MEASURING WILLINGNESS TO PAY FOR HEALTH RISK REDUCTIONS:

LESSONS LEARNED FOR VALUATION OF CHEMICAL POLLUTION

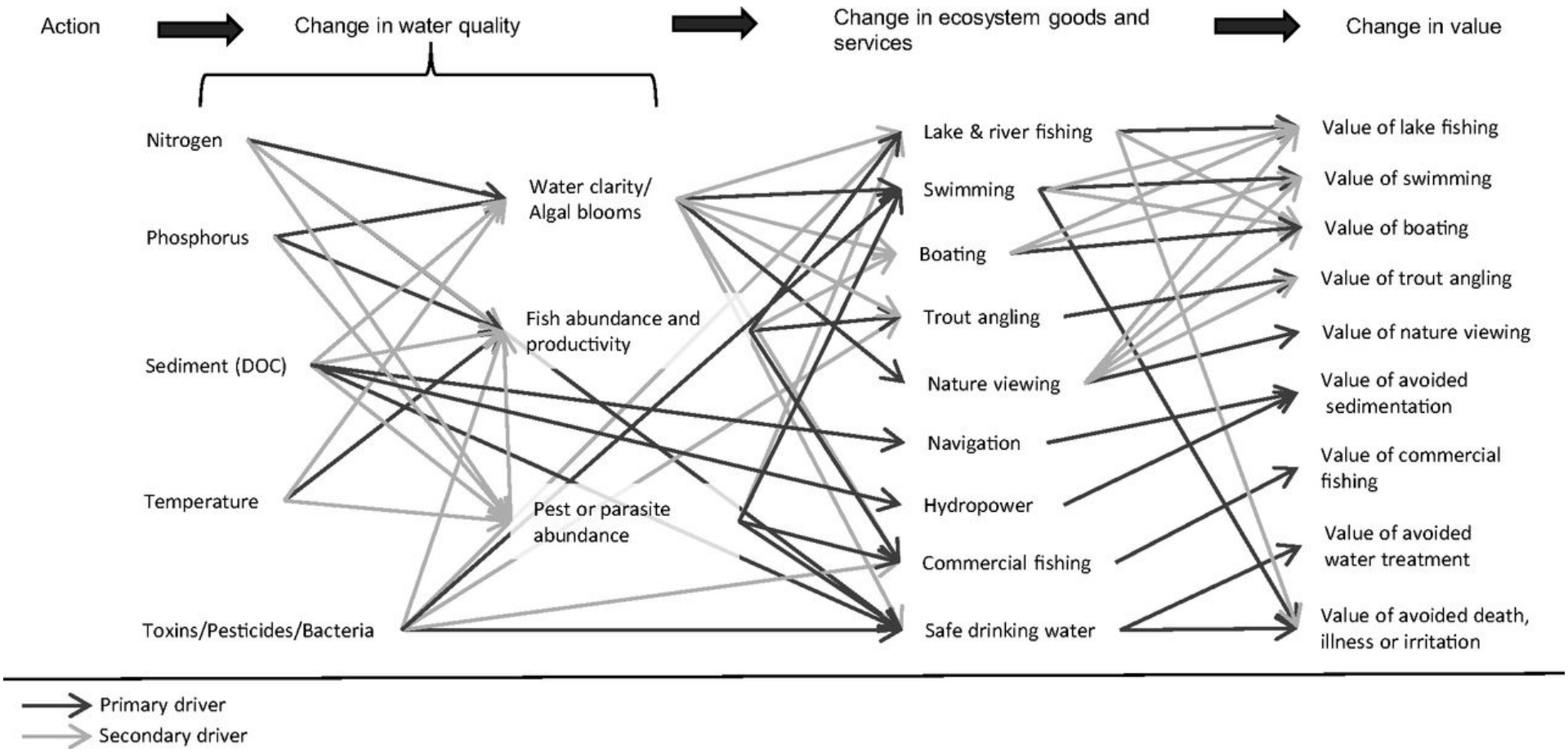
Vic Adamowicz
University of Alberta

Collaborators: Shelby Gerking, Mark Dickie, Marcella Veronesi

UNIVERSITY OF ALBERTA

Department of Resource Economics and Environmental Sociology
Faculty of Agricultural, Life and Environmental Sciences

Relationships between water quality change, multiple ecosystem goods and services, and associated changes in values.



Keeler B L et al. PNAS 2012;109:18619-18624

Cases

- Mortality / morbidity are *probably* the largest portion of Willingness to Pay for “hazardous chemical mixture” reductions.
- Construct estimates of value of reducing risks or illness / mortality cases
  - Marginal WTP to reduce risks of illness, mortality
    - Multiple illness endpoints?
  - Context specific?
    - Water, Air, etc.
- Public Goods
  - Water treatment, etc.
- Private Goods
  - Technologies, treatments, etc
- Revealed Preference or Stated Preference

Example: Drinking Water Risks from Chlorine Treatment

- Drinking water is treated to remove pathogens

  BUT

- Chlorine used to treat water has been implicated in the production of trihalomethanes (THMs) linked to bladder cancer.

  ➔ tradeoffs

- Tradeoffs are cancer vs. pathogens vs. costs (plus morbidity risk vs. mortality risk)
- Public good (altruism)

Some Key Issues

- Endpoints
  - What affects people / enters utility function?
- Baseline Risk
  - Perceptions?
- Endogeneity
  - Ability to self-protect
- Heterogeneity
  - Preferences
  - Perceptions
- Risk Context
  - Health endpoint (mortality / morbidity; cancer / non-cancer)
  - Pathway (air, water, etc.)
- Measurement approach
  - Data
- Often very small risks
  - Information processing issues
- Altruism

An Example – Health Risk Valuation and Baseline Risks

- Standard economic model of the value of mortality risk reduction is a function of baseline risks
- What is the baseline risk (for an individual)?
  - Perceived risk?
  - Are perceived risks "accurate"?
- Is risk exogenous? (probably not: can be influenced by the individual)
- Is Marginal WTP (MWTP) increasing or decreasing in baseline risk?
- In valuing risk reductions – are we observing heterogeneity in preferences, or in risk perceptions?
- Policy implications
  - The need to "match" baseline risks
  - Understanding the role of perceptions, information and preferences.

U.S. Benefits/Costs in 2020 CAAA (in billions of 2006 dollars)

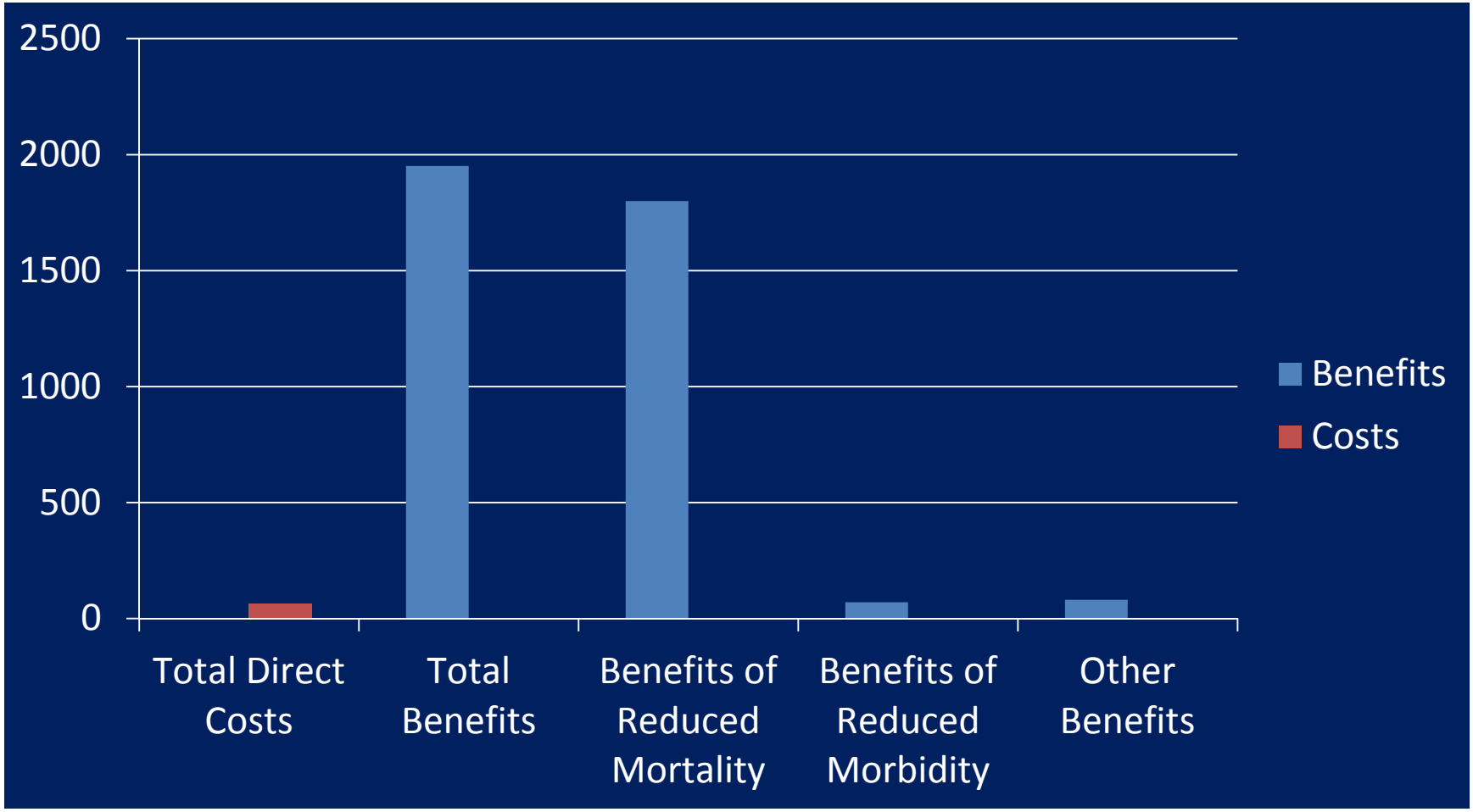
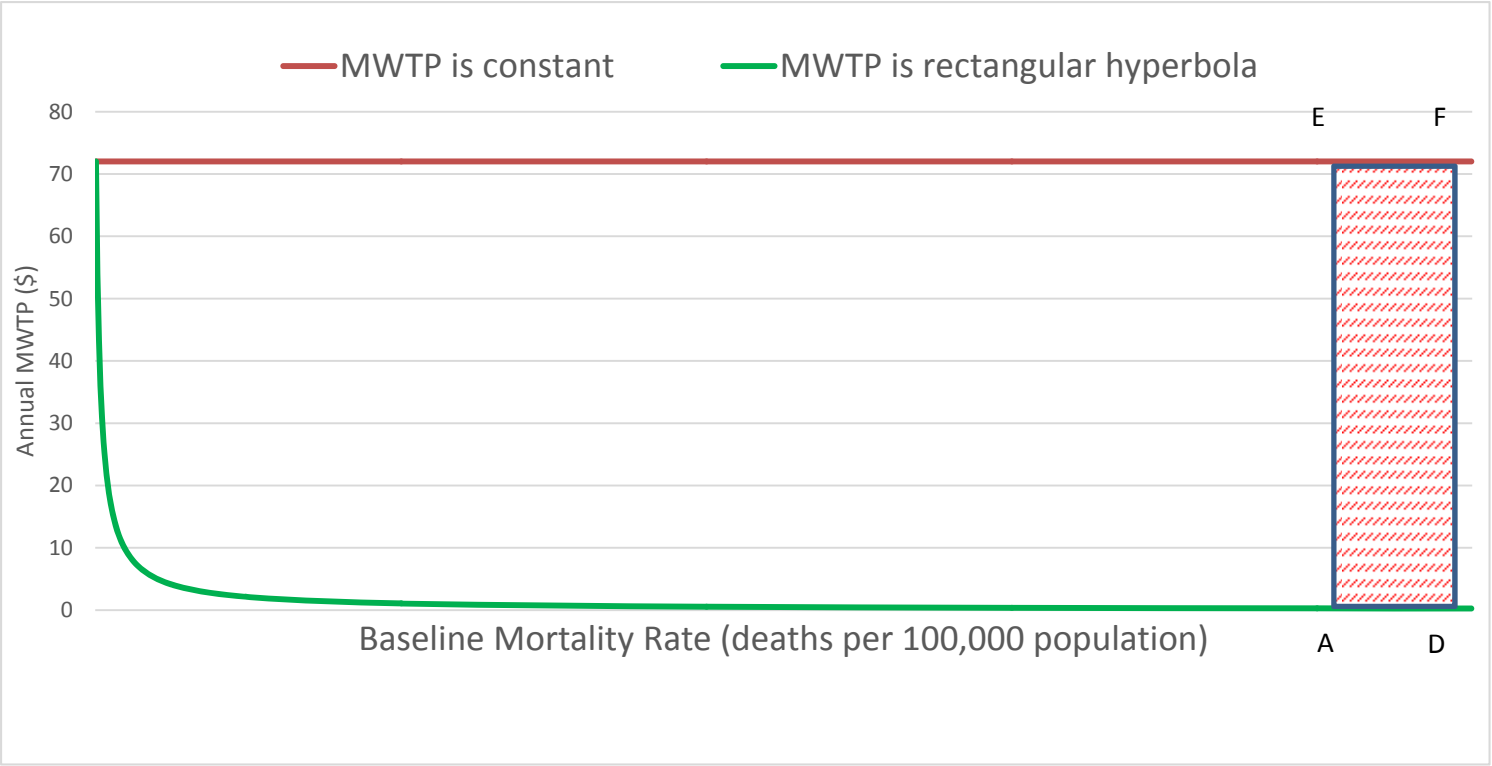


Figure 2. Annual Benefit of Mortality Risk Reduction if Marginal Willingness to Pay to Reduce Risk is a Constant or a Rectangular Hyperbola in Baseline Risk.
MWTP for 1/100,000 risk reduction is $72 at baseline risk of 3/100,000: Constant and rectangular hyperbola MWTP functions and benefit of reducing risk from 901 to 821 per 100,000 if MWTP is constant.



Endogenous versus Exogenous Risks

- According to theory
  - Exogenous risk: MWTP *typically* increases with baseline risk (Pratt and Zeckhauser, JPE 1996)
  - Endogenous risk: MWTP *may* decrease with baseline risk (Liu and Neilson, EER 2005)
- Empirical estimates are inconclusive
  - Viscusi and Evans (AER 1990)
  - Smith and Desvousges (JPE 1986)
  - Hammitt and Haninger (JRU 2010)
  - Alberini and Scasny (EE 2013)

Exogenous Risk Model: Mortality Risk Valuation

- Let EU = expected utility, H = utility if healthy, D = utility if dead, r = exogenous mortality risk, I = Income

$$EU = (1 - r)H + rD$$

$$MWTP_r = \frac{dI}{dr} = \frac{(H - D)}{(1 - r)H' + rD'} > 0$$

$$\frac{\partial^2 I}{(\partial r)^2} > 0 \qquad if \quad (1 - r)H'' + rD'' \leq 0$$

- MWTP increases with baseline risk
- "Dead-anyway effect"

Endogenous Risks

$$EU = (1 - r(X, G))H + r(X, G)D$$

- X and G are private and publically provided goods that reduce r: $r_X < 0$, $r_G < 0$, $r_{XX} > 0$, $r_{GG} > 0$, $r_{XG} > 0$

$$MWTP_r = -\frac{1}{r_x(X^*, G)} > 0$$

$$\frac{dMWTP_r}{dG} = \frac{(r_{XX}(dX^*/dG) + r_{XG})}{(r_X)^2} > 0$$

- MWTP can be inversely related to baseline risk
- Opposite to “dead anyway effect”
- Liu and Neilson, 2006; Shogren and Stamland, 2002

Morbidity Model: Exogenous Risk

- Parent risk $EU = (1-R_p)EU_{H□} + R_p EU_{S□}$
- Marginal Willingness to Pay (Parent)

$$MWTP_p = \frac{\partial I}{\partial R_p} = \frac{(EU_{H□} - EU_{S□})}{(1-R_p)EU'_{H□} + R_p EU'_{S□}} > 0$$

- MWTP increases with baseline risk if MU$ higher when healthy versus sick.
- “Sick anyway effect”
- Similar model for kid risk.

Morbidity Model: Endogenous Risk

- Parent risk $EU = (1 - R_p(X_p, G))EU_{H\square} + R_p(X_p, G)EU_{S\square}$
- Marginal Willingness to Pay (Parent)

$$MWTP_p^* = -1 / R_p^X(X_p^*, G)$$

$$\frac{dMWTP_i^*}{dG} = \frac{(R_i^{XX}(dX_i^* / dG) + R_i^{XG})}{(R_i^X)^2}$$

- MWTP decreases with baseline risk if $(R_i^{XG} > 0)$
  - G reduces the productivity of X in reducing risk

- Similar model for kid risk.

Study Objectives

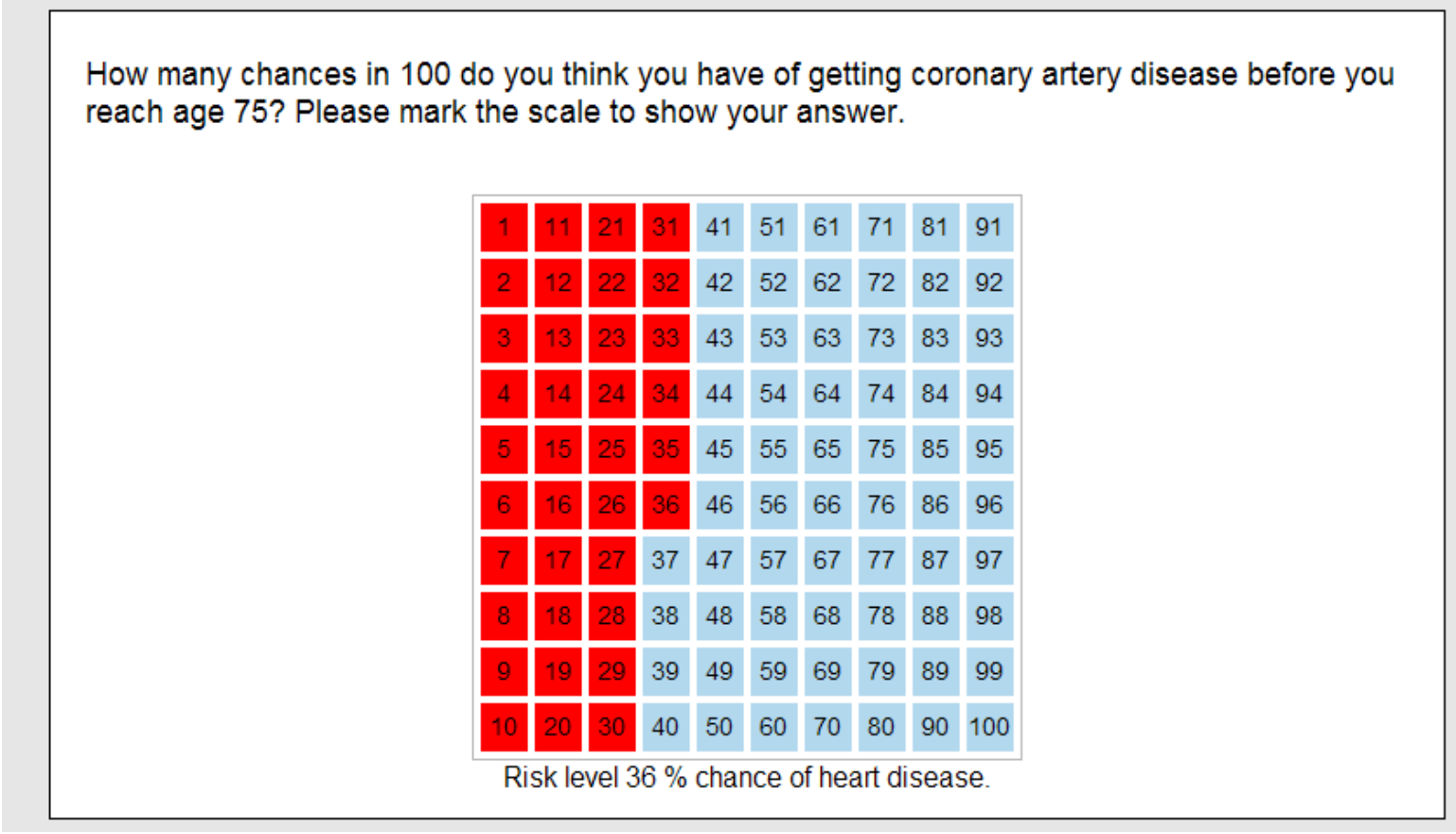
- Measure MWTP for heart disease risk reduction
  - A component of benefits from improved air quality / reduction in particulate matter
- Collect information on perceived risks of heart disease
  - Baseline risks
  - Assess “accuracy” of perceived risks
- Measure MWTP for risk reduction
  - Test whether MWTP is an increasing or decreasing function of baseline risk
  - Assess evidence for / against endogeneity of risk
- Examine source of heterogeneity in MWTP
  - Demographic characteristics or
  - Differences in risk perceptions

Field study

- Examination of heart disease risk perceptions and WTP
- National probability sample of parents from Knowledge Networks panel
- Panel is a probability sample representative of US households
- Total sample: n=3155
  - "Soft launch" n=505
  - Matched spouses sample =832
- In the first study, n=1778 of unmatched spouses
- Each respondent had at least one biological child between the ages of 6-16 years
- Sample child selected at random
- Computerized survey instrument delivered by e-mail to selected panel members

Survey Elements (1)

- Risk scale to elicit perceived risk of coronary artery disease before age 75 years.



Survey Elements (2)

- Provide information about heart disease
  - Average risks
  - Gender
  - Risk factors: smoking, cholesterol, blood pressure, diabetes, BMI, diet, exercise, family history.
- Elicit revised perceptions of risk by allowing changes in initial answer

Risk Perceptions of Coronary Artery Disease before Age 75

	Fathers' Mean Risk Estimates			Mothers' Mean Risk Estimates		
	Initial	Revised	n	Initial	Revised	n
Self	37	35	746	35	33	1458
Sons	28	24	388	31	26	748
Daughters	27	22	358	28	23	710
"Objective Risks" ("current")	35			19		

	Objective Probabilities		
		Male	Fem.
Current Smoker?			
	No	28	14
	Yes	34	21
Body Mass Index			
	< 25	28	15
	25 - < 30	30	18
	>= 30	42	22
Diagnosed with diabetes?			
	No	30	16
	Yes	67	57

	Parents' Subjective Probabilities: Means			
		Fathers		Mothers	
		Init.	Rev'd	Init.	Rev'd
Current Smoker?					
	No	37	34	34	32
	Yes	44	44	44	42
Body Mass Index					
	< 25	29	25	28	24
	25 - < 30	33	31	35	32
	>= 30	43	40	42	43
Diagnosed with diabetes?					
	No	37	34	35	32
	Yes	47	52	46	50

Risk Perceptions – Baseline Risks

- **Some are "accurate" – some not (why?)**
  - What is "accurate"?
- **Some measures of "marginal" risk (e.g. smoking) are very "accurate", some are not (why? Policy implications?)**
  - See also Shaw, 2017; Shaw et al, 2012.
- **What's the role of providing "information" in elicitation?**
  - Similar to information provision in stated preference valuation?
- **Why do women appear to be pessimistic?**
  - May depend on measure of "accuracy"
  - Found in other literatures
    - Survival probabilities – cohort based analysis (Hurd, 2009)
    - Men "slightly pessimistic, women quite pessimistic" (Hurd, 2009)
  - Is the claim of women being more risk averse, really a risk perception difference?

Purchase Intentions

- Ask respondents about WTP to purchase a program (“vaccine”) that reduces risk
- Purchase Intentions:
  - Increased with increases in risk reduction
  - Decreased with price increases
- For the child vaccine, positive fraction of parents said “yes” at every design point
  - 18% said “yes” at 20% risk reduction/$160
  - 53% said “yes” at 80% risk reduction/$10
- Same general outcome for parent vaccine

Results

- MWTP for reduction in heart disease by 1 *percentage* point
  - Parents: $2.63
  - Children: $2.17
- MWTP for reduction in heart disease risk by 1 *chance in 100* declines as baseline risk increase
  - Rectangular hyperbola
  - MWTP (parents) = $2.63 x (100/R)
    - R = 100, MWTP=$2.63
    - R = 5, MWTP = $52.60

Results

- Estimates impose functional form of MWTP—baseline risk relationship
- Further examination – sensitivity to baseline risk
  - Construct (mean-centered) baseline risk level
    - Enter as a covariate
    - Interact with % risk reduction
    - Interact with price
  - Coefficients of interactions consistently estimated (Proof in appendix of paper)
  - Coefficients of baseline risk level not estimated consistently but are not needed in subsequent analysis

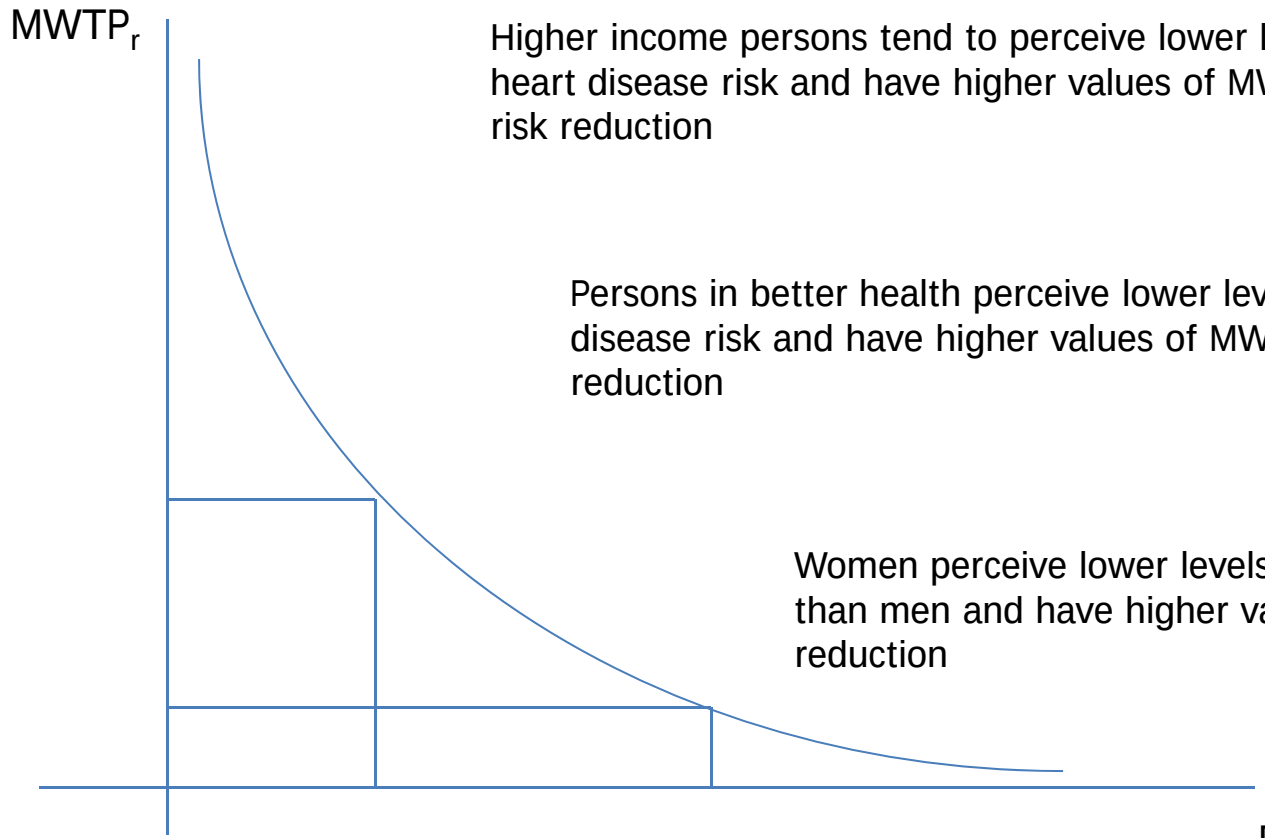
Covariate	Child Equation	Parent Equation
Constant	-0.4102** (0.0313)	-0.4743** (0.0321)
Percentage Risk Reduction	0.0076** (0.0008)	0.0100** (0.0010)
Vaccine Price	-0.0036** (0.0006)	-0.0036** (0.0006)
Interaction of Percentage Risk Reduction and Perceived Risk	0.00007 (0.00005)	-0.00002 (0.00005)
Interaction of Vaccine Price and Perceived Risk	-0.00004 (0.00003)	-0.00004 (0.00003)
Perceived Heart Disease Risk	0.0121** (0.0017)	0.0095** (0.0014)
ρ	0.9029** (0.0125)	
Log-Likelihood	-1734.45	

Covariate	Child Equation	Parent Equation
Constant	-0.3760** (0.0326)	-.4243** (0.0328)
Absolute Risk Reduction	0.0295** (0.0035)	0.0328** (0.0032)
Vaccine Price	-0.0035** (0.0006)	-0.0037** (0.0006)
Interaction of Absolute Risk Reduction and Perceived Risk	-0.0003** (0.0001)	-0.0006** (0.0001)
Interaction of Vaccine Price and Perceived Risk	-0.00003 (0.00003)	-0.00004 (0.00003)
Perceived Heart Disease Risk	0.0009 (0.0022)	0.0042** (0.0015)
ρ	0.8980** (0.0126)	
Log-Likelihood	-1736.24	

Results

- Coefficients of interactions between baseline risk level and price and baseline risk level and % risk reduction not significantly different from zero
  - Individually or jointly
- Coefficients of % risk reduction and price virtually unaffected
- MWTP for risk declines with increases in risk
- Evidence supports endogenous risk model
  - Equality of parent and child MWTP
- Broadly consistent results from similar analysis of absolute rather than % risk reduction

Implications (1)



Perceptions and Estimation: Heterogeneity

- Does heterogeneity in perceptions, rather than preferences, explain (a great deal of) heterogeneity in WTP?

Outcomes of Wald Tests that Parents' Marginal Willingness to Pay for Proportionate Reductions in Heart Disease Risk Does not Vary by Risk Factor. n = 2204. "PREFERENCE"

Risk factor	p-value
1. Parent current smoking[a]	0.71
2. Parent BMI[a]	0.46
3. Parent diabetes[a]	0.80
4. Parent high blood pressure[a]	0.90
5. Parent high cholesterol[a]	0.36
6. Parent or child family history[b]	0.33
7. Parent, child exercise sufficiency[b]	0.63
8. Parent, child fruit & vegetable consumption[b]	0.22
9. Parent, child healthiness of diet[b]	0.40
10. Parent, child subjective health status[b]	0.36

Parents' Marginal Willingness to Pay (MWTP) for Absolute (1 chance in 100) Reductions in Heart Disease Risk by Risk Factor. n = 2204. "PERCEPTION"

	MWTP	
Risk factor	Parent	Child
Parent does not currently smoke cigarettes	$7.07	$8.36
Parent currently smokes cigarettes	5.40	7.97
Parent does not have diabetes	7.03	8.43
Parent has diabetes	4.53	6.55
Parent has normal (or low) bodyweight	9.35	9.67
Parent is overweight	7.33	8.46
Parent is obese	5.61	7.57
Parent does not have high blood pressure	7.49	8.63
Parent has high blood pressure	5.40	7.47
Parent does not have high cholesterol	7.40	8.72
Parent has high cholesterol	5.65	7.37
Parent, child have no family history of heart disease	7.97	9.61
Parent, child have family history of heart disease	6.15	7.84

Conclusions

- Looked at two simple models of that support estimation of MWTP for health risk reduction
  - Exogenous risk
  - Endogenous risk
- Econometric analysis suggests support for the endogenous risk framework
  - Equal MWTP for parent and kid.
- MWTP declines as baseline risk increases
  - MU of consumption lower in the sick state
- Implications
  - Persons with lower perceived risk have greater values of MWTP for heart disease risk reduction
  - Health benefit estimates may be substantially overestimated by conventional valuation methods

Policy Implications

- Importance of understanding baseline risk
- Important role of risk perception
  - What's the role of "education" / information?
  - Accurate versus "inaccurate" risk perceptions
- Can we elicit risk perceptions "accurately"?

Discussion Issues: Valuation of Harmful Chemicals

- Pathways and endpoints
- Validity – stated preference
- Elicitation of baseline risks / role of information
- Risk perceptions – limited knowledge, unknown risks, unusual perceptions?
- Heterogeneity / role of information
- Psychology of information provision?
- Endogeneity
- Addition of MWTP for multiple endpoints?
- Altruism

Portney 1992 JPAM: Happyville

"Imagine you are the Director of Environmental Protection for the town of Happyville. There is a naturally occurring contaminant in the town's drinking water that all of the residents believe is carcinogenic and may account for the towns' above-average cancer rate. Each resident is willing to pay $1,000 to cover the cost of treatment that will eliminate the contaminant.

You have consulted with the world's top risk analysts and each has reported that, while one can never be certain a particular substance does not cause cancer, each would stake her professional reputation on the conclusion that this contaminant is benign. You have repeatedly and skillfully communicated these judgments to the citizenry, but each of them nevertheless prefers to spend the money to treat the water. What should you do? If you call for the water to be treated, you are knowingly denying every resident the other benefits he could achieve with $1,000 but every resident will believe himself to be better off. If you reject the treatment option, you are knowingly imposing a policy that every resident believes is contrary to his well-being"

Paul R. Portney, *Journal of Policy Analysis and Management,* Vol. 11, No. 1 (Winter, 1992), pp. 131-132