Multivariate Analyses of Regulatory Cost Perceptions: Supplement to Branden B. Johnson and Adam M. Finkel (2015, forthcoming, *Risk Analysis*), "Public Perceptions of Regulatory Costs, Their Uncertainty and Inter-individual Distribution"

This document functions as an appendix to the paper cited above. Due to the need to focus on descriptive findings of this pilot research, keep the article's length within journal limits, and the limited explanatory value of the multivariate analyses, we chose to report most of them here, in this online supplement. Multivariate analyses of five of the most important dependent variables were included in Table IV of the article. Most of the relevant information appears in the article (e.g., definitions of variables, dependent or independent), so here we note only a few variables and analytic details to further help the reader in interpreting the multivariate analyses reported below.

Beliefs and/or attitudes about the magnitude of regulatory costs, possible biases in agency estimates of regulatory impacts, uncertainty in such estimates, and distribution of regulatory costs are the categories of dependent variables (see first column of table below) regressed on independent variables. Among the latter, demographic variables included gender, age, education, ethnicity, political party, political ideology, home ownership, job status, and income. Numeracy was measured in both objective and subjective terms. Two of the four experimental manipulations were whether respondents were provided with "surprise" information about upward and downward biases in cost estimates, or with information on the value of a statistical life used by U.S. federal regulatory agencies, during the introduction to the survey. The other two manipulations, conducted during the tradeoff-elicitation process, were whether they were presented with a hypothetical regulation involving acute injury or one involving chronic disease, and whether they were asked to consider the size of benefits justifying a fixed regulatory cost, or the size of regulatory costs justifying fixed benefits. Expectations about regulatory estimates of costs and lives saved (benefits), beliefs about whether one's household would pay its equal share of regulatory costs and whether this share would be fair, belief in the need for regulation of the private sector, the ratio of the upper and lower bound of personal tradeoffs (tradeoff ambiguity), and the value of a statistical life imputed from the geometric mean of these bounds relative to the tradeoff anchor ($1 billion in regulatory costs or 1,000 deaths postponed per year) were constructed variables also used as potential predictors in multivariate analyses.

Most analytic methods and data should be familiar to readers of quantitative social science papers, but we note a few details here. Generalized linear models were run for non-categorical dependent variables twice: first to estimate main effects of all potential predictors, then again to identify interaction effects. Using the latter analysis to estimate "main effects" as well (a not uncommon procedure) would have been misleading, as it would have estimated their value when all other variables equal zero, a condition not pertinent to the research questions asked here. Besides standard logistic analyses run for dependent variables with two categories, multinomial (nominal) logistic regression was used for categorical dependent variables in which the respondent could answer in more ways (three here). For example, a respondent could express her beliefs about agency point estimates of cost and of lives saved by answering that the agency under-estimates, over-estimates, or is accurate, with multinomial logistic regression comparing each of the three conditions to each of the other two. Only three of the six contrasts need reporting, however, as comparing A to B equals comparing B to A. The direction of the contrast shifts only the odds ratio for a given independent variable, between being above 1.0 (e.g., A exhibits more of that variable than B) or below 1.0 (e.g., B exhibits less than A). If the 95% confidence intervals for the odds ratio exclude 1.0, the odds ratio is statistically significant at $p < .05$ or better. The reference category is the base against which another category of the variable is compared to calculate the odds ratio: e.g., for regulatory cost expectations we used under-estimation as the main reference category, because most people expected agency cost under-estimation.

The following table lists statistically significant associations ($p < .05$ or better) of experimental manipulations and non-experimental variables with dependent variables. Univariate GLM results are reported with unstandardized estimates of correlation coefficients. These coefficient estimates can be interpreted as indicating that a one-unit shift in the independent variable will change the dependent variable by the specified amount: e.g., in the first data row of the table, as probabilistic numeracy increases by one unit on the 12-point scale, the ratio of respondents' own estimate to the agency's estimate of roof-strengthening costs declines by 332.34 (i.e., over-estimation declines as numeracy rises). R^2 (third column) 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.

Standard and multinomial logistic regression results are reported with odds ratios and (in parentheses) 95% confidence intervals. 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. For example, the first data row about beliefs regarding agency estimates shows that on average people who were probabilistically numerate were less likely than the less numerate (odds ratio of .90) to report that agencies are accurate on costs rather than under-estimators of costs. One could equally well phrase this as indicating that probabilistically numerate people were more likely to assume that the agency under-estimates costs than they were to assume that it is accurate. Proportional by chance accuracy rate (third column) 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; explanations of these interactions (derived from simple plots) are provided when these are relatively brief and straightforward. Interaction results are shaded gray. Full results are available from the first author.

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	
Ratio of own estimate to annual new car production			All above
Beliefs about Agency Estimates of Regulatory Impacts			
Accurate on costs, relative to under-estimation	Probabilistic numeracy .90 (.82-.99), *p* = .029 Age .96 (.95-.98), *p* = .000 Expect to pay their share of regulatory costs, relative to more than their share 2.38 (1.42-3.99), *p* = .001 Expect to pay less, rather than more than, their share of regulatory costs 2.67 (1.34-5.32), *p* = .005	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)	Subjective numeracy; other demographics; need for regulation; expected share of regulatory costs; experimental effects
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, rather than more than, their share 3.50 (1.11-11.09), *p* = .033		Numeracy; other demographics; need for regulation; experimental effects
Accurate on costs, relative to over-estimation	Full-time jobs .34 (.14-.85), *p* = .021		Numeracy; other demographics; need for regulation; expected share of regulatory costs; unfair share; experimental effects
Interactions	Anchor *Agency * Surprise * VSL 92.72 (3.32-2592.23), *p* = .008	Model correctly predicted 60.6% of cases (n = 503; goodness of fit [deviance χ^2] = 784.04, *p* = 1.00; Nagelkerke pseudo-R^2 = .25)	

Topics and Dependent Variables	Significant Associations	Summary Statistics	Insignificant Associations
Over-estimation of lives saved, relative to accuracy	Age 1.04 (1.02-1.06), *p* = .000 Probabilistic numeracy 1.18 (1.03-1.34), *p* = .015 Unfair share 1.17 (1.00-1.36), *p* = .046 VSL sentence unseen, versus seen 1.61 (1.02-2.54), *p* = .04	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; demographics; need for regulation; expected share of regulatory costs; other experimental effects
Beliefs about Agency Estimates of Regulatory Impacts (cont'd)			
Under-estimation of lives saved, relative to accuracy	Politically conservative .79 (.66-.95), *p* = .01 Expect to pay less, rather than more, than their share .41 (1.06-2.33), *p* = .03		Numeracy; other demographics; need for regulation; unfair share; 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		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)	
Over-estimation of \$1-3 billion range, relative to under-estimation	Accuracy of earlier point estimate of costs, relative to under-estimation 10.03 (2.39-42.03), *p* = .002 Expect to pay less, rather than more, than their share 3.82×10^7 (6.44×10^6-2.26E $\times 10^9$), *p* = .000	Model correctly predicted 71.7% of cases, exceeding proportional by chance accuracy rate of 63.7% (n = 505; goodness of fit [deviance χ^2] = 616.86, *p* = 1.00; Nagelkerke pseudo-R^2 = .35)	Numeracy; demographics; need for regulation; unfair share; other demographics; expected share of regulatory costs; other experimental effects
Accuracy of \$1-3 billion range, relative to under-estimation	Accuracy of earlier point estimate of costs, relative to under-estimation 4.78 (2.89-7.91), *p* = .000 Need for regulation 1.46 (1.19-1.79), *p* = .000 Unfair share of regulatory costs .82 (.72-.94), *p* = .005 Age .97 (.95-.99), *p* = .002 VSL sentence, absent versus present 1.60 (1.03-2.48), *p* = .035		

Topics and Dependent Variables	Significant Associations	Summary Statistics	Insignificant Associations
Interactions	Agency * Surprise 5.12 (1.09-24.02), p = .038; Agency * VSL 13.77 (2.46-77.04), p = .003; Agency * Surprise * VSL .04 (.003-.45), p = .009		
Accuracy of $1-3 billion range, relative to over-estimation	Full-time job .14 (.02-8.18), *p* = .029		
Interactions	Anchor * Surprise * VSL $1.86 X 10^{-14}$ ($5.29 X 10^{-12}$-$6.54 X 10^{-15}$), *p* = .001	Model correctly predicted 73.3% of cases (n = 505; goodness of fit [deviance χ^2] = 582.40, *p* = 1.00; Nagelkerke pseudo-R^2 = .407)	Numeracy; other demographics; need for regulation; expected share of regulatory costs; unfair share; other experimental effects; expected under-estimation of earlier point estimate
Agency admission that cost estimate is uncertain indicates agency is trustworthy and honest	Accurate on costs, relative to under-estimation B = .33, *p* = .000 Need for regulation B = .21, *p* = .000 Unfair share of regulatory costs B = -.13, *p* = .000 Expect to pay one's share of regulatory costs, relative to more than one's share B = .26, *p* = .006 Income B = .04, *p* = .034 White B = .21, *p* = .029	R^2 = .26; R^2_{adj} = .23	Numeracy; other demographics
Interactions	Anchor * Agency B = -.92, *p* = .001	R^2 = .29; R^2_{adj} = .24 Positive views of carcinogen higher than for traffic with lives-first anchor; little difference with costs-first anchor	
	Anchor * VSL B = -.61, *p* = .033	More positive views in costs-first than lives-first condition, but always more positive without VSL sentence	
	Anchor * Agency * VSL B = 1.21, *p* = .005	Traffic: VSL linked to more positive views in costs-first than lives-first condition, while absence of VSL sentence made little difference. Carcinogen: VSL linked to	

Topics and Dependent Variables	Significant Associations	Summary Statistics	Insignificant Associations
		less positive views in costs-first than lives-first condition, while its absence linked to more positive views in costs-first condition.	
Attitudes toward Certain versus Uncertain Estimates of Regulatory Costs and Benefits			
Support for regulation with certain estimate	Agency admission that cost estimate is uncertain indicates agency is trustworthy and honest B = .37, p = .000 Overestimation of lives saved, relative to under-estimation B = -.59, p = .003 Accuracy of lives saved, relative to under-estimation B = -.51, p = .002 Subjective numeracy B = .03, p = .031 Accurate on costs, relative to under-estimation B = -.30, p = .036	R^2 = .13; R^2_{adj} = .09	Probabilistic numeracy; demographics; experimental effects; imputed VSL; tradeoff ambiguity
Support for regulation with narrowly uncertain estimate	Agency admission that cost estimate is uncertain indicates agency is trustworthy and honest B = .40, p = .000 Over-estimation of lives saved, relative to under-estimation B = -.44, p = .026 Probabilistic numeracy B = -.08, p = .01 Subjective numeracy B = -.04, p = .013	R^2 = .14; R^2_{adj} = .10	Demographics; other experimental effects; agency accuracy on costs; tradeoff ambiguity
Interactions	Anchor * Agency * Surprise * VSL B = -.998, p = .045	R^2 = .16; R^2_{adj} = .10	
Support for regulation with widely uncertain estimate	Agency admission that cost estimate is uncertain indicates agency is trustworthy and honest B = .42, p = .000 Over-estimation of lives saved, relative to underestimation B = -.66, p = .002 Accuracy of lives saved, relative to underestimation B = -.39 , p = .022 Probabilistic numeracy B = -.10, p = .004	R^2 = .19; R^2_{adj} = .15	Subjective numeracy; other demographics; other experimental effects; tradeoff ambiguity

Topics and Dependent Variables	Significant Associations	Summary Statistics	Insignificant Associations
	Lives-first, relative to costs-first, anchor B = -.44, *p* = .002 Traffic, relative to carcinogen, hazard B = -.27, *p* = .038		
Support for certain estimate, relative to narrowly uncertain estimate			Numeracy; demographics; experimental effects; agency accuracy on costs and lives; agency admission that cost estimate is uncertain indicates agency is trustworthy and honest; imputed VSL; tradeoff ambiguity
Support for certain estimate, relative to widely uncertain estimate	Probabilistic numeracy B = .13, *p* = .001 Accurate on costs, relative to under-estimation B = -.70, *p* = .000 Agency admission that cost estimate is uncertain indicates agency is trustworthy and honest B = -.23, *p* = .008	R^2 = .14; R^2_{adj} = .10	Subjective numeracy; demographics; experimental effects; agency accuracy on lives; imputed VSL; tradeoff ambiguity
Support for uncertainty (wide $\geq$ narrow $\geq$ certain), relative to support for certainty (certain $\geq$ narrow $\geq$ wide)	Over-estimation of costs, relative to under-estimation 4.16 (1.32-13.16), *p* = .015 Accurate on costs, relative to under-estimation 2.89 (1.33-6.28), *p* = .007 Probabilistic numeracy .83 (.70-.98), *p* = .03	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 pseudo-R^2 = .19)	Subjective numeracy; demographics; experimental effects; agency accuracy on lives; imputed VSL; tradeoff ambiguity
Support for wide uncertainty relative to certainty, due to expecting positive end of range to be more likely	Over-estimation of costs, relative to under-estimation .31 (.13-.79), *p* = .013 Accurate on costs, relative to under-estimation .46 (.27-.79), *p* = .005	Model correctly predicted 81.1% of cases, less than proportional by chance accuracy rate of 86.7% (n = 493; goodness of fit [deviance χ^2] = 431.44, *p* = .90; Nagelkerke pseudo-R^2 = .14)	Numeracy; demographics; experimental effects; agency accuracy on lives; agency admission that cost estimate is uncertain indicates agency is trustworthy and honest; imputed VSL; tradeoff ambiguity Other demographics; experimental effects;

Topics and Dependent Variables	Significant Associations	Summary Statistics	Insignificant Associations
Support for wide uncertainty relative to certainty, due to betting on a positive outcome	Agency admission that cost estimate is uncertain indicates agency is trustworthy and honest .59 (.42-.82), *p* = .002 Accurate on costs, relative to under-estimation .50 (.28-.90), *p* = .02 Education .73 (.58-.92), *p* = .008 Subjective numeracy 1.07 (1.00-1.14), *p* = .04 Probabilistic numeracy 1.16 (1.02-1.32), *p* = .03 Non-Republican .42 (.18-.98), *p* = .045	Model correctly predicted 86.4% of cases, less than proportional by chance accuracy rate of 92.8% (n = 493; goodness of fit [deviance χ^2] = 361.41, *p* = 1.00; Nagelkerke pseudo-R^2 = .20)	agency accuracy on lives; imputed VSL; tradeoff ambiguity
Preferences for Distribution of Regulatory Costs			
Support for equal distribution of regulatory costs	Unfair share of regulatory costs B = -.33, p = .000 Traffic, relative to carcinogen, hazard B = -.53, *p* = .001 Agency admission that cost estimate is uncertain indicates agency is trustworthy and honest B = .28, *p* = .004 Expect to pay less, rather than more, than one's share B = -1.15, *p* = .000 Expect to pay, rather than more than, one's share B = -.60, *p* = .005 Over-estimation of lives saved, relative to under-estimation B = -.64, *p* = .014	R^2 = .21; R^2_{adj} = .16	Numeracy; other demographics; other experimental effects; agency accuracy on costs; imputed VSL; tradeoff ambiguity
Interactions	Anchor * VSL B = 1.33, *p* = .039	R^2 = .22; R^2_{adj} = .16 VSL sentence presence makes no difference in lives-first condition, but reduces support for equal distribution when it is absent in cost-first condition	

Topics and Dependent Variables	Significant Associations	Summary Statistics	Insignificant Associations
Support for rich paying greater share of regulatory costs	Unfair share of regulatory costs B = -.26, *p* = .000 Politically conservative B = -.14, *p* = .02 Expect to pay less, rather than more, than one's share B = -.94, *p* = .000 Expect to pay, rather than more than, one's share B = -.46, *p* = .018 Over-estimation of lives saved, relative to under-estimation B = -1.09, *p* = .000 Accuracy of lives saved, relative to under-estimation B = -.63, *p* = .001 Agency admission that cost estimate is uncertain indicates agency is trustworthy and honest B = .38, *p* = .000	R^2 = .26; R^2_{adj} = .22	Numeracy; other demographics; experimental effects; agency accuracy on costs; tradeoff ambiguity
Support for non-equal random distributions (1% pay $10,000 ≥ 1% pay $500 ≥ equal distributions), relative to support for equal distributions (equal distributions ≥ 1% pay $500 ≥ 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 64.7% 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
Support for alternative distributions, relative to wealth-based payment of $500 (richest 1% ≥ random 1% ≥ poorest 1%)	Lack full-time job .57 (.34-.97), *p* = .04 Probabilistic numeracy .84 (.74-.95), *p* = .005 Accurate on costs, relative to under-estimation 2.57 (1.53-4.30), *p* = .000	Model correctly predicted 69.1% of cases, exceeding proportional by chance accuracy rate of 67.6% (n = 431; goodness of fit [deviance χ^2] = 500.48, *p* = .001; Nagelkerke pseudo-R^2 = .182)	Subjective numeracy; other demographics; experimental effects; agency accuracy on lives; agency admission that cost estimate is uncertain indicates agency is trustworthy and honest; imputed VSL; tradeoff ambiguity; expected share; unfair share

Topics and Dependent Variables	Significant Associations	Summary Statistics	Insignificant Associations
Expect to pay less rather than more than one's share	Income .79 (.66-.95), *p* = .012 Age 1.03 (1.002-1.06)), *p* = .036 Accuracy of lives saved, relative to under-estimation2.44 (1.05-5.69), *p* = .039 Over-estimation of costs, relative to under-estimation 5.08 (1.19-21.78), *p* = .029	Model correctly predicted 64.4% of cases, exceeding proportional by chance accuracy rate of 57.9% (n = 492; goodness of fit [deviance χ^2] = 795.79, *p* = 1.000; Nagelkerke pseudo-R^2 = .221)	Numeracy; other demographics; experimental effects; agency admission that cost estimate is uncertain indicates agency is trustworthy and honest; imputed VSL; tradeoff ambiguity
Expect to pay equal rather than more than one's share	Agency admission that cost estimate is uncertain indicates agency is trustworthy and honest 1.69 (1.29-2.20), *p* = .000 Over-estimation of costs, relative to under-estimation 4.64 (1.44-14.89), *p* = .01 Accurate on costs, relative to under-estimation 2.09 (1.21-3.61), *p* = .009		Numeracy; other demographics; experimental effects; agency accuracy on lives; imputed VSL; tradeoff ambiguity
Regulatory costs will be equal across businesses and consumers in long run	Over-estimation of lives saved, relative to under-estimation B = -.52, *p* = .000 Unfair share of regulatory costs B = -.13, *p* = .000 Probabilistic numeracy B = -.08, *p* = .000 Agency admission that cost estimate is uncertain indicates agency is trustworthy and honest B = .14, *p* = .007 Democrat B = .21, *p* = .046	R^2 = .22; R^2_{adj} = .17	Subjective numeracy; other demographics; experimental effects; agency accuracy on costs; imputed VSL; tradeoff ambiguity; expected share
Foreknowledge of who will pay or not pay regulatory costs is improper selection of winners	Age B = .011, *p* = .01	R^2 = .07; R^2_{adj} = .02	Numeracy; other demographics; experimental effects; agency accuracy on costs and lives; agency admission that cost estimate is uncertain indicates agency is trustworthy and honest; imputed VSL; tradeoff ambiguity; expected share; unfair share

Topics and Dependent Variables	Significant Associations	Summary Statistics	Insignificant Associations
Unequal distribution of regulatory costs is fair only if those who pay are also beneficiaries	Politically conservative B = .10, *p* = .02 Over-estimation of lives, relative to under-estimation B = .32, p = .046	R^2 = .07; R^2_{adj} = .02	Numeracy; other demographics; experimental effects; agency accuracy on costs; agency admission that cost estimate is uncertain indicates agency is trustworthy and honest; imputed VSL; tradeoff ambiguity; expected share; unfair share