47)	0.170 (0.199)	0.163 (0.196)	1.886	0.059

Note: The note in table 2 applied to table 3.

Table 4. Analysis of Scope, per-cup WTP per cup (€), engaged bidders

	Choice #2 6 cups *Q*=6	**Choice #3 8 cups *Q*=8**	**z-value**	**p-value**
	Mean (Std. Dev.)			
BDM (N=42)	0.257 (0.139)	0.218 (0.108)	-4.808**	0.000
BMS (N=23)	0.259 (0.257)	0.234 (0.261)	-0.152	0.879

Note: The note in table 2 applied to table 4.