Diminishing Marginal Value

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Abstract

The notion of diminishing marginal value has had a profound impact on the development of neoclassical theory. Early neoclassical scholars had considerable difficulty convincing contemporaries of the new paradigm's value until political economists, including Jevons and Walras, used the critical assumption of diminishing marginal value to link utility and demand. While diminishing marginal value remains a key component of modern economic intuition, there is surprisingly little empirical verification of its existence or level. This paper gathers field data across a myriad of subject pools—from undergraduate students to PTA members to sportscard enthusiasts—to examine several aspects of preferences in both price and exchange institutions. Examining behavior of nearly 900 subjects across several treatments, we find strong evidence of diminishing marginal value.

Diminishing Marginal Value[1]

The assumption that having more of a good will lead an individual to place a lower value on an additional unit of that good – which we call diminishing marginal value – is a pervasive component of economists' beliefs about human behavior. Robert Frank, summarizing this intuition, writes that "the more one consumes of something, the less one is willing to pay to obtain more of it. Even a hungry person would be willing to pay less for a second sandwich than for the first."[2]

This concept was highly influential in the development of economic thought. Initiated in the 1870s, the "Marginalist Revolution" represented such a severe break from the prevailing approaches that many contemporaries reasoned that the new paradigm was "quackery" because it lacked a direct connection between utility and demand. Combining the critical assumption of diminishing marginal value with equivalent marginal utilities (per dollar spent) across goods, H.H. Gossen (1854) initially made this connection.[3] Jevons (1871) later independently developed his own results linking demand and utility, making use of diminishing marginal utility. Other figures in the Marginalist School also frequently appealed to diminishing utility; Walras wrote: "The want which we have for things, or utility which things have for us, diminishes gradually as consumption increases." Jevons wrote: "Each increment of food is less necessary, or possesses less utility, than the previous one."

This presumption of diminishing marginal value was based on its plausibility and intuition, not specific empirical evidence. Our goal is to fill this gap. This objective requires us to be more precise about what is being measured. Early writers wrote in terms of diminishing

[1]We thank Ted Gayer, Glenn Harrison, and John Worth for helpful comments.
[2]Frank suggests that this intuition applies to "ordinary" goods.

utility. In this paper, we look at diminishing marginal value (DMV) where value is measured in terms of either (i) money or (ii) another good that must be exchanged for the good in question. Note that the link between preferences and demand has been considerably refined since the nineteenth century; we focus here directly on the idea expressed by Jevons and Walras, which formed the germ of early economic progress.

To test for DMV, we conducted three types of experimental treatments. The first set of treatments uses a standard willingness-to-accept format and examines whether the compensation an individual requires to give up a unit of some good decreases when the individual has more of that good. This is a money-based measure of diminishing marginal value and it has the most general applicability. Economists are interested in knowing, for example, whether environmental improvements become more valuable as environmental quality deteriorates. Since an environmental improvement typically requires a "general sacrifice" that might best be measured in money terms, a money-based measure of diminishing marginal value (for "environmental quality") is most informative for making the necessary inference.

In a second set of treatments we examined subjects' willingness to trade one unit of an endowed good for one unit of another good. We gave our experimental subjects different amounts of the endowed good. Diminishing marginal value means that more individuals are willing to make a trade when they have more of the endowed good. This is a goods-based measure of DMV. This formulation comes closer, we feel, to the kind of exchange situation that the early writers envisioned. Furthermore, it enables us, with some additional experiments, to trace out a demand curve, thereby roughly following the early linkage.

The properties of the utility function are most interesting for public goods since these are

[3] Diminishing marginal utility came well before Gossen, however. For example, Bernoulli employed the concept to

goods for which demand curves are usually missing. Policy decisions should be made on the basis of the values that people place on the goods being provided; policies should be consistent with these values or, if this consistency were to fail, be reconsidered. In a dual sense, we can also look to policies to see the values that they imply. In this context, DMV manifests itself clearly in the U.S. in the Endangered Species Act, which places a high implicit value on a species when its population is low enough to be labeled "endangered," and a much lower implicit value when the population is above this threshold. DMV is also implicit in the Clean Air Act, which imposes stricter standards on plants locating in areas with high levels of certain air pollutants than in areas that meet ambient air quality standards; in other words, the lower the air quality, the higher the (implicit) marginal value of possible improvements (or deterioration).

In this regard, it is interesting to consider how non-DMV would manifest itself. The U.S.'s Office of Management and Budget, which issues guidelines for benefit-cost analysis, species a value-of-a-statistical-life that is identical across situations; that is, independent of the baseline mortality of the affected population.[4] This implies *constant* marginal value.[5] The Wilderness Act prohibits road-building in designated wilderness areas, which must be roadless to qualify for such designation. This is *increasing* marginal value: pristine areas are prohibited from receiving new roads, while highly-roaded areas are subject to additional roads with many fewer restrictions. The broader policy issue, and the one that underlies are our examination of DMV, is whether the (marginal) value of environmental quality goes up as environmental quality deteriorates. The alternative, non-DMV possibility is that people quickly adjust to any

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solve the St. Petersburg Paradox.

[4]These guidelines have been recently changed to specify benefits in terms of quality-adjusted life-years (QALY), but the value-per-QALY remains independent of the age of the population being affected.

[5]Constant-marginal-value policies present something of a dilemma for understanding of the prevalence of DMV – Do such policies reflect underlying preferences of the citizenry or are they better characterized as bureaucratic convenience?

deterioration of the environment, and that their willingness to pay for environmental improvement is unaffected by the "background" environmental quality.

Although a true policy-relevant field experiment is impossible to conduct, we designed a third set of treatments to test whether DMV is exhibited in a collective choice setting. In these treatments, subjects were endowed with one good and asked whether they were willing to trade it for one unit of another good; however, the trade would take place only if a majority of subjects agreed to it, and all subjects would be required to trade their good in that case. We tested for DMV by changing the endowment of the initial good for all subjects and examining whether more individuals were willing to vote to make the trade when they had more of the initial good.

The evidence we find for DMV is strong. In the money-based treatments, which elicited a continuous measure of value, *all* possible comparisons show a decrease in the value of the items as the endowment of the good in question increased. We find consonant results in the exchange treatments: increases in the endowment significantly increased subjects' willingness to trade part of it away (*i.e.*, the trading rate) in all of our treatments, in both individual choice and collective choice situations.

Previous research has largely been content to find demand curves that are consistent with an underlying utility function. What is at stake in our research is a more explicit connection between a utility-based view of behavior and a demand-based view. In Section 3 of the paper we report a set of demand-curve experiments that we then link to the DMV results using a specific utility function. If we allow for a reference-point effect, then these experiments show demand curves that are highly consistent with the DMV behavior we previously uncovered.

2. Experimental Design and Results

Our treatments fall into three categories based on whether value is measured in terms of money or another good and, for the goods-based experiments, whether there is individual or collective choice. Within each category, we statistically test for diminishing marginal value, using subjects who are randomly allocated into one treatment cell.

A. Treatments Involving Goods-Money Tradeoffs

Our first set of treatments was carried out with subjects in suburban Washington D.C. in the mid 1990's. We conducted seven treatments with thirteen different subject groups, all but one of which were local civic groups. Each group began with one of seven different endowments of goods consisting of mugs and flashlights. Each subject's compensation demanded (CD), also known as willingness-to-accept, was elicited for different parts of that endowment using an open-ended format, the Becker-deGroot-Marschak (BDM) mechanism. Our treatments are summarized in Appendix A.

Experimental Procedure. To illustrate the general approach, we describe the procedure for Treatment C in detail. Each subject was given one mug and three flashlights. We first asked subjects to consider selling back the mug. Each participant was asked to write down the minimum payment he or she would accept for selling the mug back to us; this is his compensation demanded. We then repeated the following BDM procedure three times for practice and then for a real transaction. The administrator drew an *offer price* randomly out of an envelope. If the subject's compensation demanded was higher than the offer price, the subject kept his mug. If his compensation demanded was less than or equal to the offer price, he returned his mug to us and received a check for the randomly drawn price. All subjects were offered the same price.

Next, we asked subjects to consider selling back their flashlights. Each subject wrote down the minimum payments he or she required to be willing to sell us back one, two, and three flashlights. We then randomly drew a piece of paper that stated the number of flashlights (per person) we would be buying back. Subjects were told each option had equal probability.

We then randomly drew the offer price. For example, we might first randomly draw the instruction to buy back two of each subject's three flashlights and then draw an offer price of $19.00. This is a price for the two flashlights, not a per-flashlight price. Subjects who had offered to sell two flashlights for $19.00 or less then turned in two of their flashlights and received a check for $19.00. They kept their remaining flashlight. Subjects who had offered to sell two flashlights for more than $19.00 kept all three flashlights and received no money.

In our experiments, subjects were not told the distribution of offer prices, a design feature that makes our mechanism different from the BDM mechanism as it is most frequently administered. In particular, we did not tell subjects what the upper limit of the distribution was, *i.e.*, the highest potential offer price. Concealing this information was useful to us for two reasons. First, it emphasized to subjects that distribution information should be irrelevant in their responses; that is, it helped reinforce our instruction that their best strategy is to determine and report their compensation demanded regardless of what they believe about possible offer prices. Second, it gives the subjects no information about what anyone else (*i.e.*, the experimenters) believes might be likely values for CD. The latter feature is obviously important in studying "true" preferences.

Although the BDM mechanism is theoretically incentive-compatible, questions have been raised about its performance. Harrison pointed out that the costs to subjects of not reporting their true values are small. Rutström found that values elicited by a slightly different version of the

BDM were different from English and Vickrey auctions, both also incentive-compatible. Such issues, however, should not be significant for examining differences in behavior across the same type of experiment, as done here.

Summary statistics are presented in Table 1. The table presents, for each treatment, the mean compensation demanded, standard error, and sample size. We used the procedures discussed in Horowitz and McConnell (2000) to identify responses that were likely not to represent true preferences; see Appendix A for the number of observations analyzed in each treatment.

Several treatments used endowments of two different goods as a way of helping subjects become familiar with the BDM mechanism, as the above discussion explains. Therefore, in these treatments we first test whether compensation demanded to give up a good depends on the endowment of the other good, rather than it depending just on the endowment of the same good, which is the essence of our DMV test.

In performing this test, we adopt the null hypothesis that the compensation demanded for a particular item is independent of the endowment of the other item. There are six tests: C versus G (CD for 1 mug); E versus F (CD for 2 mugs; CD for 3 mugs); E and F combined versus A (CD for 2 mugs; CD for 3 mugs); and D versus F (CD for 1 flashlight). Results strongly suggest we should not reject the null hypothesis; the t-values are 0.05, 0.04, 0.12, 0.35, 0.20, and 0.27, respectively. These results are consistent with the hypothesis that the compensation demanded for a good is independent of the endowment of other goods.

Results. Testing for diminishing marginal value relies on an examination of data between treatments. In each comparison, we test whether the mean compensation demanded for a good is lower in the treatment where the subjects have more of that good. We tested this hypothesis for the mean compensation demanded for one mug; two and three mugs; and one flashlight. Endowments were, respectively, one, three, or four mugs; three or four mugs; and one or three flashlights. Results are presented in Tables 2, 3, and 4.

The pattern of responses is clear. All five adjacent pairs of values show CD declining as the endowment increases, a clear demonstration of diminishing marginal value. The null hypothesis of no difference is rejected in three of six tests.

Results are even more striking in the individual treatments. There are eleven possible treatment comparisons: C vs. A, G vs. A, and A vs. B (one mug); A vs. B, E vs. B, and F vs. B (two and three mugs); and D vs. C and F vs. C (one flashlight). All eleven of these reveal compensation demanded decreasing in the endowment.

To examine the joint null hypothesis of no diminishing marginal value, we construct the following test. Suppose that in a comparison of any two treatments there is a 50-50 chance that one of the values (mean compensation demanded) will be higher than the other. In other words, consider a null hypothesis that when A is compared to B, the probability that {mean CD in treatment A} > {mean CD in treatment B} is ½; likewise, the probability that {mean CD in treatment B} > {mean CD in treatment A} is ½. Under the null, the probability that *n* independent comparisons will show {mean CD in lower-endowment treatment} > {mean CD in higher-endowment treatment} in all *n* cases is thus $(½)^n$.

To ensure that probabilities are independent, we compare any two treatments only once. This leaves seven possible pairs.[6] Under the null, the probability that we will observe diminishing marginal value in all seven is $(½)^7 = 0.0078$. Thus, the hypothesis of no diminishing

[6]These are C vs. A, G vs. A, and A vs. B (one mug); E vs. B, and F vs. B (two mugs); and D vs. C and F vs. C (one flashlight). Since all eleven pairs show diminishing marginal value, it does not matter which ones we include when restricting the test to only one pairwise comparison per treatment.

marginal value is rejected at the 99 percent level.

B. Individual Choice Treatments Involving Goods-Goods Trades

In an effort to provide a test of diminishing marginal value in a different setting, we recruited subjects from a real-world marketplace – the floor of a sportscard show in a large southern U.S. city in April 2001 – and observed their willingness to trade unique commodities.[7] This set of treatments is similar in spirit to the field experiments reported in List (2001). In the treatments reported in this section, we observe trading patterns of sports memorabilia and examine whether varying the initial endowment level influenced subjects' willingness to execute a trade.

The design is uncomplicated. A subject is initially given an endowment of good *a* (or *b*) and has the option to trade with the experimenter a fixed amount of that endowment for a specified amount of good *b* (or *a*). The trading rate is the proportion of participants who decide to execute the trade. A separate group of subjects is endowed with a higher amount of *a* and given the same opportunity to trade (1 unit of *a* for 1 unit of *b*; only one trade per subject.) Subjects exhibit DMV for good *a* if the trading rate is higher for subjects with a higher endowment of *a*. Note that this closed-ended format ("yes/no") is simpler than the open-ended format used by the BDM mechanism. Knetsch (1989) and Kahneman *et al*. (1990) have used similar mechanisms to test for endowment effects.

Our test uses two unique goods. Good *a* was a June 14, 1996, Kansas City Royals game ticket stub, which was issued for admission to the baseball game in which Cal Ripken Jr. broke the major league record for consecutive games played. Good *b* was an October 12, 1997, Tampa Bay Buccaneers game ticket stub, which was issued for admission to the football game in which

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[7]In a very different setting, Smith (1982) and Plott (1986) find that market institutions matter.

Barry Sanders surpassed Jim Brown to become the fourth all-time rushing leader in the history of the National Football League. We were fortunate to obtain these unique pieces of sports memorabilia in quantity because one of the authors attended the sporting events and collected the ticket stubs from in and around the stadiums. Although we have rarely seen the goods sold in markets, in certain regions (*e.g.*, Ripken in Baltimore and Sanders in Detroit) the stubs have sold for $40 each.

The procedure follows List (2001). The administrator asked subjects entering the trading card show if they would fill out a demographic survey that would take about 5 minutes. If the candidate subject agreed, then he or she was given an initial endowment as "payment" for completing the survey. Upon completion of the survey, the administrator retrieved the other good from under the table and informed the subject that she had the opportunity to trade. The subject was allowed to inspect both goods, after which she either made the trade or kept the original bundle. The endowment was changed at the top of each hour, so subjects' treatment was determined based on the time they visited the table at the card show. No subjects participated in more than one treatment. We summarize our experimental treatments in Appendix A.

Results. Trading rates are reported in Tables 5 and 6. Table 5 contains the results for subjects who started with the Ripken stub and had the option to trade for a Sanders stub. Table 6 contains results for subjects who started with the Sanders ticket stub.

Both sets of treatments show strong evidence of diminishing marginal value, as there is a substantial increase in trading rates when endowment levels are increased. When subjects had 1 unit of endowed good *a*, 9 out of 40 subjects (22.5 percent) will willing to trade for a unit of *b*. When subjects had 3 units of *a*, 31 out of 40 subjects (77.5 percent) were willing to trade one unit for one unit of *b*, a greater than tripling of the trading rate. Similar results occurred when *b* was the endowed good.

To test this observation more formally, we calculated Irwin-Fisher z-statistics (which are distributed normally) to determine whether the observed differences between the treatments are statistically significant. We find that in both comparisons {H vs. J} and {I vs. L}, the larger endowment induced a significantly higher trading rate at the $p < .01$ level ($z = -4.92$ for the Ripken endowment and $z = -5.42$ for the Sanders endowment). These results are consistent with those from the treatments using a goods/money tradeoff and suggest that DMV is prevalent across alternative choice situations.

C. Collective Choice Treatments

An understanding of DMV may have its most important implications for goods that are exogenously supplied, such as public goods. Consider the case of environmental policy, where the prevalence or lack of DMV seems particularly important. Suppose current environmental quality is q_0 and that deterioration of Δq can be prevented by a project that costs c, and that a majority of individuals is just indifferent to this tradeoff; they are willing to pay at most c to prevent this deterioration. Next, suppose that quality actually deteriorates to q_0-Δq. Under DMV, a clear majority of the public will now support this project (*i.e.*, be willing to pay c) to prevent any further deterioration (to q_0-$2\Delta q$). If DMV fails – say, if marginal value is constant – society might choose not to prevent this deterioration; that is, it might choose to *allow* deterioration when environmental quality is at a low level, even though it would have been just indifferent to preventing the same amount of deterioration when quality was at some higher level. In the case of increasing marginal value, a worsening of environmental quality would make environmental protection less valuable, rather than more. This pattern goes against economists' intuition about preferences, but is not far-fetched as a real-world reaction.

In this context, understanding individual behavior in a collective choice setting represents an important extension of the results presented above. To provide a test of DMV within this realm, we replicated the private good trading treatments with a collective choice analog. These treatments are identical in terms of endowments and feasible trades, as illustrated in Appendix A, but now the decision was cast in terms of the "funding" of a public good. If more than 50 percent of the subjects voted in favor of funding the public good, then all subjects had to turn in the requisite payment and the public good would be provided. If less than 50 percent voted in favor of the public good, then all subjects kept their initial endowment and the public good was not provided.

We were careful to design a public good that would share some of the important characteristics of public goods in the field. We therefore asked participants to fund "Mr. Twister," a small metal box placed at the front of the room. When Mr. Twister's handle is turned, it distributes one ticket stub. If the group chooses to fund Mr. Twister (*i.e.*, more than 50 percent of subjects vote to fund it), then all ticket stubs are turned in and the box's handle is cranked N (number of subjects in the room) times and N ticket stubs (of the other type) are delivered. Since it was necessary to have group decision-making, instead of running these treatments on the floor of the sportscard trading show we used an adjacent room in the same building.

Results. Results are presented in Tables 7 and 8. Again, there is strong evidence of diminishing marginal value. In Table 7, 14 out of 40 subjects (35 percent) voted to trade their one Ripken stub for one Sanders stub when their endowment was one Ripken stub. More than double that proportion (28 out of 35 subjects, or 80 percent) voted to make that trade when their initial endowment was three Ripken stubs. Similar behavior occurred when subjects started out with one or three Sanders stubs, as shown in Table 8.

We again calculate Irwin-Fisher statistics to test whether these differences are significant. We find that there is a significant difference in trading rates for both types of goods – subjects traded significantly more often when they were endowed with three units than when they were endowed with one unit (z = -3.92 for Ripken and z = -5.06 for Sanders).

D. Evidence from Willingness-to-Accept/Willingness-to-Pay

DMV is closely related to the relationship between willingness-to-pay and willingness-to-accept. To see the precise connection, let utility be $u(a,b)$ and let $\Delta > 0$ be a proposed change in the good. Consider the constructs:

(1) $$u(A,B) = u(A+\Delta, B-b_1)$$

(2) $$u(A-\Delta, B) = u(A, B-b_2)$$

From equation (1), b_1 is the amount of b the individual is willing to pay for Δ of a when her endowment is $\{A,B\}$; b_2 is the amount she is willing to pay for Δ when her endowment is $\{A-\Delta,B\}$. DMV for good a means $b_2 > b_1$ for all Δ. The analogous set-up for b is:

(3) $$u(A,B) = u(A-a_1, B+\Delta')$$

(4) $$u(A, B-\Delta') = u(A-a_2, B)$$

DMV for good b means $a_2 > a_1$ for all Δ'. Note that DMV for one of the goods does not imply DMV for the other good.[8]

Willingness-to-accept (WTA, also known as Compensation Demanded) being larger than willingness-to-pay (WTP) is a form of DMV. This connection should not, of course, be surprising since the difference between WTA and WTP depends on changes in the consumer's

[8] DMV in both goods implies preference quasi-concavity. Quasi-concavity, however, implies only that there must be DMV in at least one good.

endowment, as pointed out by Kahneman *et al*., among others.

To see that the WTA/WTP disparity is a form of DMV, consider the mixed direct-indirect utility function defined by v(q,y) = $\max_x$ u(x,q) subject to px = y, where x is a vector of market goods, q is the rationed good, and y is income; the vector of prices, p, is usually suppressed. Let $\Delta_1 > 0$ be a proposed change in the rationed good. WTP and WTA are given by:

(5) $$v(q, y) = v(q - \Delta_1, y + WTA)$$

(6) $$v(q, y - WTP) = v(q - \Delta_1, y)$$

Use the analog to (4) to define Δ_2:

(7) $$v(q, y - WTA) = v(q - \Delta_2, y)$$

DMV *in income* means $\Delta_2 > \Delta_1$. Thus, $v(q-\Delta_2, y) < v(q-\Delta_1, y) = v(q, w - WTP)$ or, from (7), WTA > WTP. In other words, WTA > WTP is DMV in the "other good"; in this case, income. Although the disparity between WTA and WTP has long been recognized as an income effect, the emphasis on this income-based perspective has appeared relatively recently (Bateman *et al*.; Morrison; Sugden; Horowitz and McConnell.) This perspective can also be easily appreciated by recognizing that DMV (measured in dollars) and the disparity between WTA and WTP both disappear when the marginal utility of income is constant.[9]

Our experiments have measured changes in the value of a good when the endowment of that good changes. In contrast, the ratio WTA/WTP measures changes in the value of a good as income changes. This ratio will be greater than one whenever marginal value is increasing in income. This latter property is, of course, intuitively appealing in much the same way as DMV.

Cross-sectional inconsistency of preferences. Our experiments have presented clear

[9]One way to see this is to assume constant marginal utility for money; *i.e*., no income effect. Let utility be v(q,y) = f(q) + y. Then it is easy to see that WTA=WTP, and this will be true regardless of the curvature of f(q).

evidence in favor of DMV. But a comparison across tables (Table 5 vs. 6; Table 7 vs. 8) also provides evidence about the "cross-sectional inconsistency" of preferences, which has potentially much greater implications. Consider a comparison between treatments H and I. For preferences to be consistent, the proportion of people who choose *b* over *a* should be equal to one minus the proportion who choose *a* over *b*. Ditto for the comparison between N and O. In words, subjects should exhibit the same preference for *a* over *b* regardless of which good they have in hand. This prediction clearly fails in our trading exercises.

Note that preferences can fail in this way and still exhibit DMV, and vice versa, and therefore we leave the implications of this phenomenon for a separate paper. It will be necessary to deal with this phenomenon in the following section, however.

3. Utility and Demand

A. Demand-Curve Treatments

A further set of treatments with different trading prices provides data that can be used to construct demand curves. These are demand curves denominated in goods, relevant for a simple two good economy. Subjects were endowed with 3 units of either *a* or *b*. In treatment J, already described, the subject could trade one unit of *a* for one unit of *b*, so the price of the non-endowed good, *b*, is 1 (only one trade allowed per subject.) In K, the subject must trade two units of *a* for one unit of *b*, so the price of *b* is now 2. In treatments L and M, the subjects were endowed with 3 units of *b*; the price of *a* was 1 in treatment L and 2 in treatment M.

We expect a lower trading rate as the price rises. Results are shown in Tables 9 and 10. Results show demand curves that are clearly downward sloping. In both cases the treatment with a higher price for the good being "bought" had a significantly lower proportion traded.

B. Linking Utility and Demand

In this section we link demand and utility using our results. Consider the utility function:

$$\alpha \ln(A - A_0) + (1 - \alpha)\ln(B - B_0) \quad (8)$$

where α, A_0, and B_0 are parameters. Note that we expect $\alpha > 0.5$ since the data show a slight preference for good *a* over good *b*.

Budget constraints for each of our treatments are shown in Table 11. To convert trading decisions to "consumption," we calculated items per 100 subjects. For example, in treatment J, 100 subjects would begin with 300 *a*. Thus, the budget constraint is $A+B \leq 300$. If the trading rate were 77.5 percent then those 100 subjects would end up with 222.5 *a* and 77.5 *b*.

An appropriate scale is also needed for A_0 and B_0. The endowment effect requires us to recognize that this scale may be specific to each treatment, dependent on both the endowment and framing of the decision problem. We set the baseline for the endowed good at βY, where *Y* is income, and the baseline for the non-endowed good at γY. An endowment effect implies $\beta > \gamma$; a finding of $\beta = \gamma$ implies no endowment effect. This format is arbitrary but useful. Our main goal here is to construct a model that provides a transparent role for endowment effects yet is also well-behaved as a model of choice and demand in all other regards. Values for A_0 and B_0 based on this approach are shown in Table 11.

Maximizing utility subject to the budget constraint yields demand for *A* given by:

$$A^* = (1 - \alpha)A_0 - \alpha \frac{p_b}{p_a} B_0 + \frac{\alpha}{p_a} Y \quad (9)$$

Results. We used data from experiments H through M to estimate (9) using maximum likelihood methods. Estimated parameters and approximate standard errors are $\alpha = 0.56$ (0.04),

$\beta = 0.60$ (0.05), and $\gamma = 0.12$ (0.04). Actual and predicted values for choice variables are shown in Table 12. These results show a high degree conformity with observed choices, although we recognize that such an assessment is necessarily qualitative.

The hypothesis $\beta = \gamma$ is rejected at above the 99 percent level. Since $\hat{\beta} / \hat{\gamma} \approx 5$ in our experiments, being endowed with a good makes the good roughly 5 times more valuable than not being so endowed.

As we have noted, previous research has largely been content to find well-behaved demand curves, while the underlying behaviors such as DMV have been largely unexplored. Our calculations yield a joint model of DMV and demand, provided we make allowance for an endowment effect.[10]

4. Concluding Comments

DMV is an historically important idea that helped lead the early neoclassicists to adopt a utility-based model of behavior, although it is not "the" link between utility and demand in a theoretical sense, and early historians appear to have conflated it with other relevant concepts. This property remains, for modern economists, a widely assumed behavioral feature, often the core of our intuition – indeed, it is often difficult to imagine behavior without DMV. Yet, the empirical evidence for it has remained unexplored and untested. This gap has clearly needed redressing.

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[10]Gary Becker (1962) took a different approach to this question. He argued that economic theory (mainly, predictions based on downward-sloping demand) is "much more compatible with irrational behavior than had been previously suspected" (p. 2), a claim that we corroborate but using a different argument. His notion of rational behavior consisted of a "well-ordered [utility] function" (further specified in terms of "consistency" and "transitivity"). In a reply to a critic (Becker 1963), he noted that "diminishing marginal utility (or marginal rate of substitution)" cannot apply if consistency and transitivity fail. In contrast, we posit an inconsistent individual who nonetheless has diminishing marginal value (although inconsistency, too, has taken on a slightly different meaning over the years.)

In our tests, the range of endowments being valued is small. Such small ranges provide powerful tests of our hypothesis. They do not, however, allow us to predict behavior under larger endowments. We also have looked at only three types of goods, while we expect the effect of the endowment on marginal value to be different for different goods. Economists will be most interested next, we feel, in knowing which kinds of goods are likely to have strong DMV and which are likely to have constant marginal value or even increasing marginal value. We leave these questions for a subsequent paper.

Table 1. Summary Statistics for Treatment Set I

	Treatment						
	A	B	C	D	E	F	G
CD for 1 mug	$4.40 (0.53) 61	$3.60 (0.44) 67	$5.02 (0.30) 125	--	--	--	$5.06 (0.80) 51
CD for 2 mugs	$8.67 (1.25) 61	$6.77 (0.73) 67	--	--	$9.18 (0.76) 41	$9.12 (1.10) 25	--
CD for 3 mugs	$13.70 (2.31) 61	$10.09 (1.07) 67	--	--	$13.32 (1.01) 41	$13.56 (1.79) 25	--
CD for 1 flashlight	--	--	$5.50 (0.47) 59	$6.06 (1.19) 15	--	$6.44 (0.76) 25	--

The numbers are the mean, standard error, and number of observations.

Table 2. Mean Compensation Demanded for 1 Mug, by Endowment

	Mug Endowment:		
	1 (Treatments C, G)	3 (Treatment A)	4 (Treatment B)
Compensation Demanded to give up 1 mug	$5.03** (.31) 176	$4.40 (0.53) 61	$3.60 (0.44) 67

Entries are the mean, standard error, and number of observations. **Significantly different from column 4 at the 99% level. The t-statistics for 1 vs. 3 and 3 vs. 4 are 1.10 and 1.16, respectively.

Table 3. Mean Compensation-Demanded for 2 and 3 Mugs, by Endowment

	Mug Endowment:	
	3 (Treatments A, E, F)	4 (Treatment B)
Compensation Demanded to give up 2 mugs	$8.92** (.68) 127	$6.77 (0.73) 67
Compensation Demanded to give up 3 mugs	$13.55** (1.20) 127	$10.09 (1.07) 67

Entries are the mean, standard error, and number of observations. **Significantly different from column to the right at the 99% level.

Table 4. Mean Compensation-Demanded for 1 Flashlight, by Endowment

	Flashlight Endowment:	
	1 (Treatments D, F)	3 (Treatment C)
Compensation Demanded to give up 1 flashlight	\$6.30 (0.64) 40	\$5.50 (0.47) 59

Entries are the mean, standard error, and number of observations. The t-statistic for 1 vs. 3 is 1.00.

Table 5. Trading Rates (*a* for *b*), by Endowment

	Good *a* endowment	
	1 (Treatment H)	3 (Treatment J)
Percent traded (1 unit of *a* for 1 unit of *b*)	22.5 (n = 40)	77.5 (n=40)

Table 6. Trading Rates (*b* for *a*), by Endowment

	Good *b* endowment	
	1 (Treatment I)	3 (Treatment L)
Percent traded (1 unit of *b* for 1 unit of *a*)	27.5 (n = 40)	87.5 (n=40)

Table 7. Trading Rates for Collective Choice (*a* for *b*), by Endowment

	Good *a* endowment	
	1 (Treatment N)	3 (Treatment P)
Percent voting to trade (1 unit of *a* for 1 unit of *b*)	35.0 (n=40)	80.0 (n=35)

Table 8. Trading Rates for Collective Choice (*b* for *a*), by Endowment

	Good *b* endowment	
	1 (Treatment O)	3 (Treatment R)
Percent voting to trade (1 unit of *b* for 1 unit of *a*)	29.7 (n=37)	85.7 (n=42)

Table 9. Trading Rates (*a* for *b*), by Price (Endowment of *a* = 3)

	Price of Good *b*	
	1 (Treatment J)	2 (Treatment K)
Percent traded (Demand for *b*)	77.5 (n=40)	47.5 (n=40)

Table 10. Trading Rates (*b* for *a*), by Price (Endowment of *b* = 3)

	Price of Good *a*	
	1 (Treatment L)	2 (Treatments M)
Percent traded (Demand for *a*)	87.5 (n=40)	42.5 (n=40)

Table 11. Budget constraints and reference points

Treatment	Budget constraint	A_0	B_0
H	A+B = 100	100β	100γ
I	A+B = 100	100γ	100β
J	A+B = 300, A ≥ 200	300β	300γ
K	A+2B = 300, A ≥100	300β	300γ
L	A+B = 300, B ≥ 200	300γ	300β
M	2A+B = 300, B ≥100	300γ	300β

Table 12. Predicted vs. Actual Choices

Treatment	Predictions: A* (from (9))	Actual:[a] A (Tables 5,6,9,10)
H	76	77.5
I	28	27.5
J	227	222.5
K	207	205
L	84	87.5
M	50	42.5

[a]All numbers normalize the number of subjects to 100.

Appendix A: Summary of Experimental Treatments

Treatment	Subjects	# Subjects	# Analyzed	Endowment
Private good with price elicitation				
A	Undergraduate students	37	36	3 mugs
	PTA	10	6	3 mugs
	PTA	26	19	3 mugs
B	Parents of Swim Club	52	48	4 mugs
	PTA	20	19	4 mugs
C	Parents of Cub Scouts	30	26	1 mug, 3 flashlights
	Lions' Club	42	34	1 mug, 3 flashlights
	PTA	27	24	1 mug, 3 flashlights*
	PTA	50	48	1 mug, 3 flashlights*
D	"Mothers of Multiples"	18	15	1 flashlight, 3 different mugs
E	PTA	41	41	1 mug, 3 mugs*
F	PTA	27	27; 25	1 flashlight, 3 mugs*
G	PTA	50	50	1 mug, 3 binoculars
Private good with exchange mechanism				
H	Sportscard consumers	40	40	1 Ripken stub
I	Sportscard consumers	40	40	1 Sanders stub
J	Sportscard consumers	40	40	3 Ripken stubs
K	Sportscard consumers	40	40	3 Ripken stubs
L	Sportscard consumers	40	40	3 Sanders stubs
M	Sportscard consumers	40	40	3 Sanders stubs
Public good with exchange mechanism				
N	Sportscard consumers	40	40	1 Ripken stub
O	Sportscard consumers	37	37	1 Sanders stub
P	Sportscard consumers	35	35	3 Ripken stubs
Q	Sportscard consumers	33	33	3 Ripken stubs
R	Sportscard consumers	42	42	3 Sanders stubs
S	Sportscard consumers	35	35	3 Sanders stubs

*In these treatments, compensation demanded was elicited only for returning 2 or 3 items out of the 3-item endowment. Subjects were not asked their CD to return 1 item of the 3-item group.

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