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ROBUST CONTINGENT VALUES BASED ON DICHOTOMOUS CHOICE SURVEY DATA

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SUMMARY

Estimated willingness-to-pay (WTP) is considered in the context of dichotomous choice referendum surveys. The sensitivity or robustness of estimates is investigated when some members of the population do not respond consistent with how they would vote in a real referendum. The majority of responses are presumed to be consistent with reservation prices. However, some are yea sayers and respond favourably for virtually and bid amount, and some are nay sayers reporting that they would vote 'no' even at very low bid values. The yea and nay saying leads to response curves with theoretically anomalous, but empirically important features: there are too many 'no' votes at low bid amounts, and too many 'yes' votes at high bid values. Impacts of yea and nay saying on mean WTP are in opposite directions, but magnitudes are not equal, so that it is possible for observed WTP to be large even if reservation prices in the population are small. It is conjectured that this is a plausible explanation for the CV folklore in which there is a $30 lower bound on the CV for practically any environmental good. © 1997 John Wiley & Sons, Ltd.

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1. INTRODUCTION

In a contingent valuation (CV) referendum survey a person whose reservation price is s dollars for an environmental good is asked if they would be willing to pay b dollars for the good. A 'yes' vote when $b < s$, or a 'no' vote when $b > s$ means the survey response is consistent with preferences. While consistency may be the rule in well designed surveys, the literature on CV includes many reasons why responses might differ from votes in a real referendum.

Respondents might not understand what is being valued, or they might fail to take the non-binding CV question seriously. Decision heuristics might make the answered question different from what was asked ('environmental accidents are seldom as bad as we are led to believe', or 'authorities almost always put too good a face on these things'). Refusal to accept the premises of the problem could arise because of an aversion to taxes or a view that someone else – 'industry', for example – should be held responsible. A positive response could reflect a failure to consider substitute public or private goods, or responses might be affected by a 'warm glow' that attends

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donations to any worthy cause. The respondent may view the survey as a game with the bid amount conveying information about the good's uncertain value, or people might feel that they are really being asked for the'right' or 'good' answer. Alternatively, negative responses could come from a belief that costs and benefits would be unfairly distributed. Any of these conditions can lead to survey responses that are inconsistent with reservation prices.[1]

Good surveys create incentives for responses that are consistent with preferences. It is doubtful, however, that even the most careful design could guarantee complete consistency. This raises the question of the sensitivity or robustness of estimated willingness-to-pay (WTP) to departures from the ideal case. What happens to estimated WTP when some survey responses are different from what votes would be in a real referendum?

In this note we consider a simple departure from the ideal case. Suppose the population includes individuals whose responses are consistent with preferences, but also some who are yea sayers and nay sayers. A yea sayer views the survey situation in such a way as to respond favourably to the survey question for virtually any bid amount. The nay sayer, on the other hand, always says – in the survey situation – that they would vote 'no'. We consider how such responses affect the survey response curve and the associated mean WTP.

We will see that yea and nay saying leads to response curves with anomalous features. There are too many 'no' votes at low bid amounts, and too many 'yes' votes at high bid values. No votes at low bid values are anomalous because no one presumably would vote against provision of a true environmental good with its non-negative benefits if is cost was zero[2]. At the other end of the curve, there will be 'yes' votes at what, *a priori*, seem implausibly high bid values. While these features are inconsistent with the dictates of theory, they are observed in real surveys. Yea and nay saying therefore are candidate hypotheses for these features of response distributions.

Another feature of actual referendum surveys is the absence of small mean values, no matter what the environmental good happens to be. Conventional wisdom has \$30 as the lower bound on any mean value.[3] For non-use values in the US with its 100 million families, the mean of \$30 translates to a total value of \$3 billion.

The \$30 bound could however be due to yea saying. Section 3 describes how yea and nay saying alter WTP estimates. Estimates of yea and nay saying are in opposite directions, but their magnitudes are not the same. As a result, there can be an upward bias in mean WTP even with equal proportions of yea and nay sayers, so that in a referendum survey it will be impossible to obtain low values for mean WTP.

2. THE RESERVATION PRICE AND SURVEY RESPONSE DISTRIBUTIONS

Mean WTP is to be estimated by a referendum survey regarding provision of an environmental good. People in a random sample from a reference population will be presented with a bid b_i; $i = 0, 1, \ldots, n$; $b_0 = 0$, $b_i < b_{i+1}$. Sample data will consist of (Z_{ij}, b_i), $j = 1, \ldots, n_j$, where Z_{ij} equals 1 if the jth response at bid b_i is 'yes', and is zero when the response is no.

[1] For references and discussion see Cummings *et al.* (1986), Mitchell and Carson (1989), NOAA (1993), and Gregory *et al.* (1993).
[2] On the other hand, for controversial non-public goods, such as open lands for grazing or introducing the wolf into its former – now agricultural – habitat, there can be no presumption that all individuals will have non-negative values.
[3] Don Coursey referred to this value. David Brookshire commented that the (inflation adjusted) conventional wisdom may be due to Zechauser who said about CV that you could get a \$5 mean WTP for anything.

Let $F(s)$ denote the cumulative distribution function (CDF) of reservation prices in the reference population. $F(s)$ denotes the proportion of the population whose reservation price is less than s. We assume for simplicity that all reservation prices are non-negative so $F(0) = 0$.

When survey answers are consistent with reservation prices an observation, $Z_{ij} = 1$, means the reservation price is greater than the bid amount b_i, and $Z_{ij} = 0$ means the reservation price is less than the bid amount. In this case the response curve, the proportion of 'yes' votes at bid value b, will be identical to the proportion of the population whose reservation prices are greater than b; this proportion is $1 - F(b)$.

For reasons described above, we want to allow for differences between responses to survey questions and responses based on reservation prices. We therefore let $G(b)$ denote the proportion of the population who would say *in a survey* that they would vote against provision of the environmental good if they had to pay b. Discrepancies between F and G will be modelled by supposing there is a fixed fraction of the population who say 'yes' to the referendum survey question, and another fixed fraction who say 'no' independent of their reservation prices.[4]

The population proportion of yea sayers is denoted by p_{y}, the proportion of nay sayers is p_{n}, and those whose response is consistent with reservation prices is denoted by p_{rp} ('rp' for reservation price), where $p_{\mathrm{rp}} + p_{\mathrm{y}} + p_{\mathrm{n}} = 1$.[5] The proportion of the population who would say in a survey that they vote 'no' at bid amount b is therefore given by $G(b) = p_{\mathrm{rp}}F(b) + p_{\mathrm{n}}$, and the proportion who say they would vote 'yes' is given by $1 - G(b) = p_{\mathrm{rp}}(1 - F(b)) + p_{\mathrm{y}}$.

The effect of yea and nay saying on the response curve is illustrated in Figure 1. The true response curve is $1 - F$, but the one we observe is given by $1 - G$. Compared to the response curve based on reservation prices, the survey response distribution is seen to flatten too quickly near zero, and at zero there are 'no' votes. This is due to nay saying, which becomes increasingly evident for bid values approaching zero. At high bids there is only a small effect from nay saying because 'no' votes are already likely; a nay saying and reservation price-based vote are both likely to be 'no'. On the other hand, at low bids it is more likely that a nay sayer's vote differs from reservation prices, and it is here that nay sayers significantly affect the response curve.

Yea saying, in contrast, becomes increasingly evident in the upper tail of the response function. As the bid value increases, the response function flattens too quickly and does not decline to zero. At low bids 'yes' votes are unconditionally more likely so that yea saying responses do not differ from votes based on reservation prices and yea saying has little impact on responses. It is at the high bids that yea saying most strongly affects the response curve because yea saying responses then begin to differ from responses based on reservation prices.

These features of response distributions are frequently observed in real surveys. It is common to observe 'no' votes even at $b = 0$, and this has led to consideration of negative values for environmental goods; see, for example, Habb (1995). On the other side, it is common to observe 'yes' votes at what seem to be implausibly large bid values. While these stylized facts are not

[4] This does not mean, for example, that a yea saying response is opposite preferences: it is opposite only when the bid amount is greater than the reservation price.

[5] Notice that yea and nay saying is here taken to be a feature of the population and not just a particular sample. Also, the tendency for yea or nay saying is assumed not to depend on the value of b or the reservation price. More realistic specifications would make the likelihood of consistent responses dependent on reservation prices and bid amounts. It could be the case that p_{rp} increases as b increases; at large enough bids the tendency for yea saying decreases. Alternatively, if inferences about the value of the environmental good are based on the bid value, then p_{y} might increase with b. If the latter was prevalent enough, there could be an increasing proportion of 'yes' votes as bid amounts increased, an anomaly sometimes observed in real CV surveys.

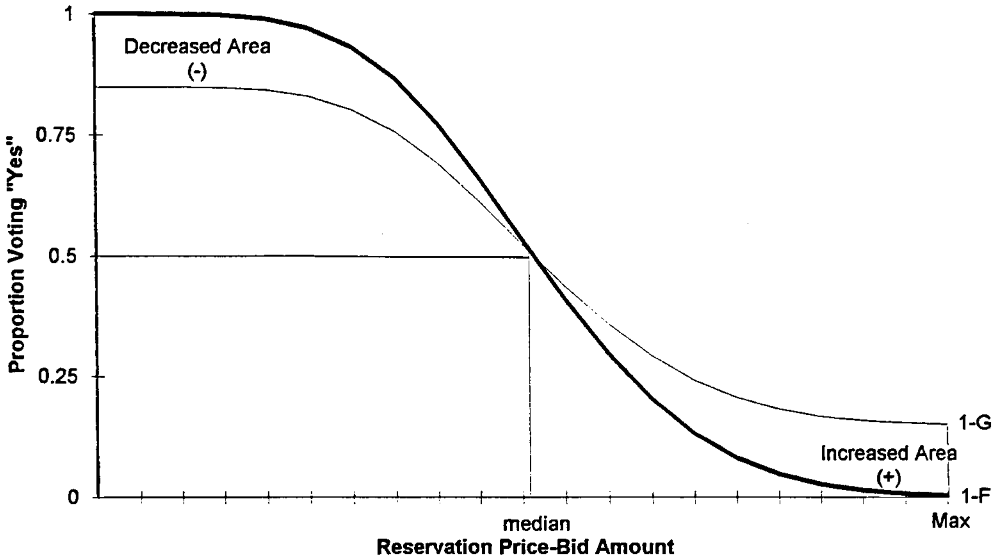

Figure 1. Response distribution with yea and nay saying

decisive evidence, they at least suggest yea and nay saying as explanations for these features of response distributions.

3. MEAN WILLINGNESS-TO-PAY

The expected WTP in the population is denoted by μ_F. Given the referendum method, the expected value is most conveniently expressed as the area under the response curve of 'yes' votes, $1 - F(s)$,

$$\mu_F = \int_0^{b_{\max}} s \, \mathrm{d}F(s) = \int_0^{b_{\max}} [1 - F(s)] \, \mathrm{d}s. \tag{1}$$

The mean WTP is estimated, in practice, by integrating under the sample proportion of 'yes' votes, which estimates, $1 - F$, at bids b_i, $i = 0, 1, \ldots, n$. A hypothesized CDF (e.g. logistic, log-normal etc.) is either fitted directly to the sample proportions, or it is modelled as a function of demographic and economic characteristics of respondents. This provides an estimate of the response function, which on integrating as in (1), provides an estimate of mean WTP for a representative individual.

When assessing the impact of tail events on mean values, it is important to distinguish between the different formulas for the mean. It is well known that the mean is sensitive to outliers; the contribution to the mean from $x_i p(x_i)$ can be large when $p(x_i)$ is very small if x_i is large enough. Sometimes this intuition is mistakenly applied to the latter formula for the mean in (1): if x_i is large and $1 - F(x_i)$ is not negligible then the mean must be large because the product of x_i and $1 - F(x_i)$ will be large. The mean based on (1) is the area under $1 - F(x)$; it is not the area under the curve determined by the product of $1 - F(x)$ and x. The effect of an outlier on the mean is indicated by the large (horizontal) area at the bottom of the $1 - F$ curve, and not by the integral of the product, $[1 - F(x)]x$.

Simple non-parametric bounds on WTP can be obtained from (1); see Green *et al.* (1995). Consider the response curve at $1 - F(b_i)$, $i = 0, \ldots, n$ where $b_0 = 0$ and suppose $F(b_n) = 1$. Partition (1) into areas

$$\mu_F = \int_0^\infty [1 - F(s)]\, \mathrm{d}s = \sum_{i=1}^{n} \int_{b_{i-1}}^{b_i} [1 - F(s)]\, \mathrm{d}s$$

and since F is monotonic

$$\sum_{i=1}^{n} [b_i - b_{i-1}][1 - F(b_i)] \leqslant \mu_F \leqslant \sum_{i=1}^{n} [b_i - b_{i-1}][1 - F(b_{i-1})].$$

These provide bounds on mean WTP that can be computed directly from $F(b_i)$, $i = 0, 1, \ldots n$. (For parametric CDFs with unbounded support (so b_n is unbounded) a finite upper bound can still be obtained by replacing the last summand with an upper bound (depending on F) for

$$\int_{b_n}^\infty [1 - F(s)]\, \mathrm{d}s.$$

We now consider the effect of yea and nay saying on mean WTP. In Figure 1 the effect of nay saying is indicated by the decreased area $(-)$ between the $1 - G$ and $1 - F$ curves up to the point where the curves cross. The effect of yea saying is reflected in the increased area between $1 - G$ and $1 - F$ at bid values above the crossing point. Technically speaking, the effect on the mean is seen to be unbounded if the limit of the integral is allowed to range over unbounded bid values. To make reasonable comparisons we suppose there is an *a priori* given upper bound on the bid values, $b_{\max}$, and consider how the mean changes when $1 - G$ is used in place of $1 - F$ in (1).

To illustrate, suppose 15 per cent of the population are yea sayers and an equal percentage are nay sayers. The density, $f(s)$, associated with F in Figure 1 is shown in Figure 2 along with the response curves $1 - F$ and $1 - G$. The density shows that reservation prices are symmetrically distributed between zero and the maximum reservation price. In this case the $(-)$ and $(+)$ areas cancel and there is no impact on mean WTP.

Figure 3 shows what happens in what is likely a more realistic case. Reservation prices are now skewed so that most of the population has low reservation prices, but a small proportion has large values. When the yea and nay saying is overlayed on this population, the mean WTP that would be observed in a referendum survey doubles in value. This is indicated by the much larger area in the upper tail between $1 - G$ and $1 - F$. (Note that in the case of equal proportions, the median – but not the mean – WTP will be unchanged for any F.) Figure 4 shows a more extreme case in which skewness of reservation prices causes a fivefold increase in the mean WTP. The negative impact on the mean from nay saying is more than offset by the very large impact from the yea sayers.

The examples show that there can be large impacts on mean WTP, even with equal amounts of yea and nay saying. Nay saying does not cancel out the effects of yea saying, and as a result mean WTP will appear to be (artificially) large.

4. DISCUSSION

The effect of yea saying on mean WTP can perhaps be most easily seen with a simple though extreme example. Suppose there is 15 per cent yea saying and bid values are in the interval

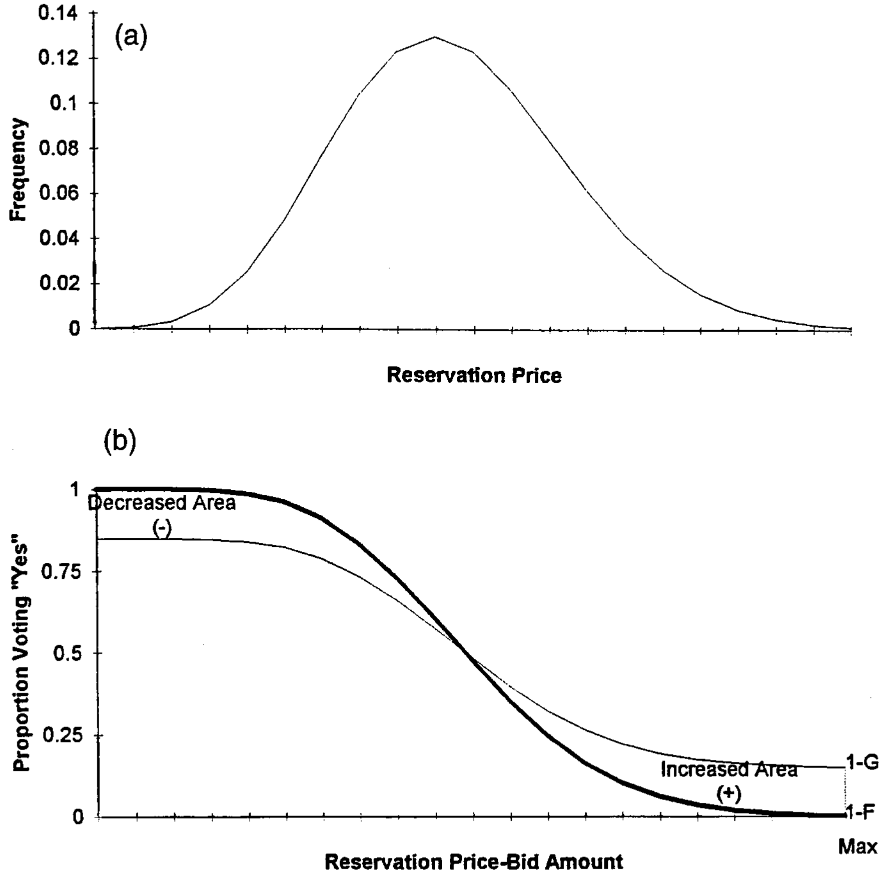

Figure 2. (as) Density, (mean G)/(mean F) = 1; (b) response distribution, nay saying = yea saying = 15%

[\$0, \$200]. Suppose everyone's reservation price is \$0. In this case, the mean WTP is \$0, but estimated WTP is \$30. This occurs because of the yea saying at bid amounts between \$0 and \$200. Yea saying can move mean WTP to a larger value than would be justified by reservation prices.

Suggestive evidence that yea and nay saying can be a problem comes in the form of response curves with substantial proportions of 'no' votes at $b = 0$, and 'yes' votes at implausibly high bid values. Additional evidence is the absence of studies reporting low values for mean WTP.

Schwarz (1995) suggests that anomalous survey responses can be understood in terms of the conventions of normal conversation. Respondents expect questions to be relevant; asking a question presupposes its relevance, else accepted conversational norms be violated. On this account yea and nay saying answers to questions about non-market, unfamiliar, goods may be the respondent's way to conform to the dictates of ordinary conversation. Inferences about the value of a good based on the bid amount would be most prevalent in situations (such as the determination of non-use values) where market prices do not exist and values are uncertain.

Informal evidence regarding the existence of yea and nay saying comes from focus groups. Our experience has been that there are always a few individuals who say they are opposed to a proposed change no matter how great the benefits or how low the cost. On the other side, there

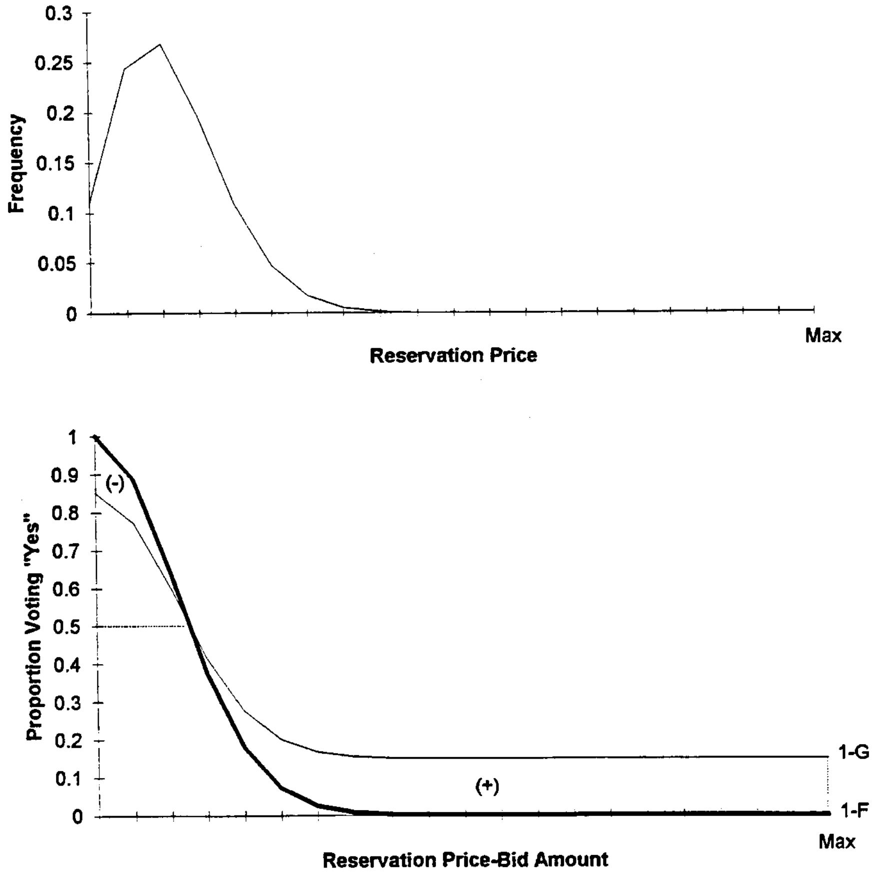

Figure 3. (a) Density, (mean G)/(mean F) = 2; (b) response distribution, nay saying = yea saying = 15%

always seem to be a few agreeable individuals who invariably interpret discussions of a change as signalling a 'good thing'. They say they would vote in favour of proposals at seemingly any cost and no matter how obscure the benefits.

The potential bias in WTP means that it is important to design surveys to try and detect and control for yea and nay saying, especially at high bid values. Direct tests might be in the form of subtly worded survey questions that alternatively ask about willingness to pay b dollars for 'A', and b dollars for 'not A'; the same response to both questions would signal a response that was not consistent with the person's reservation price.

Estimation methods might be developed that would control for the impact of yea saying on the mean WTP. The magnitude of yea or nay saying could be estimated based on demographic and economic characteristics of respondents. The proportion of yea saying would be reflected in the proportion of 'yes' votes at large bid values (and the failure of the response distribution to tend to zero). Assuming negative values can be ruled out, nay saying might be estimated from the proportion of 'no' votes at low bid values. This would allow mean WTP value to be modified to reflect varying amounts of yea and nay saying. Developing estimates is worth the trouble in light of the potentially large impacts that yea and nay saying can have on mean WTP.

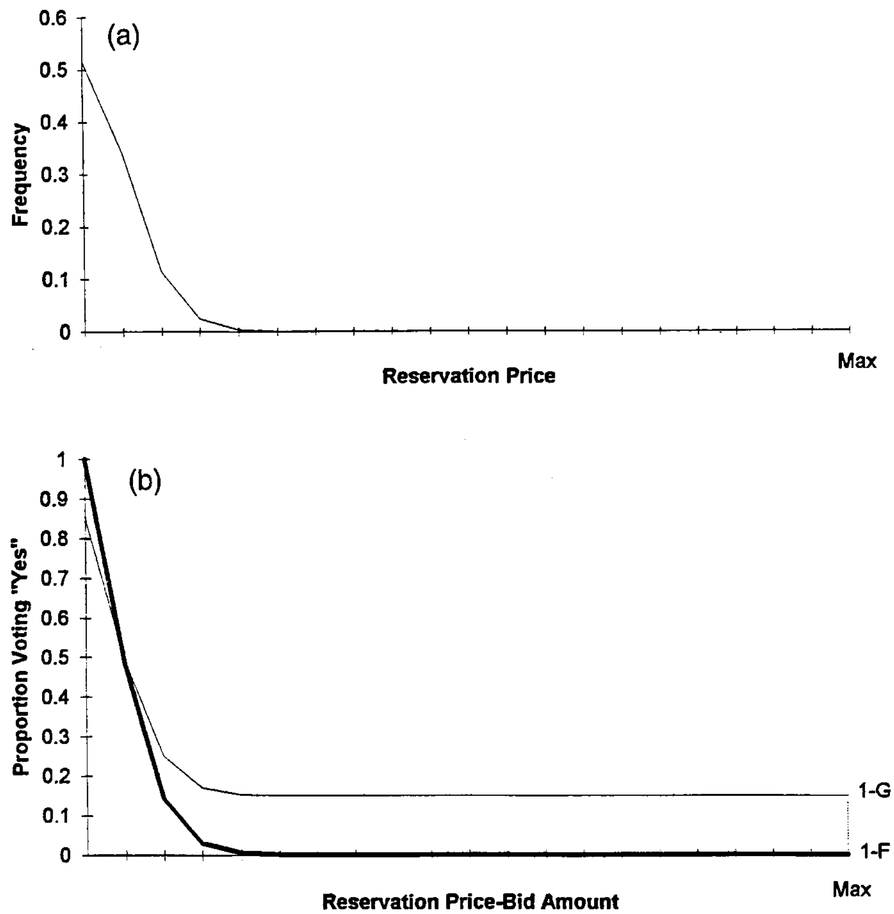

Figure 4. (a) Density, (mean G)/(mean F) = 5; (b) response distribution, nay saying = yea saying = 15%

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