Public Perceptions of Regulatory Costs, Their Uncertainty and Inter-individual Distribution

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Abstract

Public perceptions of both risks and regulatory costs shape rational regulatory choices. Despite decades of risk perception studies, this article is the first on regulatory cost perceptions. A survey of 744 U.S. residents probed: (1) How knowledgeable are laypeople about regulatory costs incurred to reduce risks?, (2) Do laypeople see official estimates of cost and benefit (lives saved) as accurate?, (3) (How) do preferences for hypothetical regulations change when mean-preserving spreads of uncertainty replace certain cost or benefit?, and (4) (How) do preferences change when unequal inter-individual distributions of hypothetical regulatory costs replace equal distributions? Respondents over-estimated costs of regulatory compliance, while assuming agencies under-estimate costs. Most assumed agency estimates of benefits are accurate; a third believed both cost and benefit estimates are accurate. Cost and benefit estimates presented without uncertainty were slightly preferred to those surrounded by "narrow uncertainty" (a range of costs or lives entirely within a personally-calibrated zone without clear acceptance or rejection of tradeoffs), and more preferred than "wide uncertainty" (a range of agency estimates extending beyond these personal bounds, thus posing a gamble between favored and unacceptable tradeoffs), particularly for costs versus benefits (but even for costs a quarter of respondents preferred wide uncertainty to certainty). Agency-acknowledged uncertainty in general elicited mixed judgments of honesty and trustworthiness. People preferred egalitarian distributions of regulatory costs, despite skewed actual cost distributions, and preferred progressive cost distributions (the rich pay a greater-than-proportional share) to regressive ones. Efficient and socially-responsive regulations require transparency about both risks and regulatory costs.

Keywords: regulatory costs, perceptions, uncertainty, equity, economic literacy

1. INTRODUCTION

In order to gauge whether any technology, regulation, or inaction "does more good than harm," it makes no sense to study only the good or only the harm. Specifically in determining whether a given health and safety regulation is worth proposing or adopting, there are great virtues in taking a balanced approach to studying both the risks that might be reduced and the costs that might be incurred.[1] In general, risk and cost analyses merit similar analytic intensity and rigor, presentation clarity and honesty, individualization, valuation of individual and social utilities, analysis of countervailing (risk-risk; cost-cost) effects, *post hoc* corroboration, and study of lay and expert beliefs. For many such desirable attributes, however, particularly with regard to the analysis of uncertainty, far more attention has been paid to these desiderata in risk assessment than in cost assessment.[2]

This article is to our knowledge the first that evaluates lay understanding of and reactions to regulatory costs, including their uncertainties and the incidence of those costs across affected consumers and producers. Scholars have studied intensely how individuals process and react to information about risk, including lay beliefs and attitudes about toxicology[3] and exposure[4], risk aversion and risk taking[5, 6], responses to uncertainty in risk estimates[7], and individual differences, as in cognition and by demographics.[8, 9, 10] They also have studied responses to information about private costs (e.g., prices[11], present versus future costs[12], fairness of taxes[13]), but not how citizens process and react to information about social costs, particularly regulatory costs. Progress in understanding—and thence in reducing—miscommunication or allegedly irrational responses to risk information cannot begin to be replicated on the "cost side" of regulatory policy until we gauge the baseline of "regulatory economic literacy" and perception of regulatory costs, and probe reactions to changes thereof. This paper reports results of a path-breaking and therefore broad pilot study of lay "cost perception," involving a psychometric survey with respondents numerous and diverse enough to allow for initial conclusions and recommendations.

This article is part of a larger project[1] on analytic, methodological, cultural, and ethical differences between risk assessors and regulatory economists.(1, 14, 15, 16, 17) Perceptions of regulatory costs are covered here. In a subsequent companion piece to this article we will explore the relevance for the "value of a statistical life" (VSL) literature of a novel method for eliciting judgments about costs-lives tradeoffs first developed in the survey discussed here. (18)

This paper focuses on four basic research questions:

(1) *How well-informed are laypeople about the costs of regulations?* This parallels prior studies of basic economic knowledge about prices, taxes and other economic topics.(19, 20, 21)

(2) *Do laypeople interpret information from regulatory agencies about cost (and lives saved) as being exaggerated or understated?* This parallels research on whether public ratings of risk magnitude match official statistics.(22)

(3) *(How) do people's preferences for hypothetical regulations change when certainty of cost (or benefit) is replaced by a mean-preserving spread of uncertainty?* This parallels research on public response to uncertainty in risk estimates.(7, 23, 24)

(4) *(How) do preferences change when equal inter-individual distributions of regulatory costs are replaced with various unequal distributions, some correlated with income and some not?* Just as risks are not equally distributed,(25, 26) neither are regulatory costs,(15, 27, 28) so understanding public preferences for alternative distributions is important.[2]

The remainder of this article describes the design, instrument, and analytic approaches of this research, reports univariate and selected multivariate results, and discusses their implications for research and practice.

2. METHODS

2.1. Instrument

2.1.1. Overview

[1] See https://sites.google.com/a/adamfinkel.com/nsfprojectoutputs/home for project papers and materials.

[2] We are unaware of any parallel study that explicitly probes subjects' preferences over, or perceptions of, inter-individual distributions of risk.

The online survey instrument presented respondents with a lengthy but methodical walk-through of the estimation of, reactions to, and value judgments inherent in regulatory costs. Excluding various screens with background information or introductions to upcoming questions, respondents were asked roughly 40 questions with yes/no, Likert-scale, or single-number answers. At the heart of the survey (see Section 2.1.5 below), respondents completed an exercise in which they gauged their own beliefs about tradeoffs between social costs and life-saving benefits that they deemed wasteful, acceptably expensive, or a “bargain” for society. Respondents were compensated for their time (Section 2.3), as the survey was rather involved; the median time to complete it was 38 minutes. The survey instrument is available on-line (see footnote 1), both as a static .pdf file and as an interactive .html file that readers can use to mimic the act of taking the survey if desired.

2.1.2. Background Information

The survey opened with several short narratives emphasizing that tradeoffs are inevitable in daily life and public policy, that regulations have benefits (such as greater longevity or visibility) as well as costs (such as business costs to install complying technology or worker layoffs), that whenever we take individual or collective action to reduce risks to a certain point but no further, we have implicitly decided that further costs would exceed further benefits, and that the stopping point for life-saving regulation depends in part on the tacit or explicit value we put on avoiding a premature death—a personal judgment that *might* be informed by considering such things as lifetime earnings, jury awards, or how much an individual would pay to avoid a risk.

Just before the tradeoff elicitation (Section 2.1.5), all respondents saw a table (freely available in a pop-up window throughout the remaining survey) containing five examples of U.S. causes of death (from 5 to 125,000 deaths/year), five different examples of public expenditures ($29 million to $55,000 million annually), and three examples of programs saving lives for widely-varying costs (e.g., extrapolating 2010 Chilean miner rescue costs to the U.S. population; annual U.S. heart transplants). Respondents were also reminded that the U.S. has roughly 100 million households, that about 2 million Americans die of all causes each year, and that the U.S. GDP of about $14 trillion is equivalent to about $45,000 per person. These prompts meant that our hypothetical regulatory base case (a rule possibly saving 1000 lives nationwide, at a cost of $1 billion—see Sections 2.1.4 and 2.1.5 below) would be viewed in the context of hazards with both more (Gehrig's disease, or ALS) and fewer (rabies) annual victims, and of programs with annual expenditures both much larger (homeland security) and much smaller (air tracking of hurricanes).

2.1.3. Expected Regulatory Costs

The first questions assessed expectations about actual regulatory costs, telling respondents that

> Recently, the U.S. National Highway Traffic Safety Administration (NHTSA) required that by the year 2015, every new car sold in America will have to have a stronger roof. It must be able to withstand a force equal to three times the weight of the car if it rolled over, without crumpling, compared to current cars, whose roofs can withstand a force of 1.5 times the weight of the car. More than 10,000 Americans are killed in rollover crashes in a typical year. Taking into account only the cost to strengthen the car roof, how much do you think this regulation will add, averaged over all cars, to the cost of each new car?

Respondents also were asked to estimate the number of new cars produced in the U.S. each year, and the total annual cost of this new regulation.

2.1.4. Beliefs about Agency Estimates

A scenario about a hypothetical USEPA regulation to remove fine particles from outdoor air preceded questions about the agency's estimates of $1 billion in costs and 1000 premature deaths prevented per year, respectively. For both costs and lives saved,[3] we asked whether people expected the true value to be more, less, or the same as the agency's estimate; if they thought it would differ, by how much; and their reasons for thinking that the true value and the agency's estimate might differ (the "surprise paragraph" [Section 2.2] was an experimental manipulation testing whether people would offer different answers if prompted about unexpected outcomes).

2.1.5. Reactions to Uncertainty in Cost or Benefit Estimates

[3] The instrument used "lives saved" for simplicity, but respondents were explicitly cautioned that this meant only that the probability of death from that particular cause was reduced or eliminated, not that a regulation could prevent eventual death.

The limited research on public reactions to institutional uncertainty about risk [7, 23, 24] has not been matched with any studies of public reactions to institutional uncertainty about costs, so we probed both here by comparing attitudes about hypothetical regulations whose costs or benefits were expressed first with certainty and then with varying degrees of uncertainty (always preserving the original point estimate as the mean of each permutation with uncertainty). At the outset, we needed to ensure that each respondent would face uncertain outcomes meaningfully different for her from certainty; for example, the question "how would you feel about buying an ice cream cone costing $100, versus one that might cost between $80 and $120?" would likely elicit indifference from most people, as would comparing a certain cost of a 2-cent cone versus an uncertain cost ranging from 1 to 3 cents. The same could easily happen for hypothetical regulations, depending on the respondent's general views about what balance between cost and benefit is obviously sensible or foolish. Thus we developed personalized uncertainty ranges off of each subject's *own* reported range where she had a definite preference either for or against a regulation with a given balance of risk reduction and cost, as described below.

A hypothetical regulation of either an accident or a disease hazard was described either as costing $1 billion *or* as saving 1,000 lives (Section 2.2). The respondent first went through a process of iteration to find a value of benefit high enough (or cost low enough) that "you would definitely support the regulation." For example, for a traffic safety regulation estimated to cost $1 billion per year, the respondent (in the half-sample randomly given the cost figure and asked to balance it against lives saved) might conclude she would definitely support the regulation if it prevented at least 2000 deaths per year, but any fewer lives saved would leave her "really unsure whether you can justify the regulation to yourself" (Figure 1). Similar iteration would yield a personal estimate of how few lives saved would lead her to definitely oppose the regulation, with any intermediate value leaving her unsure whether to support or oppose it. A similar but obverse set of judgments made by the other half-sample determined the largest amount of regulatory costs in dollars at which each of these respondents would find he could definitely support a regulation that would definitely avert

1,000 premature deaths, and the lowest cost at which he would definitely oppose it. To aid in this iteration, a horizontal onscreen slider showed the raw number of dollars or lives being weighed at that point, and the implied value of a statistical life (i.e., costs divided by lives, with one such number from the instrument scenario and the other from where the respondent currently placed the slider—Figure 2). In "lives-first" scenarios, where respondents entered dollar figures, the slider also reported costs averaged across both U.S. households and per capita. By moving the slider to the left or right, the respondent could receive immediate feedback on the implications of a given value, and thus perhaps more easily intuit when reaching satisfactory boundary values between acceptable and ambiguous, or ambiguous and unacceptable.

We believe this double-bound method is a significant advance over, or at least complementary to, previous methods of eliciting point estimates in stated-preference studies. Eliciting single switch-points (i.e., where opposition changes to support, as opposed to our pair of bounds at which either opposition or support changes to indeterminacy) is common in the stated-preferences field for estimating willingness-to-pay for non-market goods or the value of a statistical life. But this strategy can be inferior to the double-bound method, as it can be difficult for people to confidently select a precise point where this switch between acceptability and unacceptability occurs, and preference reversals can occur.[29, 30]

Insert Figures 1 & 2 about here

Once these personal bounds on acceptable and unacceptable tradeoffs had been specified, subsequent questions introduced uncertainty. The manipulation involved three steps and two uncertainty ranges, described here for the "costs-first" condition (see Figure 1). First, a respondent was asked to rate her likelihood of support for a regulation that would entail definite regulatory costs of $1 billion to save the precisely-known number of lives computed as the arithmetic mean M of her two self-generated bounds. For example, if her bounds were 100 lives and 240 lives, we would ask about her support (on a scale of 1 = *very unlikely*, 4 = *completely unsure*, 7 = *very likely*) for a regulation costing $1 billion to definitely save 170 lives—explicitly explained as being the average of her bounds—or an imputed value of life of roughly $5.9 million. Next, she saw an uncertain agency estimate (“wide”) that challenged her to consider the rule as one she could clearly oppose *or* clearly support, but still preserving the original mean. In this permutation, she was told there was a uniform probability[4] that the number of lives saved is between 0.6*L and H+(0.4*L)—thus, for the hypothetical bounds above, the “wide” uncertainty range is 60-280 lives saved (i.e., a change of 110 lives both above and below her mean of 170). The likelihood-of-support question was repeated for the wide range, followed by a direct question on whether she would support the regulation more given certainty versus wide uncertainty, with numerical response options personalized to the respondent’s own bounds (e.g., “1 = *I support much more the regulation when its estimated benefit is an uncertain number of lives between 60 and 280*; 7 = *I support much more the regulation when its benefit is definitely 170 lives saved”*). Third, a “narrow” range of uncertainty was constructed based on M ± [(H-L)/4], a range entirely within the respondent’s “ambiguous” range;[5] using the same example, “narrow” uncertainty would involve between 135 and 205 lives saved, still with a mean of 170 lives. A likelihood-of-support question was again followed by a question on whether she would support the regulation more given certainty or narrow uncertainty.[6]

2.1.6. Reactions to Differing Scenarios of Inter-individual Variability in Regulatory Cost

Presenting a hypothetical traffic safety regulation that would definitely save 1000 lives a year at a cost of $5 billion, we explained that the roughly 100 million U.S. households would thus

[4] The specific wording was “any number in this range has an equal chance of being the true number” of dollars or deaths prevented; “[t]he two endpoints of the range are no more or less likely to be the true value than any other number within the range.” We did not probe whether respondents understood uniform probability, and findings (end of Section 3.5.1) imply many respondents either did not, or understood but questioned the assumption’s validity.

[5] This value (with M = (H+L)/2) must be within the ambiguous range because (3/4 H + ¼ L) must be < H because L < H, while (3/4 L + ¼ H) must be > L, because H > L.

[6] The lives-first version was similar but reversed: a respondent would rate her likelihood of support for (1) a regulation that would save 1,000 lives at the mean M of her two self-generated bounds, which we computed for her as L [low cost, definitely support] + H [high cost, definitely oppose])/2 (e.g., $3 billion if her bounds were $1 billion and $5 billion, or an imputed value of life of $3 million); (2) the same regulation with a “wide” uncertain agency estimate with a uniform probability that the cost is between 0.6*L and H+(0.4*L)] (for this hypothetical case, $600 million to $5.4 billion, or an equal change of $2.4 billion above and below her mean); and (3) the same regulation with a “narrow” range of uncertainty based on M ± [(H-L)/4] (in this case, from $2 billion to $4 billion).

each pay about $50 if the regulatory costs were equally distributed, but that the agency did not know how those costs would actually be distributed across society. We asked how likely the respondent would be to support the regulation if costs were distributed equally, or in various unequal distributions allocated randomly or by income (Section 3.6). To assess whether expectations for personal regulatory costs would affect judgments about fairness, we also asked whether the respondent would expect his own household to pay more, less, or the same as the $10 average of $1 billion in total regulation-induced price increases for "something that virtually everyone buys, such as gasoline or electricity," and whether he thought this outcome fair. This set of questions ended with three general questions about attitudes towards distributions of regulatory costs.

2.1.7. General Attitudes and Demographics

Attitudes probed included those towards government uncertainty about regulatory impacts; government regulation of personal conduct and of externalities imposed by industrial activity; and use of numbers (five items from an eight-item measure of subjective numeracy[(31)]). A validated measure of objective numeracy was available, from a prior study, for 83% of the sample; it assessed respondents' ability to cope with probabilities, in frequency and percentage terms, scored as the number of correct answers (0-11).[(32)] Respondents supplied demographic information including gender, age, education, ethnicity, political party, political ideology, home ownership, job status, and income.

2.2. Experimental Design

The instrument came in 16 variants (2 X 2 X 2 X 2 design). The aim of the four randomly-assigned manipulations was to test the effects of: (1) varying the hazard subject to potential regulation (acute injury or chronic disease); (2) varying whether participants were asked to consider the size of benefits justifying a fixed regulatory cost, or the size of regulatory cost justifying fixed benefits; (3) providing or omitting information on upward and downward biases in various types of cost estimates in common use; and (4) providing or omitting information on the value of a statistical life used by U. S. federal regulatory agencies.

First, the hypothetical regulation being considered with and without uncertainty in cost or benefit (see Section 2.1.5 above) would either reduce deaths from traffic accidents (proposed by NHTSA) or a carcinogen in drinking water (proposed by USEPA), testing the effect of acute versus chronic mortality.

Second, preferred tradeoffs between regulatory costs and benefits might vary by which side of the ledger is considered first (see Section 2.1.5). This framing effect *might* invoke anchoring[33] due to the differential magnitude of regulatory impacts: billions of dollars (possible for the estimated costs of a major U. S. regulation) or thousands of lives (the maximal magnitude of health and safety benefits, in lives saved, for most regulations). Alternatively, any framing effect could be due to thoughts elicited by being "given" either money or a life-saving opportunity and asked to trade for it.

Third, respondents either did or did not read the following paragraph about "surprise" In the costs of regulation before answering questions about the accuracy of agency estimates:

> It can sometimes be hard to know what something will cost before we produce it. Sometimes we think a highway tunnel can be built under a city for $5 billion, but it ends up costing far more. Other times, we overestimate cost, as when technology becomes much cheaper as it improves; think of smart phone or plasma TV prices this year versus 5 years ago. Like future construction or technology costs, surprises in either direction (higher or lower actual numbers) can occur for estimates of regulatory costs. The same can be said of regulatory benefits; for example, many scientists now think the artificial sweetener saccharin does not cause cancer in humans as previously assumed. On the other hand, concern is rising about possible health effects of (currently unregulated) exposures to electromagnetic fields from power lines and cellphones.

This manipulation allowed us to see whether people had a confirmation bias for agency inaccuracy or uncertainty in estimates of regulatory costs and benefits, by prompting some respondents but not others to consider overruns or "underruns." We did not test for order effects (e.g., if surprises in benefit estimates versus cost estimates, or in cost savings versus overruns, were cited first).

Fourth, after reading about general issues in value-of-statistical-life (VSL) estimation and just before questions on hypothetical costs/lives tradeoffs, half of the sample read this sentence reporting the average and range of most federal VSL estimates:

> Based on such studies [of earnings, jury awards, willingness-to-pay surveys, etc.], U.S. Federal agencies have calculated the value of saving a single (unidentified) human life as between $0.6 million and $10 million, with an average value of about $5 to $7 million.

This manipulation allowed us to determine whether a numerical anchor might affect respondents' considerations of appropriate cost/lives tradeoffs.

Randomization yielded relatively balanced sub-samples across these experimental manipulations, as 160 (21.5%) read the NHTSA lives-first and 206 (27.7%) the NHTSA cost-first versions; 183 (24.6%) read the EPA lives-first and 195 (26.2%) the EPA cost-first versions. Some 375 (50.4%) saw the Surprise paragraph, while 390 (52.4%) saw the VSL sentence. ANOVA revealed no differences across the four contrasts in gender, age, income, education, full-time employment, home ownership, political partisanship or ideology; statistically significant but substantively minor differences occurred in subjective and probabilistic numeracy, and white ethnicity (see first author for details).

2.3. Sample

An invitation to participate in the study was issued to the then-1,498 members of the Decision Research (DR) online panel, a diverse, quota-recruited (gender, age, education) sample of American adults, most with job and/or family responsibilities. Their responses in NSF-funded studies on other topics (e.g., the 2008 financial crisis[(34)]) resembled those of representative samples. A payment of ten dollars was offered due to the expected difficulty of some questions, supplemented by a lottery (weighted by early response) for twenty $100 gift cards. After data collection slowed, an incentive of $100 for the 750th respondent was added. Data collection occurred over June and July of 2012.

2.4. Analyses

We report here descriptive statistics, correlations, and reliability analyses. As noted in Section 3.7, we also ran multivariate analyses (generalized linear models; logistic regressions; multinomial logistic regressions) to explore whether any of our experimental manipulations or several other factors (e.g., demographics; beliefs about need for regulation; beliefs and attitudes about agency estimates of regulations' impacts) were associated with dependent variables (Section

3). All multivariate results, and descriptions of the methods, appear on the project website (see footnote 1).

3. RESULTS

In Section 3 we discuss in turn 1) characteristics of the respondents; 2) descriptive statistics for numeracy and regulatory attitudes (some of which feature as significant multivariate independent variables in Section 3.7); 3) descriptive statistics regarding our four research questions; and 4) a summary—and selected specific results—of multivariate analyses.

3.1. Respondents

Our 796 responses (53% of panelists contacted) were trimmed to 744 after deleting respondents who did not use the slider (19 people), reversed slider answers (e.g., giving high bounds with low bounds requested—17 people), answered too quickly or too slowly (7), gave the same answers (6) or similar options (e.g., all "a" in multiple choice—2) multiple times, or had substantial missing data (1).

The resulting sample was slightly more female, more educated and higher-income, and about the same ethnicity, as the U.S. population. Respondents were 45% male and 78% white, with a mean age of 43 (SD = 13). Some 42% were college graduates, with a modal income category (among ten) of $50-74,000 (23%), and 20% at $100,000-plus. The sample included 34% Democrats and 21% Republicans, and 35% liberals and 31% conservatives. Some 54% were fully employed,[7] and 66% were house owners.

3.2. Descriptive Statistics for Numeracy and Regulatory Attitudes

The measure of objective probabilistic numeracy (n = 619) had a mean of 7.91 on the 12-point scale (SD = 2.36). Subjective numeracy (n = 714) had a mean value of 21.78 (SD = 4.96), in a potential range of 5 to 30, and correlated modestly with probabilistic numeracy (+.38, $p < .001$).

[7] In the summer of 2012, shortly before this survey, non-seasonally-adjusted employment of more than 30 hours per week in the U.S. was a bit more than 44% of all adults (see http://www.gallup.com/poll/125639/gallup-daily-workforce.aspx; data accessed 27 October 2014).

Four questions with a 1 (strongly disagree) to 5 (strongly agree) response format assessed attitudes about government regulation overall: (1) the need for the private sector to be regulated to protect public health and safety (51.5% agreed or strongly agreed; these two response categories define “agreed” in the rest of this paper), (2) the general ineffectiveness of such regulation to actually protect health and safety (38.5% agreed), (3) the appropriateness of regulation of private individual behaviors, such as marijuana smoking, abortion, handgun ownership, and spanking one’s children (34.5% agreed), and (4) whether regulation of behavior in one’s home or with one’s body constitutes government “meddling” (14.1% agreed). Factor analysis found no single factor included all four, and reliability analysis found consistency among these items was very low, so in multivariate analyses the first item only was used as a predictor.

3.3. Descriptive Statistics on Beliefs about Regulatory Costs

The median estimate of the cost to double the impact that a new car’s roof could resist was \$950 (90^{th} percentile confidence interval: \$50-\$6,000), a gross over-estimate compared to NHTSA’s estimate of \$54 per car.[8] Estimates of new cars sold in the U.S. per year, however, were too low, a median of 2 million (90^{th} CI: 30,000-20 million), versus the true figure of about 10 million.

3.4. Descriptive Statistics on Beliefs about Agency Estimates of Regulatory Impacts

Given hypothetical EPA estimates that it would cost \$1 billion to regulate fine particles of soot, and that in so doing 1,000 lives would be saved, respondents generally regarded lives-saved as more likely for EPA to estimate accurately than costs (Table I, top), which they generally thought EPA would underestimate. Overall (Table I, bottom), the most common response pair was to believe that EPA was accurate on both costs and lives, followed closely by belief that the agency was accurate on lives but underestimated costs. Systematic “pro-regulation” bias by the agency (under-estimation of

[8] Retrospective analyses of this regulation’s true cost are yet to be done; the rule only became effective in late 2013 (pers. comm. with NHTSA staff, Sept. 2013). Agency contractors found the technology of wider roof struts already becoming available on some car models with no change in price; although that is not the same as having no regulatory cost, \$54 may be close to (and may well exceed) the true cost.

cost *and* over-estimation of lives saved) was deemed roughly three times more likely than an "anti-regulation" bias (over-estimation of cost *and* under-estimation of lives).

INSERT TABLE I ABOUT HERE

Those who suggested that the agency would misestimate costs and/or lives saved were asked for their rationales in an open-ended question that allowed for multiple answers per respondent. Table II shows a diverse and often-sophisticated set of explanations from this well-educated sample. Both quotations in the table and estimate-specific rationales (e.g., expecting that reducing pollution will reduce non-lethal impacts as well, labeled by the authors as "morbidity co-benefits") reflect the actual complexity of responses rather than authors' categorization. Explanations were dominated by very general expectations of government error among those expecting cost under-estimation, based on stereotypes or extrapolation from predicted costs of projects directly funded by government (i.e., not estimates by government of others' costs) or even personal experience with contractors. This differs from expectations for surprise or deliberate under-counting, also common among those expecting cost under-estimation. Estimate-specific explanations were relatively rare, dominated by technological innovation (cost over-estimation), the difficulty of removing soot from the air and omitted costs (cost under-estimation), competing mortality causes (lives over-estimation), and under-estimation of air quality as a cause of mortality (lives under-estimation).

INSERT TABLE II ABOUT HERE

Near the end of the survey, after respondents answered questions about trade-offs, we returned to the theme of agency accuracy and presented a hypothetical EPA regulation that the agency estimated would cost between $1 billion and $3 billion (thus the agency announced a range of estimates rather than a point estimate, as in the earlier question). A plurality thought the true cost would be between $2 and $3 billion (41%), followed by more than $3 billion (33.1%; i.e., belief in agency cost under-estimation), $1-$2 billion (22.3%), and less than $1 billion (3.5%; belief in agency cost over-estimation). Thus cost under-estimation was expected for a range as well as for a point estimate.

Finally, we asked respondents to evaluate a government agency statement that it “doesn’t know with a high degree of certainty how much the regulation will cost.” Some 41% (Table III, top) thought this statement connoted honesty, a moderate plurality were neutral on whether it signaled incompetence or trustworthiness, while almost two-thirds each thought agency uncertainty was due to the inherent difficulty of cost estimation and that such an agency would be uncertain on regulatory benefits as well. Competence (incompetence reverse coded), honesty, trust and inherent difficulty formed a weakly reliable index of positive views of agency uncertainty about costs (α = .68).[9] For multivariate analyses we used a two-item honesty-trust index with the greatest reliability (α = .76).

INSERT TABLE III ABOUT HERE

3.5. Descriptive Statistics on Attitudes toward Certain versus Uncertain Estimates of Regulatory Costs and Benefits

“Narrow” uncertainty in government estimates of the costs or benefits of a specific regulation was at least as acceptable as certainty, and even “wide” uncertainty was acceptable to many, when uncertainties were computed as functions of one’s personal tradeoffs just elicited. Presented with a regulation whose cost (or benefit) was known to fall exactly at the arithmetic mean of each respondent’s high and low bounds, 66.4% of the entire sample (i.e., without distinguishing those who saw cost versus lives anchors) were likely to support it, with 12.3% unlikely (the rest were neutral). Given narrow uncertainty, 61.9% were likely and 11.4% unlikely to support the regulation. Asked about their relative support for the same regulation with these different levels of uncertainty, 35.9% tended to more support for the certain estimate, while 40.2% tended to more support for the narrowly uncertain estimate. Given wide uncertainty in an agency estimate, 52.3% of respondents

[9] Cronbach’s alpha is a measure of consistency between items in an index, with values closer to 1.00 indicating greater consistency; values less than .70 are usually deemed unacceptable except for exploratory purposes.

were likely and 19.5% unlikely to support the regulation. In this case, relative support was 47.8% for the certain estimate, and 34.3% for wide uncertainty. So, looking just at the total proportion expressing support for the regulation, the plurality decreased from 66% under certainty, to 62% under narrow uncertainty, to 52% under wide uncertainty—indicating some discomfort with increasing (mean-preserving) uncertainty, but still with many respondents whose support was unaffected even by wide uncertainty.

Given the relative inattention in federal cost-benefit analyses to uncertainty in costs,[(2)] we focused on responses of those exposed to the lives-first anchor, who thus would be responding to uncertainty bounds expressed in dollars. Proportions did not substantially differ from those reported above: 65% support to 13% opposition on certain estimates, 61% to 15% on narrow uncertainty, 46% to 23% on wide uncertainty; 46% preferring the certain estimate to 41% preferring the narrow uncertainty estimate, 47% certain versus 35% wide. Using *t* tests for independent samples, support for the regulation with a widely uncertain estimate was significantly lower for the lives-first group ($M = 4.33$, SD = 1.54), dealing with uncertainty in costs, than for the costs-first group ($M = 4.73$, SD = 1.51; $p < .001$), dealing with uncertainty in lives. Thus distaste for *wide* uncertainty in costs was greater than for *wide* uncertainty in lives saved, but this disparity did not occur for either narrow uncertainty or for certainty, as no other differences were statistically significant.

The last two paragraphs discussed subjects whose support diminished with increasing uncertainty. Also of interest is the extent to which uncertainty matters—that is, what proportion of subjects changed their views *in either direction* when point estimates of cost or benefit were replaced by mean-preserving spreads of uncertainty? One rationalization for not estimating or reporting uncertainty[(2)] holds that laypeople care about expected consequences, not their possible spread. Measuring "affected by uncertainty" as a change of at least 2 units in the subject's Likert score of support/opposition, 23% of respondents were affected by wide uncertainty, while 48% offered the same rating for both certainty and wide uncertainty. So roughly one-quarter of this sample would be deprived of information *useful to them* if uncertainty was suppressed. Intriguingly, the proportion of subjects whose score changed by 2 or more units was greater among those confronted with cost uncertainty rather than lives-saved uncertainty (25% versus 20%). *This finding suggests that the side of the cost-benefit ledger where uncertainty is less routinely explored[(2)] is in fact the more influential of the two types of uncertainty on public attitudes.*

Asked later why they had preferred wide uncertainty to certainty, and given two choices plus an open-ended "any other" elaboration, 140 respondents thought the "support" end of the range was more likely (an optimistic stance); 133 selected "I thought seizing the possible opportunity to save lives cheaply was more important than worrying about the regulation perhaps being a bad deal" (risk seeking for gains). Focusing just on the lives-first group dealing with uncertainty regarding costs, 57% had chosen the risk seeking explanation for preferring wide uncertainty to certainty, while in the costs-first condition only 41% chose that option. Thus being honest about cost uncertainties may garner support from those more motivated by the cost distribution's left-hand tail (to save lives cheaply) than by its right-hand tail (saving lives at undue expense).

3.6. Descriptive Statistics of Preferences for Distribution of Regulatory Costs

Respondents were next asked to assume that a hypothetical intervention with a certainty of $5 billion in associated regulatory costs, distributed across 100 million U.S. households, would prevent 1000 traffic accident deaths per year. Attitudes toward these distributions were assessed on the same likelihood-of-support scale (1 = *very unlikely*, 4 = *completely unsure*, 7 = *very likely*) used in the previous section. When subjects were told that the costs would be equally distributed across all U.S. households ($50 each), 58.6% favored a regulation with this distribution, while 25.3% opposed it. With a random, and somewhat unequal, distribution of costs —1% pay $500, 90% pay $50, and 9% of households pay nothing—support and opposition were 37% and 45%, respectively, with support dropping considerably and opposition going up considerably relative to equal distribution. With a random, and quite unequal, distribution of costs —1% pay $10,000, 1% *receive* $5,000 (a "negative cost" to them), and 98% of households neither pay nor receive anything—support and opposition were 31% and 48%, respectively (thus further deterioration of support as inequality increases, but not proportionately to the change in inequality).

A separate trio of preferences was produced by comparing the somewhat-unequal distribution responses when those burdens were assumed to be dependent on income rather than random. If the 1% richest households paid $500 in regulatory costs, 90% paid $50, and the poorest 9% paid zero, 66% favored this distribution, 21% opposed it, a more favorable response to this progressive allocation than to the same distribution allocated randomly. Reversing this distribution (1% poorest paid $500, 90% paid $50, richest 9% zero), proportions were 19% and 73%, respectively; thus, the regressive distribution elicited substantial opposition.

To explore whether these preferences were at least in part self-interested, we asked how much of a total regulatory cost increase of $1 billion in "something that virtually everyone buys, such as gasoline or electricity," the respondent would expect his or her household to pay. Of three possible answers, the majority (60.8%) thought they would pay an equal share of $10, 14% expected to pay less, and 25.4% expected to pay more. When asked whether the share expected by each individual was part of a fair distribution, 58.2% agreed and 21.3% disagreed . The two items correlated weakly ($r = .15$, $p < .001$); while those expecting to pay less than or their share tended to report this as fair, those expecting to pay more than their share exhibited a symmetric distribution around the middle value of "neither fair nor unfair."

Finally, we asked about general beliefs about the distribution of regulatory costs (1 = *strongly disagree*, 5 = *strongly agree*). The bottom section of Table III shows that about a third each agreed or disagreed that the long-run collective impact of regulations would average out to be about the same for "every business or customer." About 43% agreed that an unequal distribution of regulatory costs would be ethical only if those who paid more also received more benefits, while 27% disagreed.

3.7. Multivariate Statistics

Previous trail-blazing studies in *risk* perception—e.g., how the lay public processes information about the toxicity of and exposures to hazardous chemicals [(3-4)]—have provided only descriptive statistics. We also emphasize these, but must go a bit further given that we incorporated experimental manipulations and conducted multivariate analyses that also included both demographic characteristics and regulatory-cost beliefs and attitudes as independent variables. We do not go into much detail here, as the results overall offered limited explanatory value, but all multivariate analyses can be obtained at the website identified in note 1.

Caution is warranted in interpretation of these multivariate analyses: e.g., linear regression analyses (adjusted for the number of experimental and non-experimental independent variables) explained between 0% and 23% of the variance in thirteen dependent variables; for nine logistic regressions, the model correctly predicted between 56% and 86% of the cases, with the prediction less than the proportional by-chance accuracy rate (see Table IV for definition) for two dependent variables. The four experimental manipulations (see Section 2.2) had relatively few statistically significant effects and in no discernible pattern. Of 22 dependent variables subjected to multivariate analysis, only five were significantly associated with a total of six main experimental effects, while seven were significantly associated with a total of 14 interaction effects, which were even harder to interpret.[10]

We report here on multivariate analyses of five dependent variables, which we chose in order to illustrate across our four research questions some topics for which the effects, if any, of demographic and other potential predictors should be of most interest to practitioners of cost-benefit analysis and regulation (see Table IV).

[10] For example, Table IV shows interaction effects involving the Anchor and Agency manipulations for beliefs about regulatory costs and agency estimates of regulatory impacts, even though these manipulations followed rather than preceded those questions. Probably an unmeasured attribute of the sub-samples in these manipulations affected their responses, but the same is possible for attitudes toward uncertainty and regulatory cost distributions (which followed these manipulations); one must be cautious about interpreting any main or interaction effects found for the latter as indicating causality.

First, people who were more probabilistically numerate and non-white were more accurate in estimating regulatory costs than others, potentially an important issue for regulatory education and informed citizen participation in policymaking.[11]

The next two examples concern two contrasts of beliefs about agency over-estimation versus under-estimation, of costs and lives respectively, as these are important for the credibility of agencies' regulatory-impact estimates. People who expected to pay more than their share of regulatory costs and felt this was unfair, and those who had full-time jobs, were more likely to believe in EPA under-estimation of costs than in over-estimation. Those who were more politically liberal, less numerate, and less likely to see their share of regulatory costs as unfair were more likely to believe in under-estimation of lives saved than in over-estimation. Belief in under-estimation of lives also was associated with a three-way interaction of the experimental manipulations.

Fourth, given the general lack of public information on uncertainty in regulatory impact estimates, particularly on the cost side of the ledger, it is important to understand how people might react to such information. People who felt agencies tended to under-estimate costs rather than over-estimate or accurately estimate costs, and those who were more probabilistically numerate, were more likely to be among those (n = 227) exhibiting an ordered preference for impact estimates that are certain (their absolute support for a regulation with certainty $\geq$ narrow uncertainty $\geq$ wide uncertainty), compared with those exhibiting the reverse ordered preference (n = 77).

Fifth, understanding public preferences for distributions of regulatory costs is important, given the likely mismatch between a citizen's logical assumption (in the absence of explicit distributional information) that costs are distributed equally across the population and the likely skewed distributions of actual regulatory cost. People inclined to think that agency admission of

[11] One two-way and two three-way interactions of experimental manipulations also were significant. For brevity, only one three-way interaction is described here (and we omit details of other experimental interactions in Table IV, which can be obtained from the website cited in the first footnote). When the surprise paragraph was present, the presence or absence of the VSL sentence made no difference, but without the surprise paragraph, ratios (subjects' estimated costs divided by the true cost) for people seeing the VSL sentence were a quarter the size (though still over-estimates) of ratios for those not seeing that sentence. We find it hard to interpret this interaction causally.

uncertainty in costs indicates the agency is honest and trustworthy, and those who were exposed to the carcinogen regulation rather than the traffic safety regulation, were more likely than others to support a regulation with equal distribution of costs than to support a skewed cost distribution uncorrelated with income.[12]

Of these five examples, the linear regression analysis attempting to explain the accuracy of respondents' estimate of a specific regulatory cost did very poorly, explaining at most 10% of the variance in this accuracy. The four multinomial logistic regression analyses did better, with all exceeding (if often not by much) the proportional by-chance accuracy rate.

INSERT TABLE IV ABOUT HERE

4. DISCUSSION

Table V summarizes some of our major findings and our interpretations of how they might affect practice among regulatory impact analysts or regulatory agencies (Sections 4.1-4.4). We then expound further on the relationship between these findings on "cost perception" and prior findings of risk perception research, and outline some limitations of this pilot study.

INSERT TABLE V ABOUT HERE

4.1. Beliefs about Regulatory Costs

Our findings of lay over-estimation of the unit costs of regulation, and under-estimation of total production, must be tested further to see if they generalize to other regulated goods and services beyond the traffic-safety case examined here. If these findings about both the direction and magnitude of these lay misestimates of the cost of control technology hold up, this implies that people might not believe problems can be solved as cheaply as the estimated cost figures from agencies suggest, despite the literature indicating these are over-estimates in most cases.[(35, 36, 37)] Hence citizens might suspect agencies of cost under-estimation not on general principle but due to misunderstandings about technology costs.

[12] An equivalent multinomial logistic regression on wealth-based distribution of regulatory costs could not be estimated reliably, as only 17 people in the regression analysis supported larger payments from the poor rather than the rich.

Two questions long of interest to risk perception scholars—what *do* people know about risks, and what *should* they know?—should be raised about regulatory costs as well. Research on the role of "facts" in risk judgments,[38] "intuitive toxicology,"[3] exposure beliefs,[4] or mental models of hazard evolution[39] has generally concluded that knowledge is seldom a dominant factor in risk perception, and yet risk practitioners seem to regard factual education of "the public" as essential in a democracy. Our study of regulatory-cost knowledge is one of very few attempts to study how people think about how risk is managed, as opposed to how large it is or how likely it is to occur (risk assessment), so our findings on regulatory-cost knowledge might help spur a useful expansion of risk perception research. Further experiments could test whether and how judgments of agency accuracy change—and lead to changes, if any, in citizens' participation in policy deliberations—when people are told the estimated cost of a proposed regulation, the independent retrospective estimate of an implemented regulation's actual cost, or the general finding that agency estimates tend to be biased high (and why).

4.2. Beliefs about Agency Estimates of Regulatory Costs

Expectations of agency-estimated impacts of regulations were not symmetrical (Table I), with costs deemed subject to inaccurate estimates—the majority view—more often than lives saved, for which the majority expectation was agency accuracy. This difference raises questions that have not received attention before about the judged equivalence of estimating costs versus lives saved. For example, do laypeople, as a reviewer suggested, expect agencies promulgating health and safety regulations to be good at estimating risk reductions as their core mission, whereas estimating costs is not (and thus perhaps reverse these ratings for an agency like the Department of Treasury)? Or do people expect more uncertainty from economic forecasts than from biological/physical ones,[40] perhaps reflecting a reality that "cost uncertainty" can inherently exceed risk uncertainty[2]?

Given few studies of public or advocates' beliefs and attitudes about risk assessment,(41, 42, 43) public perceptions of risk and cost estimation methods are topics ripe for more research.[13]

Our findings of differing responses to two kinds of hypothetical EPA cost estimates (costs expressed as a point estimate versus a range) imply that point estimates arouse skepticism that relatively narrow ranges of estimates might not. However, the qualitative response to an agency admitting its uncertainty about regulatory costs was mixed, likely to a large degree reflecting general distrust in government (which we did not measure). Prior research found citizens interpret an institution's statement of a range of risk estimates, versus a point (certain) estimate, in widely divergent ways regarding its honesty or competence, and that they tend to assume that uncertainty in risk assessment reflects self-interest or incompetence rather than the task's inherent difficulty.(7, 23-24, 44) Our finding that the sample as a whole was willing to believe EPA under-estimates costs but is accurate in estimating lives saved by a proposed regulation implies finer distinctions than "good" versus "bad" performance, reminiscent of the finding that trust in different actors can vary by the performance criterion used (e.g., keeping costs low versus protecting public health).(45, 46, 47)

4.3. Attitudes toward Certain versus Uncertain Estimates of Regulatory Costs

Although in general a certain estimate was preferred to any uncertain one, narrowly uncertain estimates received about as much support as certain ones (although less so when the respondent was seeing uncertainty in terms of regulatory costs rather than regulatory life-saving benefits). Even a regulation with widely uncertain impact estimates received surprisingly strong support, although less absolute support (from about half the sample, rather than from about two-thirds) than for either narrowly uncertain or certain estimates, and less absolute support when the wide uncertainty concerned regulatory costs rather than regulatory benefits. When support was directly compared, about half the sample favored the regulation with the certain estimate of

[13] An issue more germane to imputing values of a statistical life (VSLs) using lay preferences for national-level tradeoffs (Ref. 18) is whether people's expectations for regulatory cost under-estimation mean that imputed VSLs may be biased low (e.g., if people see "$1 billion to save 1000 lives" tradeoffs, and they process the information as "really $2 billion to save these lives," they will "require" more lives saved (a lower VSL) to approve of a regulation costing that amount).

regulatory impacts, but a full third favored the regulation with the widely uncertain estimates.[14] If cost-benefit analysts avoid quantifying the uncertainty in their estimates of either side of the regulatory-impacts ledger partly due to supposed widespread public distaste for uncertainty, our findings undercut that reasoning.[15]

4.4. Preferences for Distribution of Regulatory Costs

Our sample generally preferred an equal distribution of regulatory costs to random or income-based unequal distributions. Agencies currently do little to collect or report information on the distribution of regulatory costs,(48) and agencies might be conflicted about revealing the often-unequal distribution of costs given this egalitarian preference. A similar caveat might be raised about communicating the distribution of risks, despite the lack of research to date on public expectations for that distribution (footnote 2). More general beliefs and attitudes—e.g., whether short-run imbalances in regulatory-cost distribution disappear over time; whether those who pay also must be the beneficiaries for regulatory impacts to be fair—vary widely (Table III), so debates over actual regulatory cost distributions are not likely to disappear with more information.

People tend to be more concerned about those risks to which they are likely to be more exposed or vulnerable,(49,50) and in public health, where social vulnerabilities are increasingly integrated into assessments of health disparities,(51, 52) objective distributions of risks are of great interest. Probing how people think both risks and regulatory costs are or should be distributed by income, race, the geographic area of the nation or locality, or economic sectors would fill important gaps in the literature. Knowing in advance citizens' beliefs and attitudes about distribution would

[14] We should caution that, in contrast to the personally-meaningful uncertainties we generated, official estimates of the impacts of actual regulations might prompt a citizen observer to: (1) indifference, because the range of uncertainty falls entirely within estimated impact ranges where respondents automatically support or oppose the regulation, or cannot care about those levels (see Section 2.1.5); (2) support, because of general belief in the need for regulation, general trust in government, or belief that expression of uncertainty is honest and trustworthy; or (3) outrage, because competence is believed to imply certainty about regulatory impacts, or due to general distrust of regulations or of government.

[15] As a reviewer noted, other reasons for agency reluctance to present uncertainty (e.g., interest groups or the media publicizing one end of a range as the central or only estimate, to further their policy goals) are not addressed by this finding, and are beyond our scope.

help agencies avoid disbelief or other negative reactions to their publicity about actual cost (or risk) distributions.

4.5. Interpretations of Risk, Benefit, and Cost

In this section we comment briefly on potential parallels and synergies between the decades-long history of research on "risk perception" (better termed "risk interpretation"[53] to avoid presumptions that one viewpoint is correct), and the field of "regulatory cost interpretation" we inaugurate with this study.

Both risk interpretation and regulatory cost interpretation plausibly involve experts and laypeople working "at the limits of their expertise," with policy debates affected more by trust, emotion, gender and worldviews than by topical literacy and education.[54] Just as those laypeople more knowledgeable about a given technological risk may often be those most opposed to the technology,[38] the same could be true with regard to regulatory costs. Our multivariate results suggested no statistically significant effect of gender (see website, cited in footnote 1), and we did not test other such factors (e.g., do some costs seem "dreaded"?[55] does anger about costs fuel aggressive reaction, and fear about costs deferential reaction, to agencies responsible for the regulation?[56]), but assessing parallel explanations of risk and cost interpretations is warranted.

When it comes to comparing public reactions to regulatory costs and to risks, the possibilities are intriguing. For example, we appreciate a reviewer noting that people are exposed throughout their lives to information that helps calibrate their understanding of the relative prominence of dangers or causes of death (e.g., we learn of the age and cause of death for family, friends, or celebrities), even if such feedback is far from perfect, illustrated by the finding that people tend to over-estimate probabilities of rare causes of death and under-estimate probabilities of common causes of death.[57] In contrast, people have few opportunities to calibrate the costs (regulatory or otherwise) of managing risks. Even for personal risks, we may have information mainly on the costs entailed by direct personal expenses of (say) insurance, a car with a higher safety rating, or fresh produce grown organically, but with little information on indirect costs to self of one's actions (e.g., reduced future wealth due to present risk management choices[58]) or to others, and the costs of social regulation are much more opaque. Information on the incidence of regulatory costs is limited to some publicity about industries' compliance costs (which may or may not be passed on to consumers), and media fascination with arguably overwrought claims about "job-killing regulations."[59]

In contrast to the asymmetry of information across the benefit/cost ledger, we see an unappreciated parallel as well. If costs are already in the proper units to be compared to monetized benefits as a basis (or, alternatively, a rationale) for regulatory decisions, one might ask why one should study how people interpret something as seemingly natural as money? But the risk interpretation field arose[60] because observations showed that: (1) people, including experts, can be misinformed about the magnitude of risks, their uncertainties, and their distributions; and (2) people are entitled to complex, affect-rich, nonlinear, and idiosyncratic views of risk appropriate to their respective situations, not merely to expert-imposed interpretations. We assert that the same is true for costs on both counts (in particular, that CBA needs to rethink its inattention to the well-known phenomenon of the diminishing marginal utility of money[17]), and that understanding of risk management at the macro (e.g., national or societal) and micro (e.g., individual or household) levels can be enhanced if costs as well as risks and benefits are carefully estimated and given thoughtful values in terms and units of welfare, rather than longevity or money per se.[61] This is not to say that risks and costs are conceptually similar, or should be assessed in similar ways, only that issues of uncertainty,[1,2] inter-individual variability,[15] non-linearity of their respective impacts as a function of their size,[17] and inter-individual differences in perception and affect surround both costs and risks, and must be addressed on both sides of the ledger.

A long-standing but infrequently applied practice in risk analysis of considering costs, benefits and risks simultaneously,[62, 63, 64] to which our study contributes, might inspire a more systematic approach to such a synthesis. However, on those few occasions when judged benefits and risks have been considered simultaneously, much of the focus has been on personal impacts,[65] or how their interpretations affect a third variable, such as trust,[66] rather than the focus here on plausible national-level decisions and numbers (e.g., willingness to collectively pay $1 billion in regulatory costs to save 1,000 lives). McDaniels[67] found a strong congruence between lay willingness to pay for a reduction in *population* risk and the actual or proposed costs for regulations of similar hazards. Mendeloff and Kaplan[68] at a similarly early date assessed lay valuation of specific risk reductions relative to other risk reduction programs, avoiding the cognitive effort or inconsistencies that they thought might have accompanied questions about optimal budgets or risks, or about the absolute value of preventing these deaths.

Joint consideration of risk interpretation and the study of regulatory cost interpretation introduced in this article might yield a field of "regulatory choice interpretation," shedding light on such issues as how laypeople assess which national-level tradeoffs are tolerable and their implicit views of the value of a statistical life to society (that is, including rather than specifically censoring considerations of altruism). Combining regulatory choice interpretation with cost-benefit analysis might then yield systematic study of "regulatory choice analysis," incorporating how institutions do, and perhaps should, assess and value different tradeoffs, including alternative distributions of risks and costs.

4.6. Study Limitations

We review in turn five possible limitations of this study:

(1) We sampled from a diverse but not statistically representative online panel of Americans, with a 50% response rate. Men and college graduates, and to some degree the more probabilistically numerate, were more likely to respond to the survey than their proportions in the overall panel (see first author for details). These data suggest our results may have over-represented the views of those who are, or more inclined to believe that they are, capable of assessing regulatory costs. Yet

most risk perception and stated-preference economic studies intended to estimate the value of a statistical life (VSL) use even less diverse or representative samples, with lower response rates.[16]

(2) We used a narrow set of examples even within our focus on health and safety regulations, as a consequence of our wish to probe a wide variety of topics in this exploratory study of regulatory cost perceptions, and to avoid making our 16-treatment experimental design even more complex. The risk interpretation literature shows that hazards differ widely in perceived risk magnitude or probability, and that different groups of hazard managers differ widely in how much they are trusted. Thus, particularly to help generalize about how people respond to regulatory cost estimates from across government, future research should assess variance across multiple hazards and agencies, while controlling for perceived risk and trust.

(3) Several pages at the start of our instrument introduced our subjects to the unfamiliar world of regulatory costs, trying to relate it to daily tasks and familiar risks and expenditures, so that when we began asking questions the answers might be at least partly informed by specific knowledge. However, we did not test how well our respondents understood this background material or whether (or how often) they used it, and we did not test systematically other types or amounts of contextual information. Nor did we test whether there were order effects (e.g., of having the surprise paragraph precede rather than follow the VSL sentence). All such factors merit future research, to assure responses on such a difficult topic better reflect respondent preferences, which (with certain exceptions—e.g., those based on ideological heuristics) are probably constructed "on the fly."

(4) Our questions on uncertain regulatory-impact estimates were preceded by a complex process of personalizing each subject's range of acceptable tradeoffs between lives and costs, to ensure that subsequent ranges of cost estimates would have to fall within ("narrow" uncertainty) or

[16] This remark does not apply to revealed-preference methods for estimating VSL, but these methods face other imputation challenges (e.g., they assume that workers' perceived and objective risks are equivalent, that workers are fully informed about risks and able to negotiate wages, and that resulting wage premiums are commensurate with the risks they face).

outside ("wide" uncertainty) a respondent's own area of ambiguity about tolerable or intolerable tradeoffs. This process poses several potential problems: (a) errors if people could not understand the process; (b) no probing of tradeoffs common to all respondents (e.g., if everyone had been asked to compare a regulation that saved 1000 lives for $6.4 billion with certainty, against one that saved 1000 lives for a cost that might fall between $1 billion and $11.8 billion, with a mean of $6.4 billion); and (c) lability or changeability of responses, given that the task of assessing national tradeoffs, and the large numbers entailed, may both have been outside personal experience. Errors with the slider were only 2% (4% if we include those who did not provide any slider-related information), but we did not directly probe for other errors. We acknowledge that the complex process of personalizing might alter responses to subsequent questions, but argue that the main issue is how to elicit responses to meaningful questions. If through personalizing we present to respondents uncertain ranges that mean something to them, we obtain far more valid answers—however different—than those derived from presenting meaningless uncertainties. That our respondents put in considerable work on this survey (median = 38 minutes) suggests they were treating it seriously, and thus that their responses merit respect despite their potential flaws.

(5) Finally, potential lability could undermine the validity of all such results: if people construct their preferences on the fly, with possibly little context or motivation, can findings be trusted? However, this challenge is not unique to our approach (or, indeed, to studies of economic or risk perceptions generally). If there *is* lability, it likely affects imputation of the value of a statistical life based on stated preferences (covered elsewhere[(18)]) far more than our results on responses to regulatory costs. In fact, we believe this is a unique strength of our approach. By allowing the respondent to set his or her own uncertainty bounds (i.e., points at which tradeoffs that are "definitely" acceptable or unacceptable become tradeoffs for which support or opposition becomes "unsure"—see Figure 1), we did not force the choice of a definite number, neither one we

provided (common tradeoff choice) nor one the respondent selected.[17] However, future test-retest designs, with measures of motivation and understanding, would increase confidence in this method's validity and reliability.

5. CONCLUSIONS

This study has established that citizens process and react to information about regulatory costs in rich, nuanced, and idiosyncratic ways, that they labor under some misimpressions about costs, but also that they deserve more regulatory-cost information than agencies tend to provide. All such statements, of course, also apply to risk information, and on both the "risk side" and the "cost side" of the cost-benefit ledger, expert assessments and lay perceptions have valid foundations and should be reconciled rather than pitted against each other. Results from this survey suggest that agency cost-benefit analysts should be more interested in, and responsive to, public interpretations of presumed systematic bias in cost estimation, uncertainty in regulatory cost, and inequality in how regulatory costs are borne.

Clearly, advances in the field of risk interpretation have improved the practice of quantitative risk assessment and have altered regulatory decisions. For example, a major impetus for the evolution away from bright-line pronouncements about non-cancer health effects(69) is the normative concern that the citizenry should not be told that "safety" is dichotomous, but that it depends on the probability of harm. Understanding the difference between risk as assessed and as experienced can lead to different decisions: for example, NHTSA recently promulgated a back-up camera rule(70) whose assessed total costs exceeded total benefits, on the grounds that averting accidents in which parents strike their own small children while backing up their cars had benefits not fully captured by standard VSL methods.

Advances in regulatory cost interpretation have similar potential to improve the practice of cost-benefit analysis and to change the way agencies balance competing objectives on behalf of the

[17] The instructions read: "Do the best you can. . . . Don't push yourself too hard, however; there's no 'right' answer, and we just want your best guess as to where your line lies between being supportive and being unsure (or being sure you would oppose the regulation)."

citizenry. Table V offers some indications of how governments might provide better information on uncertainties, biases, and distributions of cost in light of how these inevitable (whether made explicit or not) factors affect public perceptions. We emphasize in conclusion that our findings about cost implicate the benefits side of the ledger as well, since nearly all agency benefits estimates derive from investigations into willingness-to-pay or other stated-preference studies. Practitioners assume that all current VSL (and quality-adjusted-life-year) measures are gauging the value of benefits in dollars, but they are really estimating their value in "costs as experienced by those who bear them." Understanding more about cost interpretation therefore is the key to understanding both what our hazard management system takes away and what it bestows.

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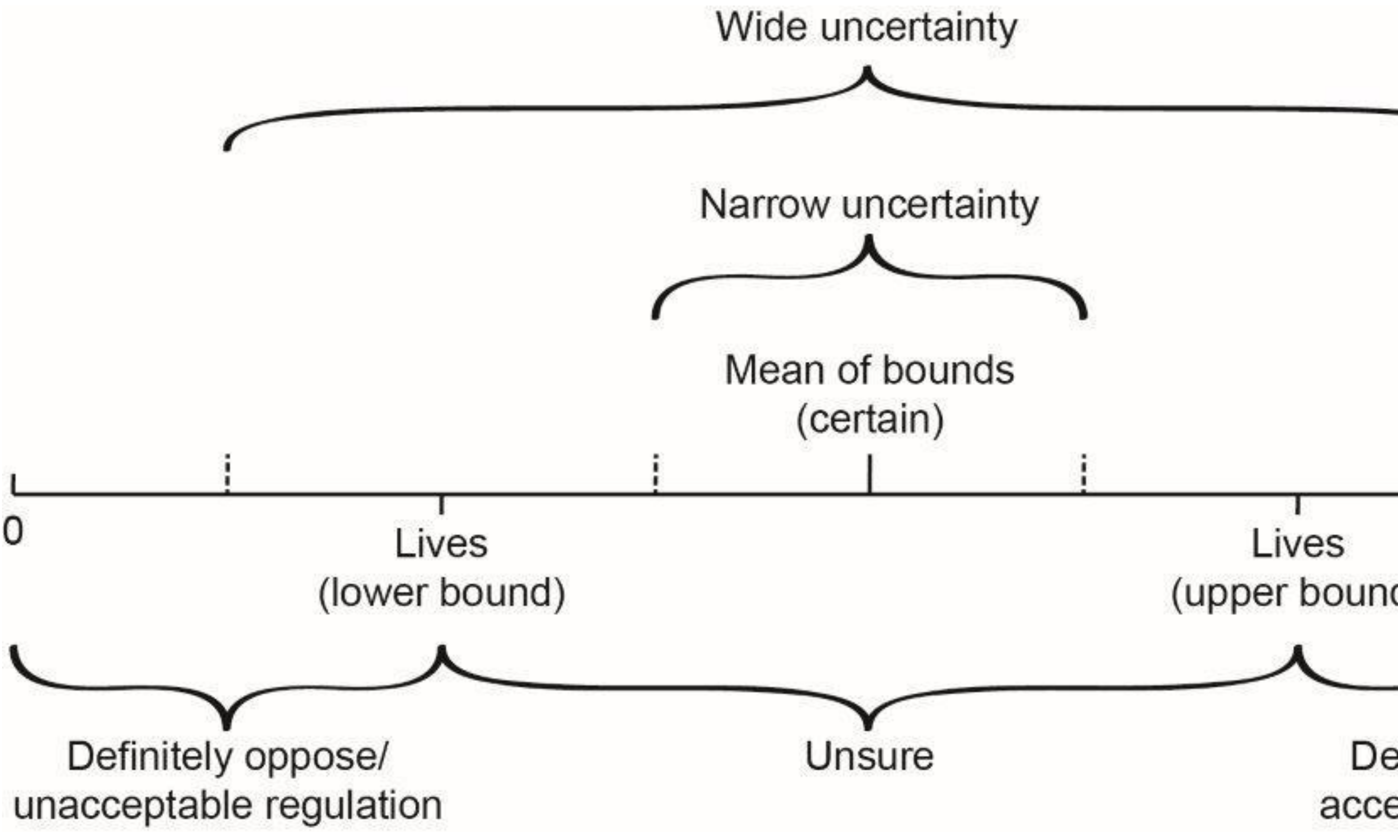

Figure 1. Relationship of respondent's elicited bounds to manipulations of uncertainty in agency estimates (cost-first example).

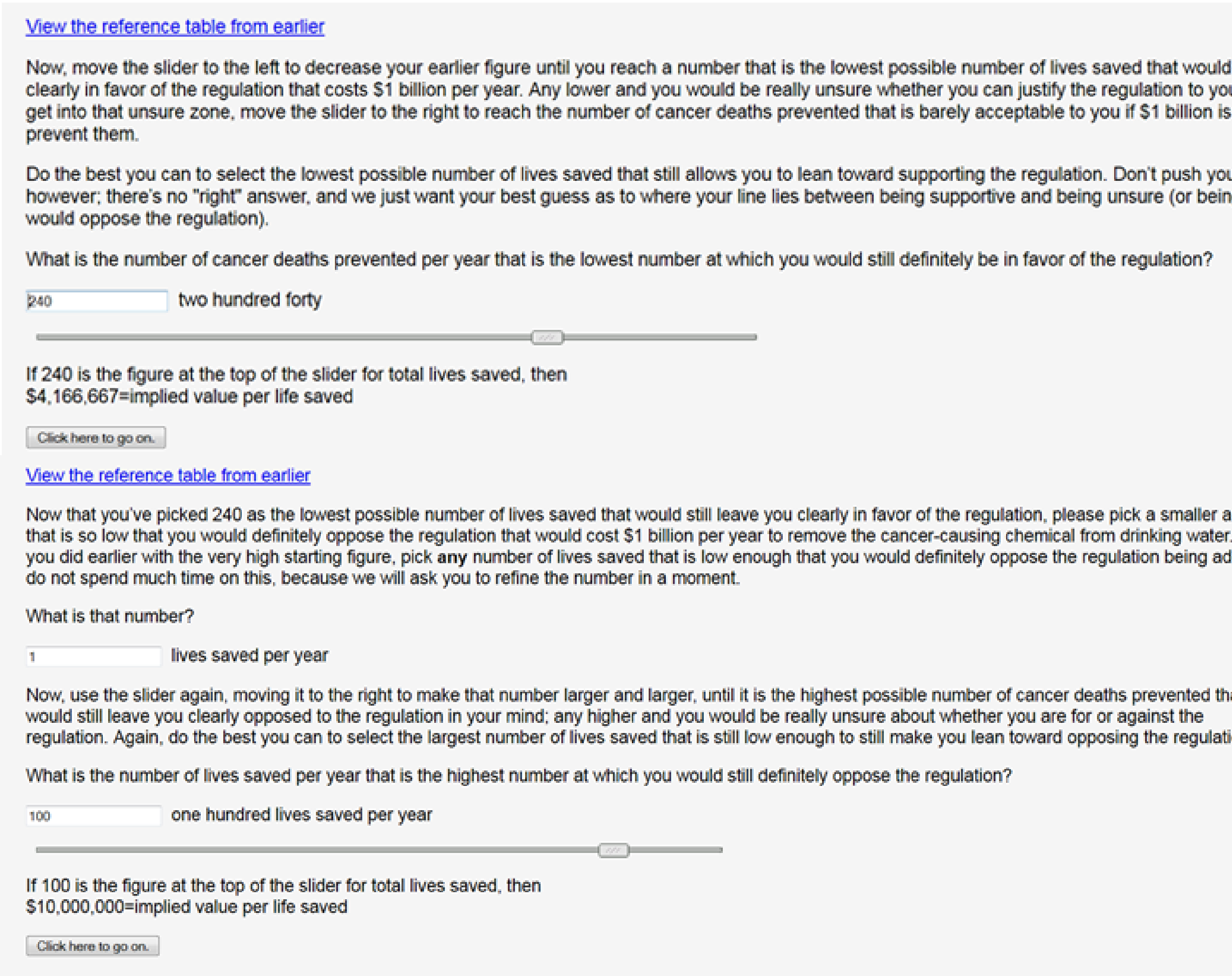

Figure 2. Example of slider allowing for selection of personalized bounds on acceptable and unacceptable tradeoffs.

Table I. Judged Accuracy of EPA Estimates of Regulation Impacts

	Underestimate	Accurate	Overestimate
Individual Dimension			
Costs	52.8%	39.5%	7.7%
Lives	24.6%	57.8%	17.6%
Overall Sample			
Both	13.2%	29.2%	1.1%
Regulatory Bias (pro- or anti-)			
(column cell refers to judged costs with lives deemed misestimated in the opposite direction; e.g., 13.3% saw agencies underestimating costs and overestimating lives saved)	13.3%	NA	4.3%
Inaccurate on this dimension, accurate on the other	26.3% Costs	NA	2.3% Costs
	7.1% Lives		3.2% Lives

NA = not applicable

Table II. Number of Respondents Offering Specific Explanations for Expected EPA Misestimates of Regulatory Costs and Benefits

	Costs		Benefits (Lives Saved)	
Explanation	**Overestimate**	**Underestimate**	**Overestimate**	**Underestimate**
Estimate-specific				
Environmental issues expensive	0	10	NA	NA
Difficulty of removing soot	0	33	0	0
Omitted costs	0	24	NA	NA
Other mortality causes (e.g., “I doubt soot is the sole cause of these respiratory deaths”)	NA	NA	22	0
Too few saved/ineffective	NA	NA	13	0
Technological innovation	12	0	1	2
Morbidity co-benefits	NA	NA	0	14
Underestimate air quality as cause (e.g., dose/response relation stronger; more afflicted than known; population growth)	NA	NA	0	39
Other (cost change; pollution change; regulations get stricter each year)	10	3	0	0
Other				
Regulated business malfeasance (e.g., “companies that must buy the new equipment will make it a point to overshoot the EPA's estimated cost”)	0	8	2	1
Deliberate (e.g., “they don’t really want to do” it; “tend to underestimate costs . . . to get the bill passed”)	6	40	18	7
Surprises happen (e.g., “costs . . . are not really predictable”)	3	47	18	0
General tendency to misestimate of “they,” “government,” “the agency” or “EPA”	7	133	15	3

Explanation	Costs		Benefits (Lives Saved)	
	Overestimate	**Underestimate**	**Overestimate**	**Underestimate**
General doubts (e.g., "distrust figures [of] government agencies")	6	0	5	3
TOTAL EXPLANATIONS	44	298	94	69
No answer (including non-explanations [e.g., offsetting health benefits] and polemics), don't know, and unclassifiable	20	111	40	100
Total Commenters	57	393	131	183*

NA = Not applicable (authors' judgment that this explanation does not logically apply to this impact).
*Total comments < total commenters; some comments implied belief that benefits are accurately or over-estimated.

Table III. Regulatory Cost Beliefs

	Mean (SD)	Strongly Disagree (1)	Tend to Disagree (2)	Neither Agree nor Disagree (3)	Tend to Agree (4)	Strongly Agree (5)
Agency Uncertainty about Costs						
The agency is being honest.	3.15 (1.05)	6.5%	21.1%	30.5%	33.5%	7.5%
The agency experts are incompetent.	2.97 (1.02)	6.9%	25.8%	36.0%	23.4%	6.7%
I trust an agency that says this.	2.84 (1.02)	10.8%	24.5%	37.1%	22.3%	3.9%
This uncertainty is due to the inherent difficulty of estimating how much a regulation would cost overall.	3.62 (0.94)	2.6%	10.8%	22.4%	50.0%	13.7%
An agency that is uncertain about regulatory costs will be uncertain about regulatory benefits too.	3.58 (0.98)	2.2%	14.4%	21.5%	46.5%	14.7%
Distribution of Regulatory Costs						
Whatever the distribution of regulatory costs is for an individual regulation, over the long run the impact of regulatory costs for all regulations collectively will average out to about the same amount for every business or customer.	2.93 (1.05)	8.6%	28.5%	26.9%	31.5%	3.6%
A non-equal distribution of regulatory costs is ethically justified only if the people who pay more also receive more of the benefits of the regulation.	3.16 (1.08)	8.2%	19.1%	28.5%	35.5%	7.8%

Uncertainty: Respondents were asked for “reactions when a government agency says it ‘doesn’t know with a high degree of certainty how much the regulation will cost.’ "
Percentages do not sum to 100, as they omit missing responses. N = 733–742.

Table IV. Selected Multivariate Analyses

Topics and Dependent Variables	**Significant Associations**	**Summary Statistics**	**Insignificant Associations**
Beliefs about Regulatory Costs			
Ratio of own estimate to NHTSA estimate of roof-strengthening costs	Probabilistic numeracy -332.34, *p* = .000 White -1009.66, *p* = .039	R^2 = .06; R^2_{adj} = .02	Subjective numeracy; demographics; need for regulation; agency under-estimate costs; other experimental effects
Interactions	Surprise * VSL -4228.10, *p* = .005; Agency * Surprise * VSL -4031.4, *p* = .05; Anchor * Surprise * VSL -4849.78, *p* = .023	R^2 = .10; R^2_{adj} = .04	
Beliefs about Agency Estimates of Regulatory Impacts			
Over-estimation of costs, relative to under-estimation	Full-time jobs .32 (.13-.78), *p* = .011 Unfair share of regulatory costs .77 (.60-.99), *p* = .04 Expect to pay equal share, relative to pay more than their share 3.50 (1.11-11.09), *p* = .033	Model correctly predicted 60.0% of cases, exceeding proportional by chance accuracy rate of 55.9% (n = 503; goodness of fit [deviance χ^2] = 812.46, *p* = 1.000; Nagelkerke pseudo-R^2 = .19)	Numeracy items; other demographics; need for regulation; experimental effects
Over-estimation of lives saved, relative to under-estimation	Politically conservative 1.45 (1.15-1.82), *p* = .002 Probabilistic numeracy 1.25 (1.08-1.44), *p* = .003 Unfair share 1.19 (1.00-1.42), *p* = .046	Model correctly predicted 56.3% of cases, exceeding proportional by chance accuracy rate of 50.7% (n = 503; goodness of fit [deviance χ^2] = 924.57, *p* = .82; Nagelkerke pseudo-R^2 = .17)	Subjective numeracy; other demographics; need for regulation; expected share of regulatory costs; other experimental effects
Interactions	Anchor * Surprise * VSL 30.00 (1.04-863.50), *p* = .047	Model correctly predicted 58.3% of cases (n = 503; goodness of fit [deviance χ^2] = 901.51, *p* = .82; Nagelkerke pseudo-R^2 = .21)	
Attitudes toward Certain versus Uncertain Estimates of Regulatory Costs and Benefits			
Support for uncertainty (wide ≥ narrow ≥ certain), relative to support for certainty (certain ≥ narrow ≥ wide)	Over-estimation of costs, relative to under-estimation 4.16 (1.32-13.16), *p* = .015	Model correctly predicted 57.2% of cases, exceeding proportional by chance accuracy rate of 48.9% (n = 376; goodness of fit [deviance χ^2] = 681.88, *p* = .75; Nagelkerke	Subjective numeracy; demographics; experimental effects; agency accuracy on lives; imputed VSL; tradeoff ambiguity
	Accurate on costs, relative to under-estimation 2.89 (1.33-6.28), *p* = .007		

Topics and Dependent Variables	**Significant Associations**	**Summary Statistics**	**Insignificant Associations**
	Probabilistic numeracy .83 (.70-.98), *p* = .03	pseudo-R^2 = .19)	
Preferences for Distribution of Regulatory Costs			
Support for non-equal random distributions (1% pay \$10,000 $\geq$ 1% pay \$500 $\geq$ equal distributions), relative to support for equal distributions (equal distributions $\geq$ 1% pay \$500 $\geq$ 1% pay \$10,000)	Traffic, relative to carcinogen, hazard 2.05 (1.18-3.56), *p* = .011 Agency admission that cost estimate is uncertain indicates agency is trustworthy and honest .59 (.42-.82), *p* = .002	Model correctly predicted 65.2% of cases, exceeding proportional by chance accuracy rate of 59.7% (n = 488; goodness of fit [deviance χ^2] = 820.74, *p* = 1.00; Nagelkerke pseudo-R^2 = .12)	Numeracy; demographics; other experimental effects; expected share; unfair share

Note. For the regulatory costs row, initial numbers in the second column are unstandardized correlation coefficients. R^2 (third column, first data row) is the variance explained in the dependent variable by the collective independent variables; R^2_{adj} is this number adjusted to account for differences in the number of independent variables across different linear regression analyses. The closer R^2 is to 1.00, the more variance in the dependent variable is explained by the independent variables. For subsequent data rows, initial numbers in the second column include the odds ratio, and its 95% confidence intervals in parentheses. If the odds ratio > 1.00, the people with the belief or attitude listed first in the first column are, compared to those listed second in the first column, more likely to have the belief or attribute, or been exposed to the experimental manipulation, listed in the second column. Proportional by chance accuracy rate (third column, all but first data row) is equal to a 25% improvement in classification of cases over the rate of accuracy achievable by chance alone. If the model's correct classification of cases, the most interpretable criterion for the usefulness of a logistic regression result, exceeds the proportional by chance accuracy rate, this indicates at least minimal adequacy. Summary statistics are included for experimental interactions only when these were statistically significant.

Table V. Summary of Selected Findings and Interpretations for Practice

Major Findings	Practical Interpretations
Beliefs about Regulatory Costs	
1) People grossly over-estimated the unit costs of a regulation (i.e., how much it costs to double the strength of a car roof), and to a lesser extent under-estimated its total scope (national production of cars)	This may help explain beliefs about agency under-estimation of regulatory costs (#2 below). People who believe it is very expensive to reduce risks may regard agency cost estimates as "too good to be true," which may hinder agencies trying to educate citizens, or engage the public in deliberations, on regulatory costs
Beliefs about Agency Estimates of Regulatory Impacts	
2) A majority of respondents believe that EPA under-estimates costs	This belief is likely to hamper any effort to educate citizens about scholarly findings that cost over-estimation is the more common result of agency behavior
3) A majority deems EPA accurate about lives saved	This belief may reassure EPA and perhaps other health and safety agencies, but how far it applies across agencies remains to be seen
4) Reasons volunteered for belief in EPA mis-estimation of costs or benefits range from general distrust of government (or extrapolations from cost overruns on home or government construction projects) to sophisticated impact-specific arguments about difficulties in estimating outcomes	This apparent diversity of mental models of agencies' analytic competence offers both opportunities and barriers for agency discussions with citizens about the limits to and accuracy of regulatory impact assessments
5) Agencies that present cost estimates that are uncertain divide citizens as to agency honesty, trustworthiness, and competence	Agencies that follow risk communicators' advice to discuss uncertainties in their work, in both risk assessments and cost estimates, should expect diverse public reactions
Attitudes Toward Certain versus Uncertain Cost Estimates	
6) A regulation with an estimate of regulatory impacts that was certain or narrowly uncertain (within one's own zone of uncertainty about tolerable tradeoffs of costs and lives saved) received similar two-thirds support. This held true when these conditions were evaluated separately, both overall and for those reacting to estimates of regulatory costs only (i.e., excluding those who saw uncertain estimates of lives saved). When they were contrasted directly, there was slightly more support for narrow uncertainty than certainty in the full sample, but slightly less among those reacting to regulatory-cost estimates	Although finding #5 (above) indicates mixed feelings about an agency's direct expression of uncertainty in its estimates, distaste for the experience of *narrow* (person-specific) uncertainty was *far less* than one might expect from general statements that people avoid uncertainty, even when only uncertainty in regulatory costs (rather than benefits) was included. This suggests that narrow (as defined by professionals) uncertainty in impact estimates *might* be acceptable to many or even most citizens if the reasons were clearly explained
7) A regulation with a widely uncertain estimate	Clearly a regulation with widely uncertain

Major Findings	Practical Interpretations
of impacts (i.e., simultaneous possibility that the outcome could be definitely acceptable, definitely unacceptable, or indefinitely acceptable to the respondent) received support from half of the sample when evaluated alone, whether overall or for costs alone; a third of the sample supported that regulation over the same regulation with a certain estimate (preferred by about half the sample), and a quarter when considering only regulatory costs	estimates (relative to a person's own uncertainty about acceptable tradeoffs) was less acceptable than its narrowly uncertain or certain counterparts, but support for such a regulation was still surprisingly high. Such support was associated with positive reactions to agency uncertainty (possibly reflecting general trust in government) and low numeracy, among other factors. In practice, it is unclear how people would respond to "wide" uncertainties in professional (not person-specific) estimates
(8) Nearly one-quarter of respondents changed their views substantially about the hypothetical regulation when its cost (or its benefit) was surrounded by "wide uncertainty." This effect was slightly more pronounced when cost was made uncertain as opposed to benefit.	Considering both those respondents who reacted very favorably and very unfavorably to wide uncertainty, it is clear that suppressing information about cost (or benefit) uncertainty can evoke public responses that differ from fully-informed responses.
Preferences for Distribution of Regulatory Costs	
9) Equal distribution of regulatory costs across households was preferred, with unequal distributions preferred to be random rather than determined by income	This preference is not surprising in the U.S., but given the likely unequal actual distribution of regulatory costs, actual distributions may not be politically acceptable if and when these are publicized
10) The fairness of equal inter-individual distributions of regulatory cost was controversial, whether in the short run for a regulation affecting a universally-used commodity or in the long run balance of multiple regulations' impacts	The gap between equality and equity in preferred regulatory cost distributions may raise the value of agencies stressing that they lack foreknowledge of who ultimately will pay regulatory costs, while increasing pressure upon them to know more about likely or experienced distributions