How Consumers Respond to Incentives

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Abstract: This paper reviews incentive theory and the principal-agent problem, and Jean-Jacques Laffont's central contributions. It applies this theory to the design and administration of economic surveys, particularly the use of appearance fees to induce subject participation, and the framing of questions and validation of responses to induce subject effort and reduce strategic misrepresentation. It concludes with a survey of evidence on consumer response to incentives in economic surveys and in real markets.

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1. Introduction

The most fundamental development in economics in the last half-century has been the theory of mechanism design, the systematic study of resource allocation methods under imperfect information. From its origins in the works of Jacob Marschak, Leo Hurwicz, Kenneth Arrow, and Roy Radner, this way of thinking about transactions among economic agents has spread across the discipline. Jean-Jacques Laffont was at the center of this translation of foundational economic theory into the language and tools that today appear in game theory, in studies of the organization of firms and markets, and in the applied economics of regulation, taxation, and the provision of public goods. In a star-studded field, Jean-Jacques stands out as one of the most complete economists, spanning the subject from the pure theory of incentive-compatible contracts to econometric issues in implementation to practical applications in regulation and public good provision.[1] His scientific papers define the field, and his expositions of incentive theory, regulation, and public economics have transformed the teaching of economic theory. The research institute he has built in Toulouse is a model for the interface of economic science with the worlds of business, education, and government. Jean-Jacques was an exemplary person and an outstanding contributor to economics. He lives on through his research legacy, and should be a role model for every young economist.

One of the first and most important applications of mechanism design was to the determination of the optimal provision of pure public goods.[2] Suppose consumers indexed n = 1,...,N have risk-neutral indirect utility functions of Gorman polar form,

$$(1) \qquad u_n = V(y_n,p,x;\theta_n) \equiv \frac{y_n - B(p,x,\theta_n)}{A(p)},$$

where x is a vector of quantities of non-rivalrous, non-excludable public goods contained in a compact set X, p is a finite-dimensional vector of prices of private market goods contained in a cone P whose interior is the positive orthant, y_n is consumer income which may be depend on p and x, θ_n is the consumer's type from a compact universe Θ, and A and B are continuous functions in their arguments that are conical, concave, closed, and non-decreasing in p.[3] These preferences are well-defined when income y_n exceeds committed expenditure $B(p,x,\theta_n)$. Beyond compactness, the set X of public good alternatives is not restricted, so that it can either be discrete or a continuum, and need not be convex, so that mutually exclusive public projects can be analyzed. This model of the Gorman preference field can, by reinterpretation of x, handle not only quantities of public goods, but also hedonic characteristics of public and private goods regulated by a social planner. The indirect utility is specialized to $V_n(y_n,p,x;\theta_n) = [y_n - B_n(p)]/A(p) + \theta_n x$ in many applications, with θ_n the consumer's willingness-to-pay vector per unit for each component of x and B_n determined by the consumer's private good preference type. A component of x may be binary, such as a zero-one decision to ban whale hunting, or an extensive hedonic quantity, such as an area of tropical forest protected from development.

Consumer types are heterogeneous, but in the specified preference field only committed expenditures vary with consumer type. The Gorman indirect utilities (1) sum to a utilitarian social indirect per capita utility function

$$(2) \qquad W(Y,p,x,\boldsymbol{\theta}) \equiv \frac{Y - \sum_{n=1}^{N} B(p,x,\theta_n)}{N \cdot A(p)} ,$$

where Y is aggregate income and $\boldsymbol{\theta} = (\theta_1,...,\theta_N)$. Because A(p) does not vary with consumer type, these preferences display the "parallel Engle Curves" property that (2) is the indirect utility of a representative consumer for the economy, with aggregate private good demands that satisfy Roy's identity applied to (2).[4] These demands are independent of the distribution of income as long as all incomes are sufficient to sustain committed expenditure; i.e., the condition is met that for all $p \in P$ and n = 1,...,N, consumer incomes satisfy $y_n = F_n(p,x) > B(p,x,\theta_n)$. Further discussion of the aggregation properties of Gorman preference fields is given in Chipman and Moore (1980, 1990) and McFadden (1999, 2004).

Aggregate income, defined as the value of resource endowments plus profit from the production of private goods less the cost of production of public goods, is a function Y = F(p,x,r) of p, x, and a variable r which influences the cost of providing the public goods. We assume that r is known to the social planner before x is determined. The function F is continuous in its arguments, and conical, convex, and closed in p.[5] In a typical application, r is a vector of real unit costs for public goods, and $F(p,x,r) = f(p) - A(p)\cdot r\cdot x$. In equilibrium, balance requires that consumer's incomes $y_n = F_n(p,x,r)$ sum to aggregate income,

$$(3) \qquad Y = F(p,x,r) \equiv \sum_{n=1}^{N} F_n(p,x,r) .$$

The private goods market clears when prices, given $\boldsymbol{\theta}$, x, r, and a balanced incomes policy, satisfy[6]

$$(4) \qquad p(\boldsymbol{\theta},x,r) \in \operatorname{argmin}_p W(F(p,x,r),p,x,\boldsymbol{\theta}).$$

Then the socially optimal level of public goods supply when consumer types are known is

$$(5) \qquad x^*(\boldsymbol{\theta},r) \in \operatorname{argmax}_x W(F(p(\boldsymbol{\theta},x,r),x,r),p(\boldsymbol{\theta},x,r),x,\boldsymbol{\theta}) .$$

The result of this calculation also determines equilibrium prices $p^*(\boldsymbol{\theta},r) = p(\boldsymbol{\theta},x^*(\boldsymbol{\theta},r),r)$ for private goods. Since $x^*(\boldsymbol{\theta},r)$ is invariant under permutation of $\boldsymbol{\theta}$, I let $\boldsymbol{\theta}_{-n}$ denote the vector of types of consumers other than n and write $x^*(\boldsymbol{\theta}_{-n},\theta_n,r)$ when I wish to isolate the effect of consumer n's type. In the specialization $V_n(y_n,p,x;\theta_n) = [y_n - B_n(p)]/A(p) + \theta_n x$ and $F(p,x,r) = f(p) - A(p)\cdot r\cdot x$, the socially optimal $x^*(\boldsymbol{\theta},r)$ maximizes $x\cdot(\sum_{n=1}^{N} \theta_n - r)$ over $x \in X$ and the

market-clearing private good prices $p^*(\boldsymbol{\theta})$ minimize $[f(p) - \sum_{n=1}^{N} B_n(p)]/A(p)$ and are independent of r.

Now suppose that consumer types are not known to the social planning principal, but are instead self-reported by consumers, possibly with strategic misrepresentation to "free ride" on the provision of public goods. Assume that consumers do not know the cost factor r when they report their consumer types, but that r has a cumulative distribution function H(r) that is common knowledge. The challenge for the principal is to announce to each consumer agent n an incomes policy $y_n = F_n(x,r)$ that depends on x and r, a private good price vector $p^*(r)$ that is a function of r, and a public good vector $x^*(\theta_n', r)$ that is a function of r and of the self-reported type θ_n' of this consumer, that are strongly individually incentive-compatible in the sense that it is an undominated Bayes-Nash strategy (Palfrey and Srivastava, 1991) for each consumer facing this announcement to report her true type, independently of the strategies of other consumers. If incentive-compatibility is achieved, then the solution (4) at self-reported types achieves the same supply of public goods as if true types were known.

In an early paper, Green and Laffont (1977) showed that incomes policies based on a generalized Groves-Clarke mechanism (Clarke, 1971; Groves and Loeb, 1975),

$$(6) \qquad F_n(p^*(r),x,r,\boldsymbol{\theta}_{-n}'') = F(p^*(r),x,r) - \sum_{j\neq n} B(p^*(r),x,\theta_j'') - K_n(r),$$

where K_n is a lump-sum net tax that is independent of x and of consumer n's reported type, define the class of direct revelation mechanisms that are strongly individually incentive-compatible. The idea is that the social planning principal and the consumer agents play the following incomplete information game:

1. Given a trial vector $\boldsymbol{\theta}''$ of self-reported consumer types, a trial public goods supply function $x''(r)$, and a trial private goods price function $p''(r)$, the principal chooses lump sum tax functions $K_n(r)$, then income functions $y_n = F_n(x,r)$ equal to $F_n(p''(r),x,r,\boldsymbol{\theta}_{-n}'')$ in (6). The principle then announces to all consumers a price function $p^*(r)$ and to each consumer n the income function $F_n(x,r)$ and a public goods supply function $x^*(\theta_n',r)$, where $p^*(r)$ is equal to $p^*(\boldsymbol{\theta}'',r)$ and $x^*(\theta_n',r)$ is equal to $x^*(\boldsymbol{\theta}_{-n}'',\theta_n',r)$ from (5). At this stage, the realization of r is unknown to the consumers.

2. Taking as given her income function $y_n = F_n(x,r)$, the price function $p^*(r)$, the public goods supply function $x^*(\theta_n',r)$, and the distribution H(r), consumer n maximizes her expected utility at a response correspondence

$$(7) \qquad \theta_n' \in T(\theta_n) \equiv \operatorname{argmax}_{\theta} \mathbf{E}_r\, V(F_n(p^*(r),x^*(\theta,r)),p^*(r),x^*(\theta,r);\theta_n) .$$

An equilibrium is achieved in the game at a fixed point, satisfying the balance condition (3), of the values $\boldsymbol{\theta}''$, $x''(r)$, $p''(r)$ under the mapping determined by the player's responses, $\boldsymbol{\theta}'$

in (7), $p^*(r) \equiv p^*(\boldsymbol{\theta}'',r)$, and $x^*(\theta_n',r) \equiv x^*(\boldsymbol{\theta}_{-n}'',\theta_n',r)$. If an equilibrium is achieved, it has the property that truth-telling is an undominated strategy for each consumer, no matter what the strategies of others. To see this, note that given an incomes policy satisfying (5), the kernel of consumer n's objective function in (7) for each possible r and vector $\boldsymbol{\theta}_{-n}''$ coincides with the planner's objective function (5) evaluated at $\boldsymbol{\theta}_{-n}''$ and the consumer's true θ_n. Therefore, among all possible reports θ_n', the truth θ_n ensures that the social planner's public good supply is best for consumer n. Then, the mechanism is individually incentive-compatible. Put another way, the incomes policy (6) internalizes the public goods externality so that each *pivotal* consumer whose self-reported type can alter the public good supply experiences the full social impact of her self-report.

Two critical requirements in the public goods provision game just described are that each consumer recognize and act upon her ability to directly influence her income and the supply of public goods through her self-reported type, and that she *not* recognize and act upon the strategic opportunities her report offers for the indirect determination of her income function and private goods prices via the influence of her reported type on the social planner's calculations to set lump sum net taxes and achieve income balance. These assumptions are somewhat strained. If the economy has a modest number of consumers, it is implausible that a consumer would be unaware of her full strategic opportunities, particularly her influence on the determination of private goods prices as well as public goods supply by the social planner, while if the economy has many consumers, it may be implausible that the Groves-Clarke incomes policy can be imposed and that each consumer will recognize the consequences of being pivotal. In addition, it is not guaranteed that an undominated Bayes-Nash equilibrium that achieves balance exists. Gibbard (1973) and Satterthwaite (1975) show that in general no non-dictatorial balanced mechanism in an economy with a finite number of consumers can be strategy-proof, so the restrictions on consumer behavior necessary to assure that the Groves-Clarke-Green-Laffont (GCGL) mechanism (6) is strongly individually incentive compatible are necessarily somewhat artificial. However, there are a few adjustments that mitigate some of these concerns. First, the game specifies that the principal communicate $y_n = F_n(x,r)$, $p^*(r)$, and $x^*(\theta_n',r)$ to consumer n. The principal need not communicate self-reported types or incomes of other consumers, so that the influence of consumer types on the determination of private goods prices and income may not be apparent to consumer n. If lump-sum taxes are set to satisfy

$$(8) \qquad K_n(r) = F(p''(r),x''(r),r)\cdot(N-1)/N - \sum_{j\neq n} B(p''(r),x''(r),\theta_j''),$$

where $\boldsymbol{\theta}''$, $x''(r)$, $p''(r)$ are trial values for the principal, then to first order, $K_n(r)$ does not depend on θ_n'' or on current public goods supply $x^*(\theta_n',r)$, and these $K_n(r)$ achieve balance when $x^*(\theta_n',r) = x''(r)$. The limited reporting requirements for the principal give some flexibility in the specification of individual incomes $F_n(p^*(r),x^*(\theta,r))$; these can be approximations that only need to lead to the same solution (7) in equilibrium that is given by (6) and (8). For example, Groves-Ledyard (1977) mechanisms for this problem can be interpreted as approximations to (6) that induce the same incentives in equilibrium.

Alternately, an important observation due to Green and Laffont (1978, 1979) that connects incentive theory to design of surveys and experiments is that one can achieve a close approximation to the socially optimal supply of public goods by eliciting preference information from a random sample of consumers. Suppose the social planner draws randomly a *jury* of M consumers from the size N population, with M much less than N. Index the jury members n = 1,...,M, denote their vector of types by $\boldsymbol{\theta}_{\leq M}$, and denote the vector of types of non-jury consumers by $\boldsymbol{\theta}_{>M}$. Suppose that all consumers are income and price takers, and that non-jury consumers take public good supply as given. Suppose that the social utility function (2) is approximated by

$$(9) \qquad W^{\#}(Y,p,x,\boldsymbol{\theta}_{\leq M}) = \frac{Y - \sum_{n=1}^{M} B(p,x,\theta_n)\cdot N/M}{N\cdot A(p)},$$

and that the incomes assigned to jury members n = 1,...,M are

$$(10) \qquad F^{\#}_{n}(p''(r),x,r,\boldsymbol{\theta}_{\leq M}'') = F(p''(r),x,r)\cdot M/N - \sum_{j\neq n \& j\leq M} B(p''(r),x,\theta_j'') - K_n(r).$$

Non-jury consumers are allocated residual income,

$$(11) \qquad F^{\#}_{>M}(r) = F(p''(r),x''(r),r)\cdot(1 - M/N) + \sum_{j\leq M}[(M-1)B(p''(r),x''(r),\theta_j'') + K_j(r)],$$

where the lump sum taxes $K_n(r)$ are fixed at levels that are sufficient for both jury and non-jury consumers to meet committed expenditures, and $p''(r)$ and $x''(r)$ are trial values that will finally be determined in an undominated Bayes-Nash equilibrium in an incomplete information game between the principal and the jury. The balance condition (3) is satisfied when x determined by the principal as a result of jury reports agrees with $x''(r)$. Suppose that private good prices are set to satisfy a version of (4),

$$(12) \qquad p(\boldsymbol{\theta}_{\leq M}'',\boldsymbol{\theta}_{>M},x,r) \in \operatorname{argmin}_p W(F(p,x,r),p,x,\boldsymbol{\theta}_{\leq M}'',\boldsymbol{\theta}_{>M}),$$

where $W(F(p,x,r),p,x,\boldsymbol{\theta})$ is the exact population welfare function from (2). Provided non-jury consumers report their true types, which is for them an undominated strategy that maximizes their utility from private goods since they have no voice in the determination of public good supply, and jury consumers also take private good prices as given, (12) achieves a Walrasian equilibrium in private goods. The solution (12) can equivalently be obtained by the principal acting as a Walrasian auctioneer. Then, in the incomplete-information public goods game played by the principal and the jury, truth-telling by the jurors is again an undominated Bayes-Nash strategy. This modified game has the following features: First, when the jury is of modest size, it is plausible that each member will recognize that she may be pivotal, and thus recognize that reporting her true type is an undominated strategy. Second, when the population is large, it is plausible that all consumers will treat the determination of income and private good prices as given and outside the range of effective individual strategic manipulation. This distance is enhanced

if the lump sum taxes for jury members are not tied to public good supply once sufficiency bounds are met, and the allocated effects of adjusting non-jury income to meet the balance condition are not noticeable to non-jury consumers. Third, if jury membership is not public knowledge, it will be difficult for jurors to form the coalitions that can upset the individually incentive compatible Groves-Clarke mechanism. Finally, the supply of public goods determined in the jury game will under mild conditions approximate well the optimal supply determined by a social planer with complete information. Assume that the committed expenditure function $B(p,x,\theta)$ is Lipschitz in its arguments on $P_1 \times X \times \Theta$, where P_1 is the intersection of P and the unit simplex. Then the jury average $\sum_{n=1}^{M} B(p,x,\theta_n)/M$ obtained by sampling without replacement has exponential functional convergence to the population average $\sum_{n=1}^{N} B(p,x,\theta_n)/N$; i.e.,

$$\text{(13)} \qquad \text{Prob}(\sup_{p,x} |\sum_{n=1}^{M} B(p,x,\theta_n)/M - \sum_{n=1}^{N} B(p,x,\theta_n)/N| > \lambda) < C\cdot\exp(-2M\,\lambda^2/D),$$

where C is a constant determined by the Lipschitz constant of B on $P_1 \times X$ and D is a bound on the variation of B in the population.[7] If the solution (4) for optimal public good supply is regular in the sense that small perturbations in the objective functions induce small perturbations in the maximand, then there will also be exponential convergence of the jury determination of public good supply to the population optimal supply.

The public goods exercise I have just outlined appears in its essential details in many textbooks, and a large literature to which Laffont was a central contributor goes on to give a full characterization of the conditions under which direct revelation mechanisms exist. This work in turn has provided a powerful framework for study of optimal contracts between principles and agents in the presence of asymmetric information. My reason for revisiting this problem is to motivate three observations: First, the task facing the social planning principal in the example, and quite generally in principal-agent problems, is an econometric task of collecting reliable data from the agents. The data in the example are consumer types that define tastes, but comparable issues arise when the desired data are perceptions, levels of effort, states, or attitudes. Second, responses from consumer agents depend on the framework and format of the elicitation, which define the task, the rewards, and the incentives that the respondents face. The principal should anticipate that consumers will not passively give accurate, truthful responses when faced with incentives to behave otherwise, and that they may make errors when responding to incentives. Third, direct revelation mechanisms that work when consumers maximize preferences and recognize undominated Bayes-Nash strategies will falter if consumers do not have well-defined stable preferences, or fail to adopt the behavior rules that preference maximization requires.

In this presentation, I am going to discuss consumer behavior, and how incentive theory can be used to design economic surveys that collect more accurate data from consumers. I will discuss what observations on consumer behavior in surveys and in real markets suggest for the limitations of classical incentive theory grounded on assumptions of

rationality. I will use these to suggest opportunities for new research on applications of incentive theory in a behavioral world. These topics are by no means new ones, and much of what I have to say draws upon an extensive literature that has been developing for a long time, and includes substantial contributions by Laffont. However, I hope to persuade you particularly that viewing incentive and principle-agent problems as econometric data collection exercises with fractious, interactive respondents, and viewing observed consumer behavior in surveys and markets as evidence on the perceptions and motivations of agents facing incentives, is quite helpful for research in applied economics.

2. Incentives and Behavior in Economic Surveys

It is natural to interpret economic surveys as principal-agent problems. Each consumer agent has information that the investigator principal wants, and an objective of survey design is to encourage consumer participation, and complete, accurate, truthful answers. *Ex ante*, subjects may be given incentives for participation and effort. *Ex post*, the investigator may use audits, calibration, cross-validation, and statistical analysis to identify and correct errors. *Ex ante* incentives may include rewards for satisfying ex post audits or consistency checks, and surveys may be designed to facilitate *ex post* error control, for example through redundancy that allows internal consistency checks.

A distinction is sometimes drawn between surveys, where incentives are often weak or hypothetical, and subjects may be rather passive, and experiments where incentives are real and treatments manipulate the environment to stimulate subject reaction. However, this distinction is blurred by internet survey technologies that now make it relatively easy to embed experiments within surveys and make survey tasks interactive. While I will concentrate on surveys, my comments will in most cases also apply to experiments.

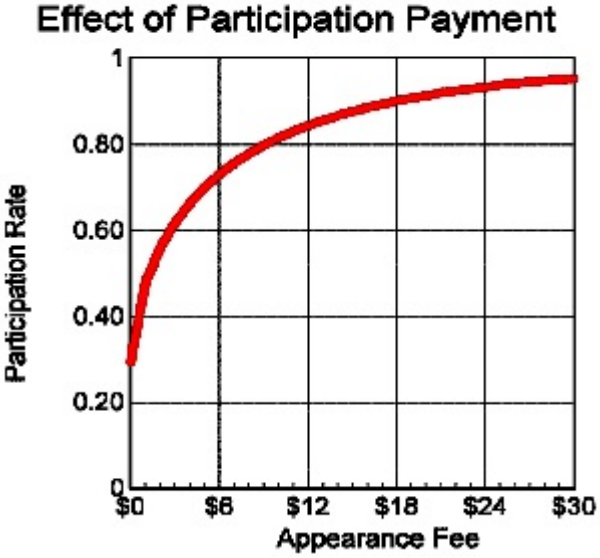
Recruitment and Attrition

Consider first the recruitment of subjects. Surveys are burdensome, and participation incentives are usually required. Experience in the U.S. is that a sufficient inducement for most consumers is roughly the minimum wage for the time the survey requires. This is often made as an unconditional payment, triggering the social norm for reciprocity, rather than as a wage for participation. These strategies seem to work because this relatively nominal payment is interpreted by subjects as a token that the survey is serious, and a well-designed questionnaire retains subjects by offering them an opportunity to talk about themselves and offer opinions. Thus, the contract for participation is a blend of monetary payments, exploitation of social norms, and non-monetary rewards. Alternative strategies for inducing participation are to offer lottery tickets for relatively large prizes, or to offer a charitable contribution in the subject's name. These are reportedly less successful, probably because it is hard for the principal to make a convincing commitment that the transaction will be completed.

As shown in a series of important papers by Philipson (1997, 1999, 2001) and Ryu, Couper, and Marans (2005), the sample recruitment problem can be considered as a version of participation constraints in the principal-agent problem. Grossman and Hart (1983), Jewitt (1988), and Laffont and Martimort (2002, Ch. 3,5) describe these constraints in the usual principle-agent setup. The major difference in survey applications is that rather than ensure the participation of a single agent, or the best among heterogeneous agents, the principal now wants to recruit as large and representative a pool of agents as possible within the survey budget. Factors entering this problem, in addition to appearance fees, are the costs of acquiring and completing interviews, the effect of appearance payments on participation, and the costs of a non-representative sample.

I will use an example to illustrate the considerations involved. Let c denote the cost of contacting a subject, k the cost of a completed interview, m an appearance fee, and p(m) the participation rate as a function of this fee. A non-commercial 30-minute computer-assisted telephone interview (CATI) in the U.S. typically has c = \$5, k = \$40, and the participation rate $p(m) = 1 - \exp(-0.35-0.3m^{0.65})$ plotted in Figure 1. The cost of a non-representative sample will depend on the application. For the example, I measure imprecision by using a method of Horowitz and Manski (1995), Manski (2005), and Imbens and Manski (2005) to attach a confidence interval to a parameter estimate that is partially identified due to sample attrition. Suppose π is the population frequency, and for the example assume $\pi = ½$. Assume also that there is no prior information on attritors that narrows their range of response. Then with at least 95 percent probability, π is covered by the Manski confidence bound

Figure 1



$$(14) \qquad [\min(p(m)\pi^{\#},\pi^{\#}-2(\pi^{\#}(1-\pi^{\#})/N)^{½}),\max(p(m)\pi^{\#}+1-p(m),\pi^{\#}+2(\pi^{\#}(1-\pi^{\#})/N)^{½}],$$

where $\pi^{\#}$ is the estimated frequency in the completed sample. Suppose the principal's objective is to minimize the width of this interval subject to $N(m + k + c/p(m)) \leq C$, where C is a survey budget constraint. Figures 2 plots optimal survey features against the survey budget, and Figure 3 plots the Manski confidence width from (14), and classical confidence widths that ignore attrition, against the survey budget. Appearance fees rise at a diminishing rate with survey budget, and the variation in optimal sample sizes with survey budget are nearly linear. As a result, the Manski as well as the classical confidence widths are nearly proportional to $C^{-½}$. Comparing the Manski and classical confidence widths, It is clear from the example that attrition can severely limit survey reliability, and substantial appearance fees may be optima even with limited survey budgets.

Figure 2

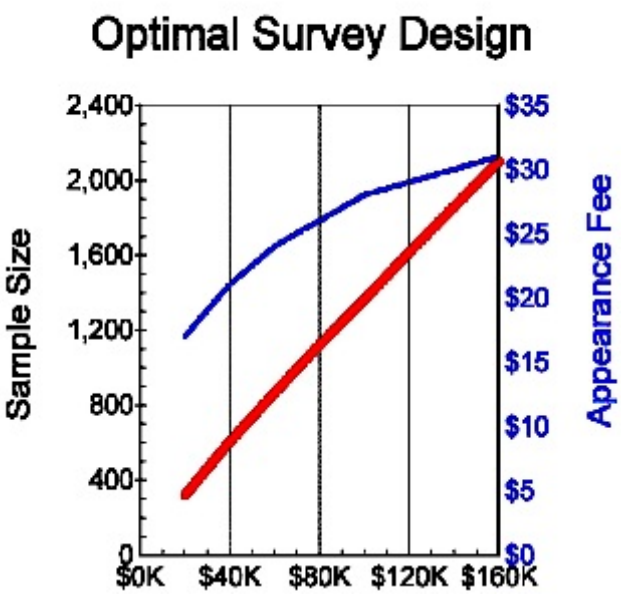
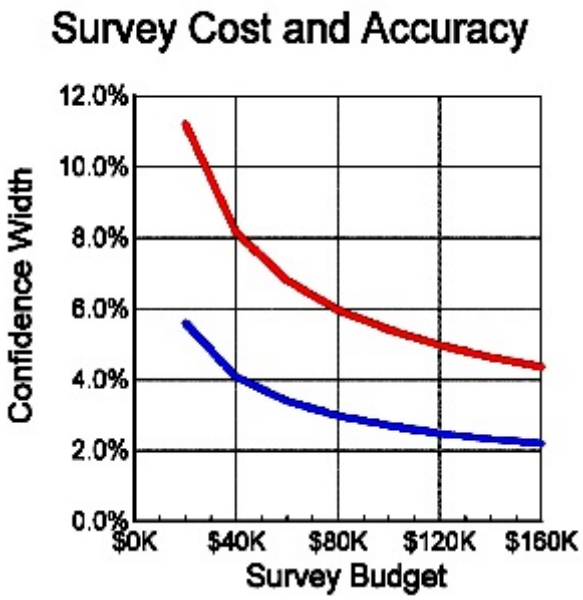


Figure 3



Reasonable incentives will not result in universal participation, and ex post mitigation of the effects of sample selection is required. Classical econometric methods for this include the univariate selection model of Heckman (1974), generalized in many papers and textbooks to handle multivariate effects and non-parametric treatments; methods for inferring the effects of treatments on the untreated (e.g., Heckman and Robb, 1975); and sample weighting (e.g., McFadden, Heiss, and Winter, 2006). Philipson (1997) analyzes the case where one is interested in the distribution of a variable, and attrition truncates a tail of this distribution. The following paragraphs extend his approach to a bivariate selection model in which the structure of the distribution of variables of interest given selection can be analyzed. What the previous example, Philipson's work, and this extension suggest is that one should consider ex ante and ex post methods for data error control in tandem, taking into account the effects of appearance fees on the need for and possibility of econometric mitigation. In particular, exogenous variation in the degree of selection is a critical element in ex post identification and mitigation, and experimental treatments in appearance fees can provide the needed identification.

The bivariate attrition model defines a latent variable a* satisfying

(15) $$d^* = g(z,m) - \eta$$

where η is a standard normal disturbance, g is a function that is increasing in the appearance fee m and influenced by observed exogenous variables z, with d* determining an indicator $d \equiv \text{sign}(d^* \geq 0)$ that is positive for survey participants. Then, $\text{Prob}(d|z,m) = \Phi(d \cdot g(z,m))$ is the conditional probability of attrition (d = -1) or participation (d = 1). The function g(z,m) can be estimated by parametric or non-parametric regression when (z,m) is observed for attritors as well as participants; see Matzkin (1992). Estimation of g(z,m)

remains possible when $z = (z_1,z_2)$ has z_1 observed for everyone, m drawn from a density $f_M(m|z_1)$ given z_1, and z_2 observed only for participants, provided the population density $f_2(z_2|z_1)$ and the overall participation rate $p(m,z_1)$ given m and z_1 are available, since then Bayes law implies $\Phi(g(z,m)) = f_2(z_2|z_1,m,d=1)p(m|z_1)/f_2(z_2|z_1)$.[8]

Suppose that the determination in the population of a variable of interest y is described by a structural model

(16) $$\varepsilon = h(y,x,\eta),$$

where ε is a standard normal disturbance that is independent of η, and h is a function that is increasing in y and influenced by exogenous variables x that may overlap z. When the shape of h is not restricted, there is no loss of generality in the assumption that η and ε are independent normal. This model has been analyzed by Imbens and Newey (2002) and Chesher (2005), and is a special triangular case of systems of nonparametric simultaneous equations for which Matzkin (2006) has provided identification conditions and estimators that apply here. If attrition occurs "at random", then h does not depend on η and its estimation is not influenced by attrition. In this case, the only purpose of appearance fees is to minimize the expected survey cost per completed interview. However, if h does depend on η, attritors have different y behavior than non-attritors, and consistent estimation of the model must account for the effects of attrition. If $h(+\infty,x,\eta) = +\infty$, then the sample conditional CDF is

(17) $$F_{Y|x,z,m,d=1}(y) = \int_{-\infty}^{g(z,m)} \Phi(h(y,x,\eta))\varphi(\eta)d\eta/\Phi(g(z,m)).$$

Diferentiate this expression with respect to m,

$$\partial F_{Y|x,z,m,d=1}(y)/\partial m = [\Phi(h(y,x,g(z,m))) - F_{Y|x,z,m,d=1}(y)]g_m(z,m)\varphi(g(z,m))/\Phi(g(z,m)),$$

and invert to obtain

(18) $$h(y,x,g(z,m)) = \Phi^{-1}[(\Phi(g(z,m))/g_m(z,m)\varphi(g(z,m)))\cdot\partial F_{Y|x,z,m,d=1}(y)/\partial m + F_{Y|x,z,m,d=1}(y)].$$

One can plug in estimates of g(z,m) and $F_{Y|x,z,m,d=1}(y)$, and their derivatives with respect to m, to obtain an estimate of h(y,x,g(z,m)). One can then vary m to map out the function h(y,x,η). However, limiting large appearance fees to control costs will lead to imprecise estimates of h at large η, and will leave h unidentified if η exceeds $g(z,m^*) < +\infty$, where m^* is an upper bound on appearance fees. Then, the population CDF of y given x, $F_{Y|x}(y) = \int_{-\infty}^{+\infty} \Phi(h(y,x,\eta))\varphi(\eta)d\eta$, will be only partially identified. If Manski bounds are attached to the partially identified and imprecisely estimated $F_{Y|x}(y)$, then the incentive problem is to design a sample size and a treatment CDF $F_{M|z}(m)$, conditioned on variables observable before participation is determined, to minimize bound width subject to a budget constraint on

expected survey costs. An important feature of this setup is the interaction between survey design and the effectiveness of econometric mitigation of the effects of attrition.

One elementary case of this model occurs when the participation disturbance in (16) has the special additive form $\varepsilon = h(y,x) - \lambda\eta$, so that attrition has a monotone effect on y, as in the analysis of Philipson (1997). Then, $F_{Y|x}(y) = \Phi(h(y,x)/(1+\lambda^2)^{1/2})$ and (18) reduces to

$$(19)\quad h(y,x) = \Phi^{-1}[(\Phi(g(z,m))/g_m(z,m)\varphi(g(z,m)))\cdot\partial F_{Y|x,z,m,d=1}(y)/\partial m + F_{Y|x,z,m,d=1}(y)] + \lambda g(z,m),$$

with the required invariance of the right-hand-side with respect to m providing a method of testing the consistency of the specification, and estimating λ.

My appearance fee examples make no allowance for the possible effect of non-monetary incentives. In a survey of the effect of incentive payments on participation and effort, Camerer and Hogarth (1999) conclude that the effects of economic incentives are confounded in practice by less easily quantified non-monetary incentives. This suggests a number of principal-agent questions. First, sample recruitment is typically a multi-stage process, from selection of sampling units to subject contact, to recruitment, to completion of the interview. At each stage, more is learned about the potential respondent. How should this information be used to refine the effectiveness of the participation payment? If attrition is correlated with unobserved and observed factors, how should this background information be collected and used to determine participation payments? Is it possible to elicit information from subjects that can be used to individualize their appearance fee and minimize the transfer of infra-marginal surplus? A question that overlaps issues of response completeness and accuracy is whether participation payments should be conditioned on performance, such as number of questions answered, number of internal consistency checks passed, or number of external audits or validations passed. How can the principal, in the context of casual contact with subjects, pre-commit convincingly that promised payments will be made based on performance?

Item Response Accuracy

Next consider the issue of reliability of survey responses. Accurate responses often require subjects to concentrate on the cognitive task that questions pose, which may demand memory recall and cognitive processing. Questions that are viewed as having factually or socially "correct answers", possibly subject to verification or audit, may induce greater effort than ones that do not. Subjects may respond to incentives, but small rewards may be ignored or overwhelmed by other motivations. Finally, there may be substantial heterogeneity in subject behavior, including differences in the construal of questions and in approaches to problem-solving.

Table 1 gives examples of different types of survey questions and associated reliability issues. The dimensions considered in this table are the degree to which construing the

question and forming a response requires cognitive effort, the degree to which the subject must recall facts and experiences from memory, and reconstruct imperfect memories, whether the question invites strategic misrepresentation for monetary or non-monetary motives, and whether the response is subject to external validation, either in the aggregate or at the level of the individual. In addition to these dimensions, questions vary in whether they are personal or impersonal (e.g., own mortality risk versus cohort mortality risk), whether they are objective or subjective (e.g., level of blood pressure versus level of stress), and whether they are of low or high volatility (e.g., level of education versus current mood). Aggregate validation typically comes from external information on population distributions or moments, but may be confounded by non-random attrition in addition to individual response errors. Individual validation typically comes from audits of consumer records or cross-links to administrative data. In addition to external validation, there may be internal consistency checks, through overlapping questions and from test-retest consistency. Finally, there are two powerful "bottom-line" methods for validation. The first is to give the subjects experimental treatments, and test for the invariance of responses to irrelevant treatments (e.g., elicitation format) and sensitivity of responses to relevant treatments (e.g., effect on mortality risk of information treatments on new therapies for cancer). The second is the predictive validity of responses (e.g., the prediction of mortality from self-rated health status.)

Table 1. Question Types and Reliability Issues
External Validation: A = Aggregate, I = Individual

Example	Cognitive Framing and Processing	Memory Reconstruction and Recall	Strategic Incentives	External Validation or Audit?
1. Age, Gender	—	—	—	A or I
2. Income	✓	✓	—	A or I?
3. Consumption, Wealth	✓✓	✓✓	—	A
4. Length of Amazon	—	✓✓	—	A
5. Number of doctor visits	✓	✓✓	—	A?
6. Mortality risk	✓	✓	—	A or I
7. WTP to save seabirds	✓✓	—	✓✓?	—
8. Self-reported health	✓	—	—	—
9. Happiness	✓	✓	—	—

In Table 1, the first five question types are objective, the last three are subjective, and the mortality risk question is a subjective perception of an objective event. In most cases, objective question responses can be validated in aggregate; e.g., the distribution of

reported ages can be compared with population life tables. Whether sample deviations from a population distribution are due to attrition or to mis-reporting may require exploration. For example, it is typical to assume that age and gender are reported accurately, so that sample deviations must be due to attrition and are potentially correctable by sample weighting. However, there may be some mis-reporting of age for non-monetary strategic reasons. In practice, this particular mis-report does not appear to be common, but in areas where there is some social opprobrium, under-reporting can be substantial (e.g., subjects systematically under-report frequency of smoking, drinking, and cheating on income taxes). Auditing at the individual level can be expensive and intrusive, for example validating reported income against social security administrative records, or validating reported medication use against pharmacy records. However, it can provide a gold standard for mitigation of response bias. Importantly, if subjects are made aware of the possibility of audits, or rewarded for consistency of reports, this can be an incentive that substantially improves effort. Philipson (1999) has studied the effects of audits and rewards for consistency on survey responses, and in a survey of physicians finds that audit-based incentives work well. This is consistent with studies of the effects of audit probabilities on compliance in income tax reports; see Kim (2005).

The example questions in Table 1 differ in terms of the demands they place on the subject for cognitive framing and processing, and for memory recall and reconstruction. First consider cognitive issues. If a question is unfamiliar or ambiguous, the subject must parse its meaning and interpret the task it poses. For example, if a subject is asked her subjective probability that she will have a heart attack in the next five years, she needs to determine what conditions constitute the event (e.g., should congestive heart failure be included?), form an estimate of population risk, combine that with an estimate of relative risk given her health history, integrate that risk over a five-year future taking into account competing and complementary risks, and finally translate this into a response on her interpretation of a probability scale. If she is asked for her income last month, she must determine whether to include realized or unrealized capital gains, whether to include transfers or gifts, whether to include income-in-kind, and whether to report before tax or after tax income. Finally, she may need to aggregate income from different sources. If questions are asked with sufficient qualifications and descriptions to reduce ambiguity, then they may be difficult for the subject to absorb. For example, Schwarz and Hippler (1995) find that the portions of survey questions that subjects attend depends on the elicitation format – in telephone interviews, the early parts of questions tend to be forgotten or obscured, while in written questions, the latter parts tend to be ignored. Some questions such as consumption last month are difficult to answer not only because of ambiguity in what items should be included (durable purchases, annual payments?), but also because the variable is not one that the individual customarily observes or calculates. The limited ability of respondents to handle numerical tasks is a source of errors, and more fundamentally a factor in task construal and problem-solving mode. For example, Peters *et al* (2006) find that subjects low in "numerosity" are likely to use analogies and emotional judgments in place of calculation, and as a result are more susceptible to "numerical illusions". In a classical experiment, subjects are offered a choice of two lotteries. In lottery A, they win if they draw a red ball from an urn containing one red and nine white

balls. In lottery B, they win if they draw a red ball from an urn containing 9 red and 91 white balls. Respondents with low numerical skills often choose urn B because it "offers more changes to win".

Questions that require memory recall present challenges to subjects similar to school tests, and are often processed in the same way, with the subject using cues embedded in the question and exemplars or analogies to reconstruct incomplete memories. For example, subjects given a multiple choice question on the length of the Amazon river tend to avoid extremes of the range presented, and anchor their responses to their perception of how the surveyor would frame the question around the correct answer. The phenomenon of anchoring, reported in an early study of Tversky and Kahneman (1974), has been widely studied. Green, Jacowitz, Kahneman, and McFadden (1998) show that it is present in "yes/no" as well as quantitative responses, and operates similarly for both objective and subjective questions. Hurd, McFadden *et al* (1998) show that anchoring is a significant issue in the framing of questions in economic surveys, with the distributions of wealth and consumption in the Health and Retirement Study substantially influenced by anchoring to bracket boundaries in unfolding bracket questions.

Recall and integration of past experience can require substantial effort, and can lead to systematic mis-reporting. Objective questions such as "How many doctor visits did you make during the last year?" are typically under-reported – initial, recent, and prominent events mask others, and it is difficult to place unmemorable past events on a time scale. Answers are reconstructed from and biased toward remembered exemplars. This under-reporting can be detected in audits, but also through internal cross-validation; e.g., are reports of doctor visits by condition or by month consistent with reports for a year. Prompting by type of visit may increase counts, just as prompting for wealth by asset category increases reports of total wealth. Subjective questions raise additional issues. The question "How happy were you yesterday?" is not simply an average of responses to a series of questions yesterday asking "How happy are you right now?" Instead, the retrospective response is colored by the extremes and the most recent of yesterday's instantaneous experiences, and also colored by current affect; see Kahneman and Riis (2005). These reporting errors reflect a combination of perceptual limits and illusions intrinsic to human memory, and mistakes due to imperfect focus and lax effort. Incentives may be effective in improving focus and effort, but typically are ineffective in overcoming illusions. On the other hand, experience and learning generally allow subjects to unravel or work around perceptual illusions.

Survey responses generally have no significant consequences for the subject, so that incentives for deliberate misrepresentation are usually weak. Exceptions are questions that the subject finds embarrassing, particularly if there is a risk that others can learn the response, or where a truthful answer would violate social norms or the image that the subject seeks to project to the interviewer. Thus, subjects may fail to report health conditions if they consider them embarrassing, or if they anticipate that a truthful report will elicit further questions and require further effort. Absent significant monetary incentives for accuracy, subjects may respond to questions with social or political content by using

their responses to express opinions and attitudes. However, there is considerable survey experience suggesting that in the absence of obvious monetary, social, or effort incentives, or perceptual illusions that distort responses, subjects are typically truthful. The usual explanation is that it is less effort for subjects to be truthful than to fabricate a consistent alternative, leading them to be truthful by default unless there are significant incentives to the contrary.

When subjects are asked to state preferences or willingness to pay (WTP) for private or public goods, substantive questions of strategic misrepresentation can arise. The history of direct elicitation of preferences dates to a 1932 paper written by the psychologist Leon Thurstone at the instigation of the economist Henry Schultz. Thurstone's direct elicitation approach was largely rejected by leading economists of that day, including Frisch, Hotelling, and Friedman. The concerns of these critics were that subjects freed of the discipline of completing market transactions would fail to take measured account of prices and budget, and would use their responses to posture, or to express attitudes and opinions, making the stated preferences unreliable for predicting market behavior. There was little further development in stated preference methods until the mid-1960's, when this approach, renamed *conjoint analysis*, began to be explored as an applied tool in psychometrics, market research, and transportation research. These developments emphasized construction of preference maps through presentation of multiple choices set by experimental design. For private goods that are familiar, or given sufficiently rich description, conjoint analysis has proven to be a reliable tool for predicting market demand, and it is widely used in the design of new products.

A largely independent development of stated preference methods, called *contingent valuation* (CV) and focused on eliciting preferences for public goods, occurred in resource economics (Davis, 1963; Randall, Ives, and Eastman, 1974). The method has been promoted and used somewhat uncritically as a tool for valuing resource damage, and there is a large and contentious literature on its validity, but in methodology it is simply a form of conjoint analysis with a truncated design for the experimental presentation of choice alternatives. Hence, the concerns of its critics are those of stated preference methods in general, with added concerns about consumer's ability to generate preferences for unfamiliar public goods, respond consistently in hypothetical and real choice settings, and respond predictably to hypothetically incentive-compatible framing of survey tasks. I will illustrate and discuss these aspects and issues of incentives using the Table 1 question on seabirds, which is drawn from the study by Green *et al* (1998). Here is a full statement of the question:

"*There is a population of several million seabirds living off the Pacific coast, from San Diego to Seattle. The birds spend most of their time many miles away from shore and few people see them. It is estimated that small oil spills kill more than 50,000 seabirds per year, far from shore. Scientists have discussed methods to prevent seabird deaths from oil, but the solutions are expensive and extra funds will be required to implement them. It is usually not possible to identify the tankers than cause small spills and to force the companies to pay. Until this situation changes, public money would have to*

be spent each year to save the birds. We are interested in the value your household would place on saving about 50,000 seabirds each year from the effects of offshore oil spills.

"If you could be sure that 50,000 seabirds would be saved each year, would you agree to pay [$5] in extra federal or state taxes per year to support an operation to save the seabirds? (The operation will stop when ways are found to prevent oil spills, or to identify the tankers that cause them and make their owners pay for the operation.)

Yes _____ No _____

"What is the MOST that you would be willing to pay? $_____ per year"

Three distinct aspects of a CV protocol are (1) the *elicitation format*, or form of the requested response, (2) the *implementation frame*, or link between survey response and the (subjective) probability that a policy will be implemented, and (3) the *payment vehicle*, specifying the condition under which payment from the subject would be required, and the link between survey response and potential payment. The seabird preference elicitation is called *referendum CV*, in that subjects are asked if they would vote "yes" in a hypothetical referendum that specifies a good to be supplied and a payment. The payment or *bid* of $5 in the question above is varied experimentally to provide a profile of the distribution function of WTP at the experimental design points. This question also asked for a follow-up *open-ended* response.[9] Variations on this elicitation format are to reverse or neutralize the "Yes/No" alternatives in the referendum question, offer a multiple choice from a range, offer an unfolding sequence of referendum choices, omit the open-ended follow-up, or ask only for the open-ended response. The seabird question above is silent on whether the subject's response would have any influence on the probability that the policy will be implemented (and hence, in the terminology of Carson, Groves, and Machina, be *consequential*), and on the linkage between response and the payment that would be required upon elicitation (i.e., with payment *coupled* to response, or *decoupled*). Then, the Green *et al* study left it to the subject to make some inference on these matters.

Consider preferences for private goods such as a steak, a basket of strawberries, or a computer bag. It is reasonable to assume that most subjects have well-formed preferences for these familiar goods, and a subject will respond to an WTP elicitation in the context of the game she thinks she is playing. If she thinks the elicitation is purely hypothetical, she may express her true WTP, or misrepresent her preferences for extraneous reasons such as whimsy, carelessness, or attitude toward the experimental setting, or may overstate or understate her WTP to express enthusiasm or disdain for the offering. The absence of incentives leaves the field open for many response rules other than truth-telling. Alternately, the subject may think there is a possibility that the WTP question may be followed by a real offer to trade. This might be induced, for example, by committing before the game that one of the hypothetical choices will be really offered. The subject's incentives in this case depend significantly on her perception of how the game will be played out. If she understands that one of her hypothetical choice tasks will be

drawn at the end of the experiment, and really executed without opportunity for reconsideration, then she should treat the hypothetical choices as incentive-compatible "take-it-or-leave-it" offers, and report her true WTP. However, if she thinks that she will later have the option of declining the trade, and places some option value on having the opportunity to take or leave the trade in the future, she may overstate her WTP. Finally, if she thinks she will have an opportunity to negotiate the terms of trade once a real commodity is on the table, she may understate her WTP to establish a bargaining position. Even when there is a possibility of a real trade, if the monetary incentives are small, they may be insufficient to overcome non-monetary motives. As McFadden (2006) emphasizes, consumers are often suspicious of markets and trade offers, and may fail to consider a small monetary reward for truthful information sufficient to "sell out".

For a public good, the situation can be much more complex. Subjects are not often required to assess how such goods affect themselves and others, to discriminate clearly between their own interests and their perceptions of the general welfare, or to translate their interests into market values. They may have to "construct" their preferences for these goods based on cues provided by the context of the elicitation, and they may have difficulty isolating a specific policy from more general attitudes toward public goods of the same type. For example, consumers may find it difficult to isolate the value of preserving a specific wilderness area from their general interest in wilderness preservation, or from the related but not identical issues of preserving endangered species or controlling development. Further, consumer perceptions of how much a particular program should cost and whether it would be implemented successfully and efficiently, their role in paying for it, and the "fairness" of the costs imposed on themselves and others, can affect how they will respond to an elicitation. As in the case of private goods, if a consumer thinks an elicitation is purely hypothetical, there are no real constraints on the response rules she may adopt. Schkade and Payne (1993) collect verbal protocols describing the thought processes leading to responses to a hypothetical WTP elicitation, and find that a variety of extraneous factors, particularly related to the cost of the project or fairness of the payment vehicle, confound reporting of preferences. The literature on "hypothetical bias" in CV, which I will survey in the final section of this paper, finds that there can be substantial bias for both private and public goods, but most critically that its importance is quite sensitive to the context and framing of the CV survey.

A key implication of incentive theory is that when consumers play a public good game in which they recognize that they may be pivotal, and recognize that their payoffs internalize the social consequences of their reports, then it is rational for them to be truthful. Then, it is natural to place CV elicitations in a context that satisfies the requirements of an incentive-compatible public goods game, an implementation frame in which there is a credible possibility that a respondent could be pivotal, and a payment vehicle that removes incentives for strategic misrepresentation. The challenge is to induce subjects to believe, or behave as if they believe, these game features.

To clarify the incentive issues in eliciting WTP for a public good, I return to the formulation of the public goods game I gave at the beginning of this paper. Suppose a

population of N consumers have Gorman polar preferences of the special form $V(y_n,p,x;\theta_n) = [y_n - B_n(p)]/A(p) + \theta_n x$, with θ_n the vector of WTP per unit of public good provided. Suppose aggregate income is $F(p,x,r) = f(p) - A(p)\cdot r\cdot x$, so that the socially optimal $x^*(\boldsymbol{\theta},r)$ maximizes $x\cdot(\sum_{n=1}^{N} \theta_n - r)$ over $x \in X$. Consider the GCGL mechanism in jury form, which gives each of M randomly drawn jurors the income

$$y_{n0} + A(p)\cdot x\cdot[\sum_{j\neq n \& j\leq M} \theta_j' - Mr/N], \tag{20}$$

where y_{n0} is their base income when no public goods are provided, and non-jurors the residual. In words, the subject is told that if a public good is provided, then her income will be adjusted in net by the difference between the sum of the WTP of other jury members and the jury's pro-rated share of the cost of providing the good. The implementation frame explains that the investigator will choose $x \in X$ to maximize $x\cdot(\sum_{j\leq M} \theta_j'/M - r/N)$, the average jury net payoff. This is a *provision point mechanism* that ties implementation to an average WTP that exceeds a specific cost threshold. If each juror believes there is a positive probability that an implementation decision will be made, that if it is made it will maximize the average jury net payoff, and there is a positive probability of a configuration of reports of others and costs that would make her response pivotal, then it is an undominated Bayes-Nash strategy for each jury member to report her true WTP. The implementation frame just described nominally requires an open-ended elicitation of θ_n', but it can also be cast into a referendum format through a sequence of unfolding bracket questions that localizes the juror's WTP. This is an important point: if subjects believe the implementation frame and payment vehicle of the GCGL jury mechanism, then the elicitation format does not matter.

Another incentive-compatible mechanism that is natural for referendum elicitations has been used in public goods games by Palfrey and Rosenthal (1990, 1994), and tacitly by Hoehn and Randall (1987). Suppose for simplicity that there is a single binary public good, x = 0,1. Suppose the subject believes a payment vehicle stating that the cost to each member of the population will be r/N in the event that real unit cost r is realized and the good is provided, and an implementation frame that states that her referendum vote changes the probability that the public good will be provided, making her pivotal. This belief may be induced by survey language such as "when the cost per person of providing the good is finally determined, then the plurality in this survey who favor the project at this cost will determine whether it is actually put on the ballot". Let θ_n' denote the threshold for costs at which consumer n would vote to support the project, so that $\mathbf{1}(\theta_n' - r/N)$ is positive when this consumer will support the project at a realized cost r/N. The probability of implementation is then

$$E_{\theta_{-n}'}\Psi\left(\frac{\sum_{j=1}^{M} \mathbf{1}(\theta_j' - r/N)}{M}\right), \tag{21}$$

where Ψ is a non-decreasing function, and $\boldsymbol{E}_{\theta_{-n}'}$ is the consumer's subjective expectation. Consumer n is pivotal if either Ψ is a strictly increasing function, or if Ψ is non-decreasing and non-constant, and its expectation with respect to the WTP reports of others is strictly increasing. The last possibility includes conventional voting rules such as majority rule, provided each consumer's subjective beliefs about others is sufficiently diffuse so that she believes her vote might be critical.

Given the consequential implementation frame (21) and decoupled payment vehicle r/N, consumer n's expected utility is

$$(22) \qquad \boldsymbol{E}_{r}(\theta_n - r/N)\cdot\boldsymbol{E}_{\theta_{-n}'}\Psi\left(\frac{\mathbf{1}(\theta_n' - r/N) + \sum_{j\neq n \& j\leq M}\mathbf{1}(\theta_j' - r/N)}{M}\right).$$

Then, any report $\theta_n' < \theta_n$ lowers the probability of implementation for some events that are desirable, and any report $\theta_n' > \theta_n$ raises the probability of implementation for some events that are undesirable. Then, truth-telling in the referendum vote is an undominated Bayes-Nash strategy.[10] The difference between this setup and the GCGL one is that in this case, the effect of being pivotal operates through the probability of provision rather than through the payoff conditioned on achieving a provision point. Again, elicitation format does not matter – asking directly for the subject's threshold θ_n' or obtaining it indirectly in various referendum setups should lead to the same answer.

3. Consumer Response to Incentives

There is a large empirical literature on consumer behavior in various economic environments in the laboratory and in the field. I am going to give a very selective review of findings that shed some light on the ability of consumers to recognize and exploit choice opportunities in their own self-interest, in the presence of the incentives that naturally appear in markets, and in laboratory settings where incentives can be designed that should lead to specific behaviors if consumers can process information and choose rationally.

Behavior in Public Good Games

Mechanisms of the GCGL type are effective in obtaining truthful information if consumers recognize the opportunities provided by the choice alternatives they are offered, and seek to maximize (risk-neutral, Gorman polar, parallel Engle curve) self-interest, unconstrained by social norms and objectives. The behavioral question is whether consumers meet this standard. Some of the most striking evidence comes from voluntary contribution systems for public goods, the ultimatum and trust games, and auctions. An early paper of Bohm (1972) found that "free riding" was uncommon even in circumstances where the incentive structure invited it. Shafir & Tversky (1992) found that the dominated

strategy of cooperation is often played in the prisoner's dilemma game, apparently induced by superstitious beliefs. Fehr and Schmidt (1999), Fehr and Falk (2002), Fehr and Fischbacher (2002, 2004) Fehr and Gachter (2004), and others have found that in the ultimatum and trust games, many participants are motivated by social norms to play dominated strategies. These results suggest broadly that in circumstances where there is a perceived mutual benefit from cooperation, consumers have altruistic motives, superstitious beliefs, and social norms for reciprocity and fairness that may override pure self-interest. On the other hand, there is considerable evidence that in the competitive circumstances of second-price auctions, where the compatibility of the incentives in the auction with truth-telling are transparent, consumers tend to bid their true values; see Harstad (1990), Friedman and Rust (1993), Garratt, Walker, and Wooders (2004). Studies of behavioral response to the GCGL mechanism find that it does not induce wide-spread truth-telling in small untrained juries, but compliance increases sharply when subjects are trained and given detailed information on the payoff structure. There is also an indication that compliance falls in larger juries where the pivotal income adjustment does not loom as large and the advantages of the dominant strategy are obscured; see Attiyeh, Franchosi, and Issac (2000) and Kawagoe and Mori (2001). Chen and Plott (1996) find that compliance in the related Groves-Ledyard mechanism depends significantly on the penalty parameter in that mechanism, indicating that the magnitude of the incentive matters. Palfrey and Rosenthal (1990) find that with training, small juries show good compliance when the public goods game is played in referendum voting form.

Contrasting these results, there appear to be three main factors that determine whether consumers will comply with individual incentives: (1) whether the game is purely competitive, versus one in which benefits of cooperation are apparent and lead to responses influenced by social norms; (2) whether the mechanism is substantially individualistic and transparent, or is obscured by the operations of other players or institutions; and (3) whether or not the penalties to deviating from a compliant response are strong and obvious. Thus, second-price auctions are generally sufficiently competitive and the incentives for truth-telling are sufficiently individualistic and transparent to induce compliance. By contrast, public goods games require considerable training and clear information on payoffs to avoid erratic, non-compliant responses. In this respect, the Palfrey-Rosenthal mechanism, or the Groves-Ledyard type with a substantial penalty, appear to have some transparency advantage over the GCGL mechanism. These factors imply for survey research applications, where it is difficult to provide strong incentives and training, that compliance with the incentives of strategy-proof mechanisms is problematic, and except for purely individualistic decisions such as private good choices, responses are likely to be influenced by social norms. Consequently, it is unclear that one can obtain more reliable information in surveys using weakly incentive-compatible mechanisms than using a framework that evokes social norms for honesty and reciprocity.

Evidence on the Reliability of CV Responses

Elicitation of stated preferences, and particularly the CV method, have been the focus of most of the concentrated attention in economic survey research on the reliability of responses and the effect of hypothetical versus real incentives. The primary concerns have been the issue of "hypothetical bias", and survey methods that minimize this bias, and the incentive compatibility properties of alternative elicitation formats.

The reliability of stated preferences and their predictive power has been studied in market research, and applied areas such as transportation research; see McFadden (1980), Ben-Akiva and Morikawa (1990), Louviere, Hensher, and Swait (1999, 2000), Shen (2005), and Train and Wilson (2005). In most cases, preferences for private goods such as new consumer products are examined. Questions have centered on the format of the elicitations, particularly the "richness" of the description of choice alternatives, the form of response (e.g., choice, ranking, rating, referendum WTP, open-ended WTP), the design of multiple elicitations, and cross-analysis of revealed preferences. Methods for studying these questions include study of the internal consistency of multiple stated preferences (e.g., transitivity, monotonicity, diminishing returns), consistency between stated and revealed preferences, and predictability of real choices from stated preferences, either to subsequent offerings within the survey or to subsequent market experience.

A very broad summary of the findings are that stated preferences for private goods in a well-designed conjoint analysis are generally consistent with revealed preferences, or can be made so by calibration. The incentives provided by a positive probability of a follow-up transaction may increase compliance, but compliance without incentives is not bad, and compliance with incentives is not perfect. Stated preferences can be influenced by the framing and presentation of attributes. For example, Tversky, Sattath, & Slovic (1988) show that the decision format can change the *prominence* given to different attributes of alternatives. In choice among products, price is given more weight in a direct choice task than it is when consumers are asked to specify an attribute level that makes two alternatives indifferent. Further, price is often given more prominence in stated preferences than it is in revealed preferences, probably because it provides a common and familiar quantitative low-effort standard for comparison. There is a strong *status quo* or *endowment* effect in stated preferences, sometimes termed the WTP/WTA gap, and while this also appears in revealed preferences, its importance may vary. When goods in a stated choice experiment are unfamiliar or sparsely described, the expressed preferences are more erratic. An overall conclusion is that stated preferences for private goods collected within an experimental design that provides a good sense of verisimilitude are generally consistent with and predictive for revealed preferences, even without positive incentives for truth-telling. However, stated preferences for unfamiliar goods are erratic, partly because of the difficulty of providing sufficiently cogent descriptions of these products to make the choice problem realistic and induce the effort needed to approximate real market behavior, and partly because consumer preferences among unfamiliar objects are a construction project, poorly formed and unstable until contextual cues, experience, and perceptions come together to fix their form.

For the public goods that are commonly the target of CV surveys, such as recreational facilities, uncontaminated groundwater, and seabirds, most studies suggest that hypothetical bias is significant; see List and Gallet (2001), Venkatachalam (2004). The methods used for this assessment include internal consistency of WTP elicitations that vary by extent, adding up, and context, but most importantly the relationship between stated willingness to contribute and actual contributions. Elicitation format influences responses, and it is possible that subjects are influenced by the nominal incentive compatibility of some hypothetical formats. However, altruism, social norms, and perceptual anomalies are more likely explanations for the observed patterns; see Kahneman, Ritov, and Schkade (1999) . Authors finding substantial hypothetical bias include Azevedo, Herriges, and Kling (2003), Bennet, Provencher, and Bishop (2004), Champ and Bishop (2001), Cummings, Elliott, Harrison, and Murphy (1997), Diamond and Hausman (1994), Johannesson, Liljas, and Johansson (1998), Loomis, Brown, Lucero, and Peterson (1996, 1997), and McFadden (1994). Authors finding limited hypothetical bias include Carlsson and Martinsson (2001), Carson, Flores, and Meade (2001), Haab, Huang, and Whitehead (1999), Whitehead (2002), and Willis and Powe (1998). An overall assessment is that studies finding the least bias focus on private goods, and that proponents of CV find fewer problems with hypothetical bias than do critics.

Incentive compatibility of CV elicitations of WTP, and the role of elicitation format, has been a continuing concern of environmental economists; see Randall, Ives, and Eastman, 1974), Randall, Hoehn, and Brookshire (1983), and Hoehn and Randall (1987). Careless treatment of incentive issues, particularly failure to distinguish clearly between circumstances where incentives are hypothetical or real, and to distinguish between the theoretical incentive compatibility of mechanisms and behavioral compliance, have led to confusion in the resource economics literature regarding the influence of elicitation formats, and the relevance of private good choice behavior to public good choice behavior; e.g., the claim by Hoehn and Randall (1987), Carson, Groves, and Machina (1999), and Loomis, Brown, Lucero, and Peterson (1996) that only a referendum format can potentially elicit incentive-compatible responses. The discussion of incentive compatibility given in the previous section of this paper, based on Green *et al* (1998), shows that when a CV elicitation is presented within a consequential implementation frame that has a credible possibility that the respondent is pivotal, then either the GCGL or Palfrey-Rosenthal jury mechanism is incentive-compatible. While there are issues with the transparency of the mechanisms, which could interact with elicitation format, and with the training needed for subjects to be aware of their payoffs, there are no first-order differences in incentive-compatibility between elicitation formats that employ the same payment vehicle.

The most relevant experimental tests of incentive-compatibility for public goods have been conducted in laboratory or quasi-laboratory settings where small juries have used alternative mechanisms to determine provision and cost-sharing. Results are mixed, with many studies finding significant hypothetical bias. Champ, Flores, Brown, and Chivers (2002) find that payment vehicle (e.g., referendum on mandatory tax, unspecified voluntary donation, and voluntary contribution with provision-point mechanism for implementation) matters in a hypothetical, but perhaps taken as realistic, elicitation of WTP for acquisition

of park land in Boulder, Colorado. Cummings, Harrison, and Rutstrom (1995) and Cummings, Elliott, Harrison, and Murphy (1997) find in a laboratory CV experiment conducted under hypothetical and real conditions that subjects are not usually truthful in referendum responses. Lusk and Schroeder (2004) find significant hypothetical bias in WTP for beef steaks. Loomis, Brown, Lucero, and Peterson (1996, 1997) find strong hypothetical bias in experiments comparing hypothetical CV and real second-price auctions. However, Frykblom (2000) does not find significant hypothetical bias in another comparison of referendum and second-price auction mechanisms. A number of authors have suggested variations on the CV method that appear to have less hypothetical bias, or provide a better basis for calibration to remove this bias. List (2002) investigates choice experiments for a private good and a public good contribution, This method fits within the general methods of conjoint analysis used in market research. The findings that private good choices conform to truth-telling is then not surprising, but the carry-over to the voluntary contribution task is, and the details of List's mechanism may prove instructive to designers of WTP elicitations. Rondeau, Schulze, and Poe (1999) and Poe, Clark, Rondeau, and Schulze (2002) compares hypothetical referendum WTP with that obtained from a provision point mechanism, finds smaller gap than in experimental comparison with a voluntary contribution mechanism. However, calibration is an imperfect method for overcoming hypothetical bias, because it must rely on comparison commodities that may not be good proxies for the target good. For example, Fox, Shogren, Hayes, and Kliebenstein (1998) find that calibration factors are commodity-specific.

Consumer Response to Large Incentives

At a basic level, the fact that humans can function and survive in market economies indicates that they recognize and act upon the economic incentives they face. However, there is a long-standing question in economics as to whether this comes from conscious, relentless preference maximization, or from less coherent and organized use of heuristics that give satisfactory results in most circumstances. In familiar settings, these alternatives models of behavior may be largely indistinguishable, but in an unfamiliar setting such as play of a public goods game or making a choice among new products and services, heuristics may be incompatible with rational response to the incentives in the situation. Then, it is useful to look for designed or natural experiments where consumers are confronted with novel decisions and their responses can be assessed against rational standards. The answers can help to guide mechanism design – can it rely on economic incentives alone, or is a degree of paternalism needed to inform, train, and coax consumers to act in their self-interest?

There is considerable evidence that in familiar decision-making circumstances where self-interest matters, consumers are approximately rational. Studies of choice among lotteries with large payoffs by Binswanger (1980) and by Attanasio, Barr, and Cardenas (2006) have been found to conform closely to postulates of rational decision-making under uncertainty. List (2003) and Garratt, Walker, and Wooders (2004) find that experienced market decision-makers show few behavioral anomalies. Winter, Heiss, and McFadden

(2006) and Heiss, McFadden, and Winter (2006) study the opening of a new subsidized prescription drug insurance program in the U.S. for the elderly. This program works through voluntary enrollment in one of a menu of private plans. Immediately prior to the start of the program, we surveyed consumers and asked their enrollment intentions. That survey also collected data on prescription drug use, which determines whether the program would be immediately beneficial to a risk-neutral consumer. Immediately after the open enrollment period ended, we surveyed these consumers again and asked their enrollment choices. The tables given below that summarize some findings from this study are weighted to correct for attrition, and totals differ because of attrition and item non-response; see McFadden, Heiss, Jun, and Winter (2006).

This study finds, among those who faced a choice, a significant association between the prospective that the program would yield current benefits and intentions to enroll. Table 2 shows, however, that 19.6 percent of those for whom the program would be currently beneficial stated an intention to not enroll, contrary to self-interest, and 57.2 percent of those for whom the program is not currently beneficial nevertheless stated that they intended to enroll. Risk aversion and the option value of locking in a low premium give some future value to enrollment even without current benefits, but intentions overall do not seem to reflect careful analysis of benefits.

Table 2. Is Coverage Immediately Beneficial? & Intentions

Likely to Enroll?	No		Maybe		Yes		Total	
Yes	125	57.2%	121	57.6%	941	80.4%	1,187	74.2%
No	94	42.8%	89	42.4%	229	19.6%	412	25.8%
Total	219		210		1,170		1,599	
	13.7%		13.1%		73.2%			

As Table 3 shows, intentions are moderately predictive for choice. However, most who thought it unlikely that they would enroll nevertheless did so. This program was relatively complex and consumer information was initially limited. Stated intentions did not prove to be reliable in this circumstance where the alternatives were complex and the information incomplete, even though these consumers faced an immediately pending decision.

Table 3. Likely to Enroll? versus Enrollment Choice

Enrolled?	Yes		No		Total	
Yes	948	97.4%	282	83.0%	1,231	93.7%
No	26	2.6%	58	17.0%	83	6.3%
Total	974		340		1,314	
	74.1%		25.9%			

Table 4 gives actual enrollment choice for consumers for whom the program is immediately beneficial or not. Virtually all consumers for whom the program would be clearly immediately beneficial discovered this and enrolled; only 3.9 percent of this group made a choice contrary to their self-interest. On the other hand, 82.6 percent of those for

whom the program would not be immediately beneficial also enrolled, a rate difficult to explain by rational calculation of risk-aversion or option value. Overall, 14.3 percent of the elderly population made choices that are poorly explained by the immediate benefits of the program, and are unlikely to be adequately explained by risk-aversion and discounting. Overall, these results are consistent with the proposition that most, but not all, consumers faced with substantial incentives respond rationally.

Table 4. Is Coverage Immediately Beneficial? & Choices

Enrolled?	No		Maybe		Yes		Total	
Yes	150	82.6%	153	91.7%	928	96.1%	1,231	93.7%
No	32	17.4%	14	8.3%	38	3.9%	83	6.3%
Total	181		166		966		1,314	
	13.8%		12.7%		73.5%			

Conclusions

In overview, I conclude that when incentives are large, consumer behavior shows little deviation from rationality, not only in familiar choice settings, but also surprisingly in complex, unfamiliar ones. There are exceptions. The quality of decision-making is heterogeneous, and there will usually be a fringe of consumers who are unable to get it right. When choices involve remote future consequences, uncertainty, or affect, this fringe grows. However, when incentives are small or unclear, less effort goes into determining best choices, and irrelevant factors play a larger role. Consumers are surprisingly truthful in circumstances where they don't need to be, but they may not supply the concentration and effort required to be accurate. Unfortunately, most economic surveys fit the case of small or unclear incentives, with little built-in control of effort and accuracy. The use of incentive theory, for example the Philipson (1999) suggestion to reward responses that are validated, is a promising avenue for bringing economic consumers up to the task of providing the information needed to implement the broad program of mechanism design set out by Jean-Jacques Laffont and others for organization of resource allocation for public and private goods in a world of imperfect information. However, inconsistency in consumer response to incentives, particularly when their consequences are perceived as small or ambiguous, appears to be a problem that needs to be taken into account in drawing policy conclusions from principal-agent theory.

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ENDNOTES

1. In addition to Jean-Jacques Laffont, major contributors to the theory of incentives and resource allocation in the presence of asymmetric information include George Akerlof, Peter Diamond, Jerry Green, Ted Groves, Oliver Hart, Bengt Holmstrom, John Ledyard, Eric Maskin, Jim Mirrlees, Paul Milgrom, Roger Myerson, Joe Stiglitz, Jean Tirole, Oliver Williamson, and Bob Wilson.

2. Sources for the following description are Green and Laffont (1977, 1979), Groves and Ledyard (1977), Maskin (2004), and McFadden (1999, 2004).

3. I use the conventional terminology that a concave function A(p) is *conical* if it is homogeneous of degree one, and *closed* if its epigraph $\{(p,a)\in P\times\mathbb{R}|a\leq A(p)\}$ is a closed set. A closed concave function is continuous on the interior of P, and finite and upper semicontinuous on $P = \{p|A(p) < +\infty\}$. When income is sufficient to cover committed expenditure, the Gorman polar form is dual to the preferences

$$U(z,x,\theta_n) = \inf_{p\in P} V(p\cdot z,p,x;\theta_n) \equiv \inf_{p\in P} \frac{p\cdot z - B(p,x,\theta_n)}{A(p)}.$$

4. Roy's identity applied to (1) gives private good demands

$$z_n \in \nabla_p B(p,x,\theta_n) + (y_n - B(p,x,\theta_n))\nabla_p A(p)/A(p),$$

where "∇_p" denotes the subgradient correspondence, which always exists because A and B are concave, and is almost everywhere single-valued. Aggregating gives

$$Z \in \sum_{n=1}^{N} \nabla_p B(p,x,\theta_n) + (Y - \sum_{n=1}^{N} B(p,x,\theta_n))\nabla_p A(p)/A(p),$$

which coincides with the result of applying Roy's identity to W(Y,p,x).

5. Assume that for p in the non-negative unit simplex P_1 and all $x \in X$ and disturbances r, F is bounded and *sufficient*; i.e., there exists a constant M such that $M > F(p,x,r) > \sum_{n=1}^{N} B(p,x,\theta_n)$. This

assumption is satisfied, for example, if each consumer can subsist on her private endowment ω_n, or $p\cdot\omega_n > B(p,x,\theta_n)$, the outputs of the technology of the economy are bounded when its inputs are bounded, and there is a public endowment ω_0 sufficient to produce any public good vector in X. Shephard's identity gives private good supply $Q = \nabla_p F(p,x)$, where ∇_p denotes the subgradient correspondence which always exists because of the convexity of F, and is almost everywhere single-valued.

6. The assumptions on A, B, and F and the sufficiency of income guarantee that the social indirect utility function $W(F(p,x,r),p,x,\boldsymbol{\theta})$ is non-negative, quasi-convex, closed, and homogeneous of degree zero in p on P, and is continuous on X. Hence the minimum of this function in p exists for each x and is continuous in x, and the minimand $p(\boldsymbol{\theta},x,r)$ is a correspondence that is upper hemicontinuous on X. The net private good supply Q - Z of the economy is contained in the subgradient correspondence $\nabla_p W(F(p,x),p,x) = \nabla_p F(p,x) - \sum_{n=1}^{N} \nabla_p B(p,x,\theta_n) + (Y - \sum_{n=1}^{N} B(p,x,\theta_n))\nabla_p A(p)/A(p)$; then, the minimand $p(\boldsymbol{\theta},x,r)$ achieves balance in private goods markets and defines a competitive equilibrium for each x, r, and profile of consumer types $\boldsymbol{\theta}$. Substituting $p(\boldsymbol{\theta},x,r)$, $W(F(p(\boldsymbol{\theta},x,r),x,r),p(\boldsymbol{\theta},x,r),x,\boldsymbol{\theta})$ is continuous on the compact domain X, so that $x^*(\boldsymbol{\theta},r)$ and $p^*(\boldsymbol{\theta},r) = p(\boldsymbol{\theta},x^*(\boldsymbol{\theta},r),r)$ exist. They are not necessarily unique. The vector $(x^*(\boldsymbol{\theta},r),p^*(\boldsymbol{\theta},r))$ defines an equilibrium when all consumers self-report their consumer type truthfully, and treat p*, x* and their income functions as given and not subject to strategic manipulation. The setup given here coincides with Green and Laffont (1977) and Groves and Ledyard (1977) with the minor exceptions that I allow the quasi-linear Gorman utility to be influenced by interactions between public and private goods, and include a disturbance r so that the final cost of provision of public goods may be unknown to consumers when they report their types.

7. This result is based on Hoeffding's inequality, which applies to independent mean zero random variables with bounded range. But the distribution of the absolute value of a sample mean from a sample without replacement is stochastically dominated by that of a sample mean from a sample with replacement. Hence, the inequality also applies for sampling without replacement from a finite population. The uniformity of the bound is obtained from pointwise application of the Hoeffding inequality on a grid, and use of the Lipschitz property of B.

8. Estimation is impeded if high appearance fee treatments are sparse due to cost considerations. It may be necessary to impose a semi-parametric structure that facilitates extrapolation, such as $g(z,m) = g_1(z) + g_2(z)\cdot m^{\gamma}$, and test if this adequately approximates the tail behavior of g(z,m).

9. The referendum bids in this study were set at approximately the 25, 50, 75, 90, and 95 percentiles of the WTP distribution in a preliminary calibration sample that was asked only the open-ended question. Other common CV elicitation formats ask for a multiple choice from a bracket in a range, or an unfolding sequence of referenda.

10. In this result, it is important that the required payment given implementation is independent of the latent self-report that determines referendum votes. If, alternately, the payment is coupled to θ_n' through a payment function $q(r^*/N,\theta_n')$ that is increasing in θ_n', then the subject has an incentive to "free ride" by under-reporting θ_n'.