Topic 8

- Nonmarket goods
- Hedonics
  - Regression
    - Source: Kelly D. Bradley University of Kentucky
  - Examples
- Contingent valuation
- Value of a statistical life

Nonmarket Environmental Goods and Bads

- Bads
  - ▷ Air pollution, water pollution, noise pollution
  - ▷ Toxic waste, nuclear waste, solid waste
  - ▷ Global warming, ozone depletion, tropical deforestation
- Goods
  - ▷ National parks, open space, hiking trails, visibility
  - ▷ Biodiversity, fish, wildlife
- Presence of nonmarket goods and bads affects willingness to pay for certain market goods

Hedonic Price Methods

- These methods decompose a market good into its attributes and estimate the implicit prices of each attribute, including nonmarket goods
  - ▷ Hedonic – having to do with pleasure
  - ▷ Can use hedonic methods to estimate demand for a non-market good

Some Simple Examples of Hedonic Prices

- Most goods that we purchase are bundles of attributes
  - ▷ Suppose z_1, z_2, ..., z_N are quantities of each attribute
  - ▷ Hedonic regression

$$P = p_0 + p_1 z_1 + p_2 z_2 + ... + p_N z_N$$

- Pizza: size, type of crust, number of toppings, extra cheese

- Automobile: make and model, fuel economy, sound system, AC, transmission, engine size

Basic Hedonic Technique

- Decompose a product into its attributes
- Estimate the implicit price of each attribute
- Usual estimation method is multiple linear regression

What Is Multiple Linear Regression

- Predicting an outcome (dependent variable) based upon several independent variables simultaneously.

- Why is this important?
  - ▷ Behavior is rarely a function of just one variable, but is instead influenced by many variables. So the idea is that we should be able to obtain a more accurate predictions by using multiple variables to predict our outcome.

The Multiple Linear Regression Model

- Prediction applications in which there are several independent variables, $x_1, x_2, x_3, \ldots$. A multiple linear regression model with p independent variables has the equation

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_p x_p + e$$

  - ▷ β_0 is the intercept; i.e. the prediction when all x_i are zero
  - ▷ β_i is the marginal effect of variable x_i
  - ▷ e is random error with mean zero that represents prediction error

The Prediction Equation

- The equation for this model fitted to data is

$$\widehat{y} = b_0 + b_1 x_1 + b_2 x_2 + \ldots + b_p x_p$$

  - ▷ Where $\widehat{y}$ denotes the predicted value computed from the equation, and b_i denotes an estimate of β_i.

- The b_i are computed by least squares.

  - ▷ For each observed y and corresponding prediction $\widehat{y}$, find those b_i that make the sum of the squared errors $\sum(y-\widehat{y})^2$ the smallest.

Doing the Calculations

- Computation of the estimates by hand is tedious.

- They are ordinarily obtained using a regression computer program.

- Standard errors also are usually part of output from a regression program.

  ▷ A confidence interval for a coefficient is the estimate plus and minus twice the standard error.

Assessing the Utility of the Model: Hypothesis tests

- Test if all of the slope parameters are zero: F-test.
  - ▷ Rule of thumb: Should be bigger than 2 if have at least 30 observations.

- Test if a particular slope parameter is zero given that all other x's remain in the model: t-test.
  - ▷ Rule of thumb: Should be bigger than 2 if have at least 30 observations.

Interpreting Coefficients

- Constant, b_0, is the prediction when all the independent variables x_i, are set to zero.

- Other coefficients, b_i are the regression coefficients, are interpreted as the change in the dependent variable y for each unit change in the corresponding independent variable, x_i all other variables held constant.

  - ▷ I.e., b_i is the marginal effect of x_i.

What if the Effect a Variable is Curvilinear?

- Quadratic model

$$\hat{y} = b_0 + b_1 x_1 + c_1 x_1^2 + b_2 x_2 + \ldots + b_p x_p$$

- Marginal effect of x_1 is now $b_1 + 2c_1 x_1$

What if I have a Qualitative Independent Variable?

- Create a dummy variable (indicator variable.)
  - ▷ E.g. $x_i = 1$ if subject is a female and $x_i = 0$ if subject is a male.

What if the Relationship of an IV Depends on the Value of Another IV?

- Interaction model

$$\widehat{y} = b_0 + b_1 x_1 + b_2 x_2 + c_{1,2} x_1 x_2 + \ldots + b_p x_p$$

- Marginal effect of x_1 is now $b_1 + c_{1,2} x_2$

Example: Organic Fresh Tomatoes

- What is the demand for organic tomatoes?

- What price premium are buyers willing to pay for organic versus conventional tomatoes?

- Which types of buyers are willing to pay the most for organic tomatoes?

Example: Organic Fresh Tomatoes

Huang and Lin (Review of Ag Econ, 2007)

- Data: 2004 Nielsen homescan panel data (UPC-level data)
- Markets: Northeast, Central, South, West
- Product attributes: organic, brand (A, B, C, D)
- Purchaser attributes: income, age, race

Technique: Run a Regression

- Regression

$$
\begin{aligned}
\ln P = \quad & a_0 + a_1 \cdot \text{organic} \\
& + a_2 \cdot \text{brand A} + a_3 \cdot \text{brand B} + a_4 \cdot \text{brand C} + a_5 \cdot \text{brand D} \\
& + a_6 \cdot \text{income} + a_6 \cdot \text{age}{<}40 + a_7 \cdot \text{age}{>}64 \\
& + a_8 \cdot \text{black} + a_9 \cdot \text{hispanic} \\
& + \text{controls for month of year}
\end{aligned}
$$

- Run a separate regression for each of the four markets

Regression Output

Northeast Market

$$
\begin{aligned}
\ln P = \; & a_0 + 0.132 \cdot \text{organic} \\
& + 0.161 \cdot \text{A} + 0.073 \cdot \text{B} - 0.174 \cdot \text{C} - 0.258 \cdot \text{D} \\
& + 0.024 \cdot \text{income} + 0.059 \cdot \text{age}{<}40 - 0.014 \cdot \text{age}{>}64 \\
& - 0.096 \cdot \text{black} - 0.090 \cdot \text{hispanic} \\
& + \text{controls for month of year}
\end{aligned}
$$

Marginal Willingness to Pay

- Interested in the marginal willingness to pay for organic fresh tomatoes

$$\ln P = a_0 + 0.132 \cdot \text{organic} + \ldots$$

- If we had not used the log of price, the MWTP would be \$0.132
- But we did use the log of price ...

MWP Using Logs

- Consider the equation:

$$\ln P = a_0 + a_1 X$$

- We can rewrite this as:

$$P = e^{a_0 + a_1 X}$$

- We can differentiate to get:

$$\frac{\partial P}{\partial X} = a_1 \cdot e^{a_0 + a_1 X} = a_1 \cdot P$$

- Thus, the MWTP for organic fresh tomatoes is:

$$a_1 \cdot P$$

- We will use the average price to do this calculation

MWP by Market

	organic regression coefficient	average price ($/pound)	organic MWTP ($/pound)	organic price premium
Northeast	0.132	1.86	0.25	13%
Central	0.070	1.94	0.14	7%
South	0.173	1.69	0.29	17%
West	0.071	1.93	0.14	7%

Brand Preference by Market

MWTP by Market for Brands A, B, C, and D ($/pound)				
	A	B	C	D
Northeast	0.30	0.14	-0.32	-0.48
Central	0.11	0.16	-0.14	-0.41
South	-0.14	-0.41	0.01	-0.19
West	-0.18	-0.38	-0.15	-0.44

- Consumer preference for brands A, B, C, and D (relative to unbranded and smaller brands of tomatoes) varies across markets

MWP by Demographics

MWTP by Market and Demographic ($/pound)				
	Age<40	Age>64	Black	Hispanic
Northeast	0.11	-0.03	-0.18	-0.17
Central	0.22	-0.07	-0.12	-0.30
South	0.12	-0.18	-0.16	-0.28
West	0.01	-0.24	-0.29	-0.31

- MWTP varies by market and demographic

Organic Tomatoes Summary

- Estimated price premia for organic fresh tomatoes of 7% to 17% are consistent with existing studies

- Analysis is limited to the "at-home market" – tomatoes differ from other fruits and vegetables with about 30% of the fresh market being handled away from home

- "However, there is little to no information about consumer demand for organic foods when they eat out." (H&L, p. 797)

  - ▷ Topic for future research

Example: Organic Babyfood

Maquire, Owens, and Simon (J Ag and Resource Econ, 2004)

- What is the price premium associated with organic babyfood?

- "To the extent this premium reflects consumer willingness to pay to reduce pesticide exposures, it could be used to infer values for reduced dietary exposures to pesticide residues for babies."

  ▷ (MOS, p. 132)

Organic Babyfood Regression

- Regression (price in $/ounce)

$$\begin{aligned} P = \quad & a_0 + a_1 \cdot \text{organic} \\ & + \text{controls for product characteristics} \\ & + \text{controls for type of store} \end{aligned}$$

- Run a separate regression for each of two markets, San Jose and Raleigh

Why Raleigh and San Jose?

- Cities of similar size (in 2003)

- Percentage of population under one year of age similar – 1.4% and 1.5% resp.

- Composition of population differs – hispanic 10% and 30% resp.

Regression Output

- San Jose, CA, grocery stores

$$\begin{aligned} P = \quad & a_0 + 0.026 \cdot \text{organic} \\ & + \text{controls for product characteristics} \\ & + \text{controls for type of store} \end{aligned}$$

- Raleigh, NC, grocery stores

$$\begin{aligned} P = \quad & a_0 + 0.033 \cdot \text{organic} \\ & + \text{controls for product characteristics} \\ & + \text{controls for type of store} \end{aligned}$$

- "These values translate into a 10¢ to 15¢ per jar price differential between organic and conventional babyfood, assuming an average jar size of 4 ounces (the size of stage 2 jars)." (MOS, p.144)

Babyfood Summary

- Study estimates how consumers (specifically, parents of babies) value reductions in pesticide exposure, as evidenced through the organic babyfood market. Results indicate WTP of 10¢ to 15¢ per jar (approximately 16-27%).
- The information could be used to estimate a value of reduced lifetime cancer risks associated with childhood dietary exposures.
- "Economists use information on health and safety products to infer values of risk reductions. ... Because babyfood is targeted to a very specific age group, examining this market presents a unique opportunity to further estimate parental willingness to pay to reduce risks to their children-specifically, willingness to pay to reduce dietary pesticide exposures in infants." (MOS, p.147)

Value of Clean Air in Boston

- Determine the willingness to pay for clean air

- Based on the seminal paper:
  - ▷ Harrison, David, Jr., and Daniel L. Rubinfeld (1978), "Hedonic Housing Prices and the Demand for Clean Air," *J Environ. Econ. Mgmt*. 5, 81–102.
  - ▷ Comprehensive discussion of hedonic market analysis

- Their data are publicly available.
  - ▷ Available at the course web site (BostonHousing.csv)
  - ▷ Or type "Boston housing data" into Google

Boston Housing Data

Variable	Definition
MV	Median value of owner occupied house
RM	Number of rooms
AGE	Age of the house
B	$(\text{proportion black} - 0.63)^2$
LSTAT	Proportion of population that is low status
CRIM	Crime rate
ZN	Proportion of large lots nearby
INDUS	Proportion of nonretail business acres nearby
TAX	Property tax rate
PTRATIO	Pupil-teacher ratio in nearby schools
CHAS	Dummy for adjacent to Charles River
DIS	Distance to major employment areas
RAD	Index of accessibility to radial highways
NOX	Nitrogen oxide concentration in pphm

From census tracts in the Boston SMSA

Boston Housing Hedonic Regression

$$
\begin{aligned}
\log MV &= a_1 + a_2 RM^2 + a_3 AGE \\
&+ a_4 \log DIS + a_5 \log RAD \\
&+ a_6 TAX + a_7 PTRATIO \\
&+ a_8 B + a_9 \log LSTAT + a_{10} CRIM \\
&+ a_{11} ZN + a_{12} INDUS \\
&+ a_{13} CHAS + a_{14} NOX^2
\end{aligned}
$$

$$
\begin{aligned}
\log MV &= 9.756 + (0.006328) RM^2 + (0.00009074) AGE \\
&+ (-0.1913) \log DIS + (0.09571) \log RAD \\
&+ (-0.0004203) TAX + (-0.03112) PTRATIO \\
&+ (0.3637) B + (-0.3712) \log LSTAT + (-0.01186) CRIM \\
&+ (0.00008016) ZN + (-0.0002395) INDUS \\
&+ (0.09140) CHAS + (-0.006380) NOX^2
\end{aligned}
$$

Note: log is the natural logarithm

Using the Regression Equation

Regression results

Intercept	RM2	AGE	ln DIS	ln RAD	TAX	PTRATIO	B	ln LSTAT	CRIM	ZN	INDUS	CHAS	NOX2
9.756	0.006328	9.07E-05	-0.1913	0.09571	-0.00042	-0.03112	0.3637	-0.37116	-0.01186	8.016E-05	2E-04	0.091	-0.00638

Average Values

Intercept	RM2	AGE	ln DIS	ln RAD	TAX	PTRATIO	B	ln LSTAT	CRIM	ZN	INDUS	CHAS	NOX2
1	39.98932	68.5749	1.188032	1.86766099	408.237	18.4555	0.35667	-2.23421	3.613524	11.363636	11.14	0.069	32.10877

Intercept	RM2	AGE	ln DIS	ln RAD	TAX	PTRATIO	B	ln LSTAT	CRIM	ZN	INDUS	CHAS	NOX2
1	43.23063	65.2	1.408545	0	296	15.3	0.3969	-2.99974	0.00632	18	2.31	0	28.9444
1	41.22924	78.9	1.602836	0.69314718	242	17.8	0.3969	-2.39251	0.02731	0	7.07	0	21.9961
1	51.62423	61.1	1.602836	0.69314718	242	17.8	0.39283	-3.2114	0.02729	0	7.07	0	21.9961
1	48.972	45.8	1.802073	1.09861229	222	18.7	0.39463	-3.52676	0.03237	0	2.18	0	20.9764
1	51.07961	54.2	1.802073	1.09861229	222	18.7	0.3969	-2.93182	0.06905	0	2.18	0	20.9764

Effect of a 20% decrease in NOX

Using the Regression Equation

Predicted ln MV	Predicted MV	Predicted ln MV with lower NOX	Predicted MV with lower NOX	Increase in MV
9.94	20,791	10.02	22,382	1,591

Effect of a 20% decrease in NOX

1. Calculate the average value for each variable
2. Calculate the predicted ln(MV) using the averages =SUMPRODUCT(*averages*,*regression coefficients*)
3. Calculate the predicted MV using =EXP($\cdot$)
4. Calculate the predicted ln(MV) if NOX were 20% lower =SUMPRODUCT(*averages* except NOX, *regression coefficients*)$+(-0.006380)(.8\sqrt{32.10877})^2$
5. Calculate the predicted MV using =EXP($\cdot$)
6. Subtract to get the change in predicted MV

Using the Regression Equation

% decrease in NOX	20%
average change in MV	$1,573

Predicted ln MV	Predicted MV	Predicted ln MV with lower NOX	Predicted MV with lower NOX	Increase in MV
10.24	28,023	10.31	29,949	1,926
10.02	22,513	10.07	23,679	1,167
10.39	32,483	10.44	34,166	1,683
10.47	35,396	10.52	37,143	1,747

More sophisticated approach

1. For each row, calculate the predicted MV using the regression =EXP(SUMPRODUCT(*data row,regression coefficients*))
2. For each row, calculate the predicted MV if NOX were 20% lower =EXP(SUMPRODUCT(*data row except NOX*, *regression coefficients*)+(−0.006380)$(.8 \cdot NOX)^2$
3. For each row, calculate the change in predicted MV
4. Calculate the average change in predicted MV

Marginal Willingness to Accept Pollution

- What subsidy is required. I.e., by how much does the median value of a home decrease when the NOX concentration increases by 1 pphm. We change sign to convert a buyer discount to a seller subsidy.

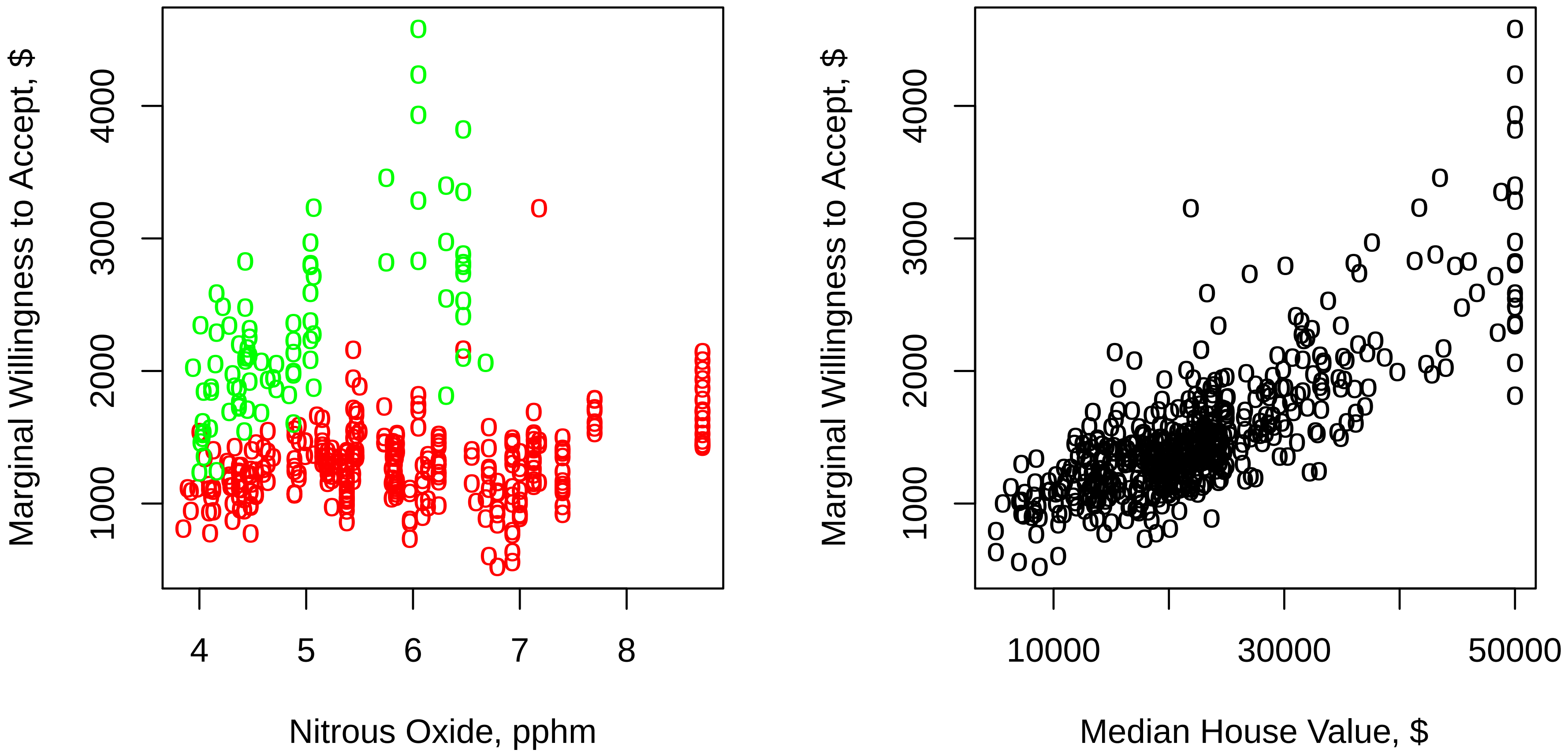
$$MWTA = -\frac{\partial \widehat{MV}}{\partial NOX}$$

- If $\widehat{MV} = a_1 + ... + a_{14} NOX$, then $-\frac{\partial \widehat{MV}}{\partial NOX} = -a_{14}$
- Because the regression uses $\log MV$ and NOX^2, we have*

$$\begin{aligned} MWTA &= -\frac{\partial \widehat{MV}}{\partial NOX} = -(\widehat{MV})(2)(-0.006380)(NOX) \\ &= (0.012760) \cdot \widehat{MV} \cdot NOX \end{aligned}$$

*$\widehat{MV} = e^{\log \widehat{MV}}$, so $\frac{\partial \widehat{MV}}{\partial NOX} = e^{\log \widehat{MV}} \frac{\partial \log \widehat{MV}}{\partial NOX} = \widehat{MV} \frac{\partial \log \widehat{MV}}{\partial NOX} = \widehat{MV}\,(2)\,(-0.006380) NOX.$

Willingness to Accept from Hedonic Regression



Red have median house values less than $23,000; green larger.

Boston Housing Hedonic Market Analysis

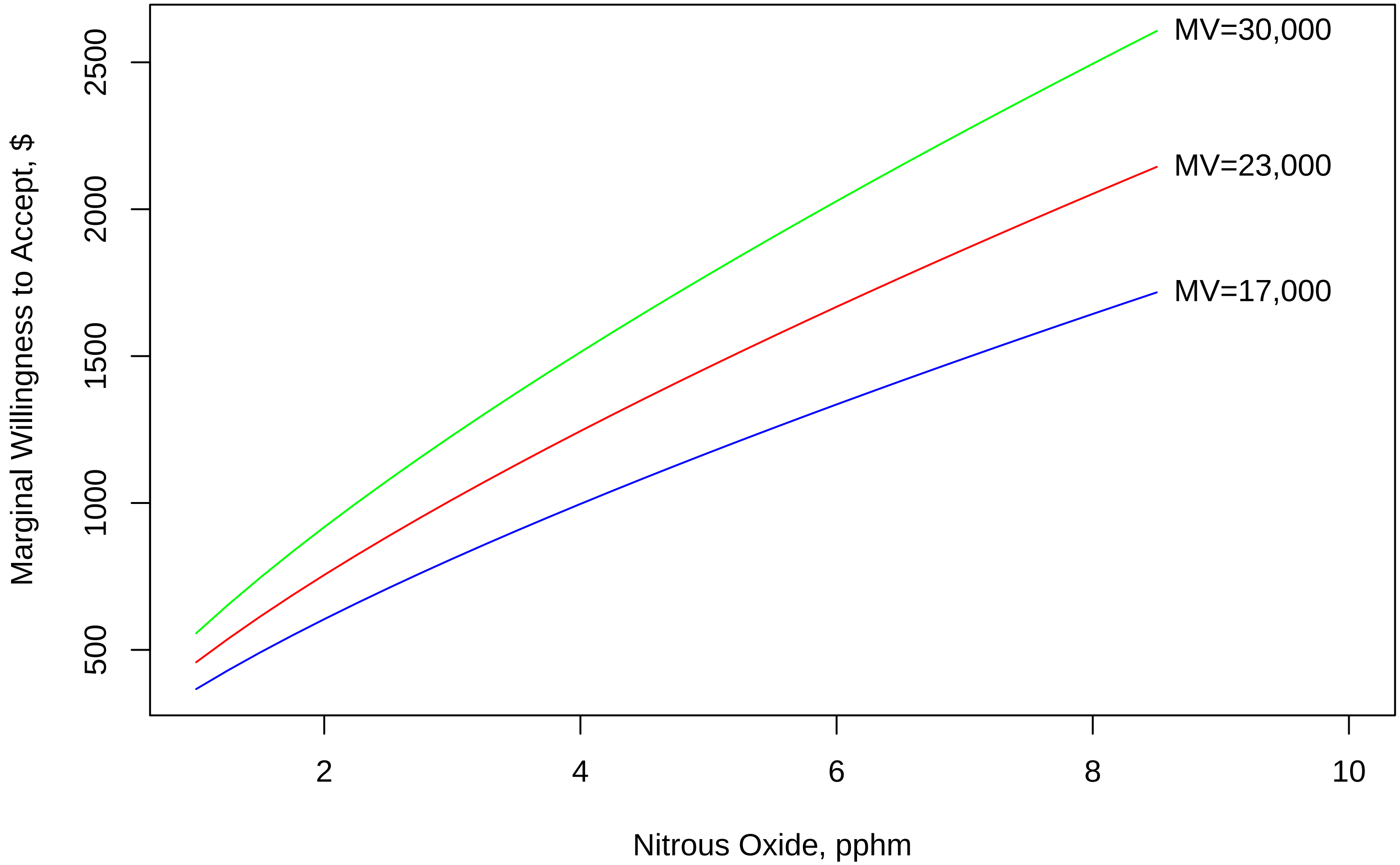
- We have found that $MWTA$ depends on MV and NOX

- We can summarize that relationship by running another regression, the "demand regression":*

$$\log MWTA = -1.25628 + (0.72136) \log NOX + (0.73512) \log MV$$

*Harrison and Rubenfeld used annual income, not MV, in their demand. However, income is not in the publicly available data, MV is highly correlated with annual income, and MV can be regarded as proportional to permanent income.

Willingness to Accept: Demand Regression



Willingness to accept a 1 pphm increase in NOX concentration, by NOX level for households in three income levels (log-log version).

Annual Willingness to Accept Pollution

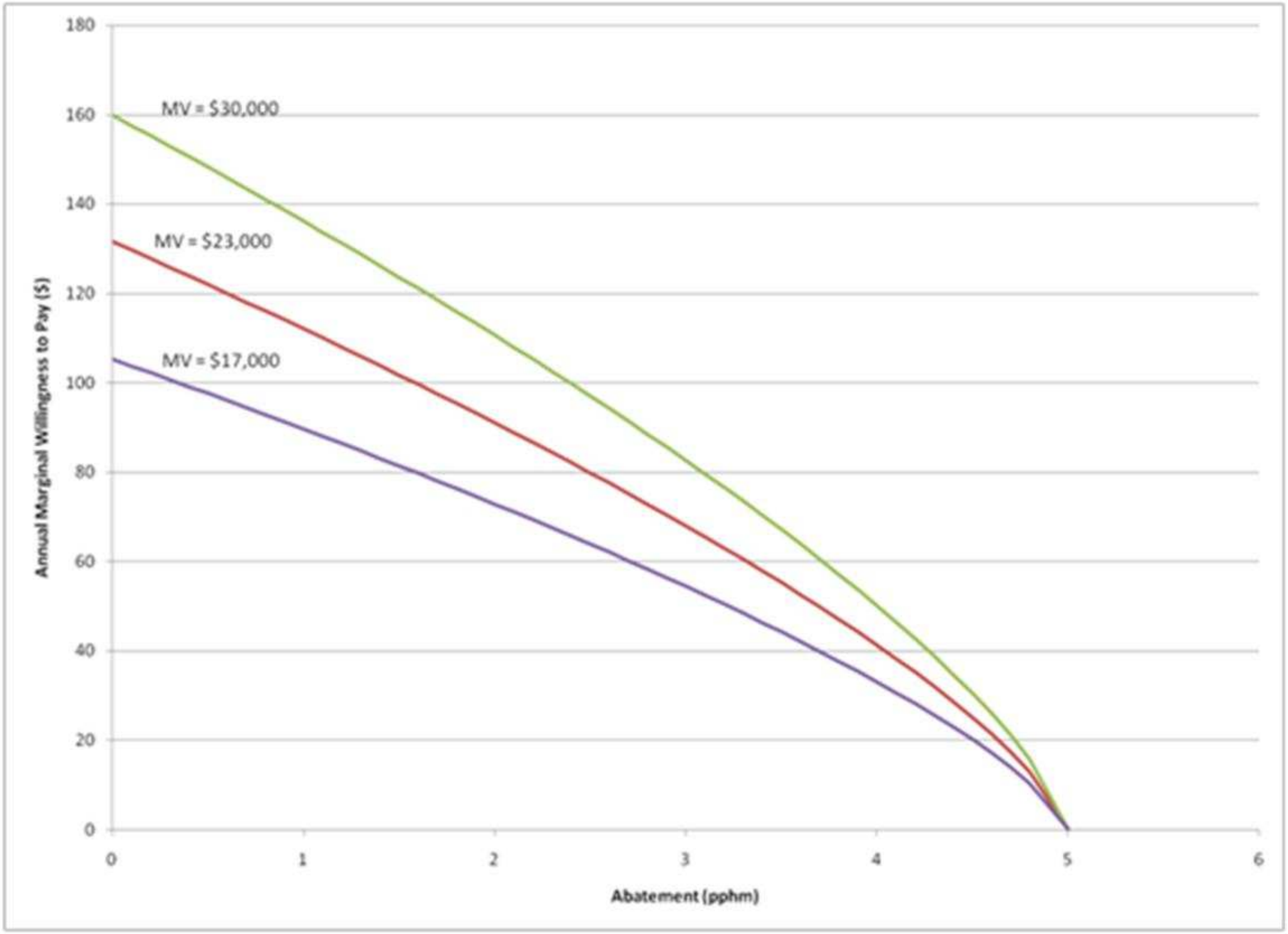
- MV represents the discounted present value of all future rental services

- $MWTA$ is in discounted present value dollars, not in annual rental value dollars

- Annual $MWTA = (0.09)MWTA$ (assuming $r = 10\%$)*

*With an interest rate of 10%, the discount factor is $\delta = \frac{1}{1+r} = 0.91$. Thus, $MWTA = \frac{1}{1-\delta}(\text{Annual } MWTA) = \frac{1}{1-.91}(\text{Annual } MWTA)$, which implies that Annual $MWTA = (0.09)MWTA$.

Annual Willingness to Pay for Abatement



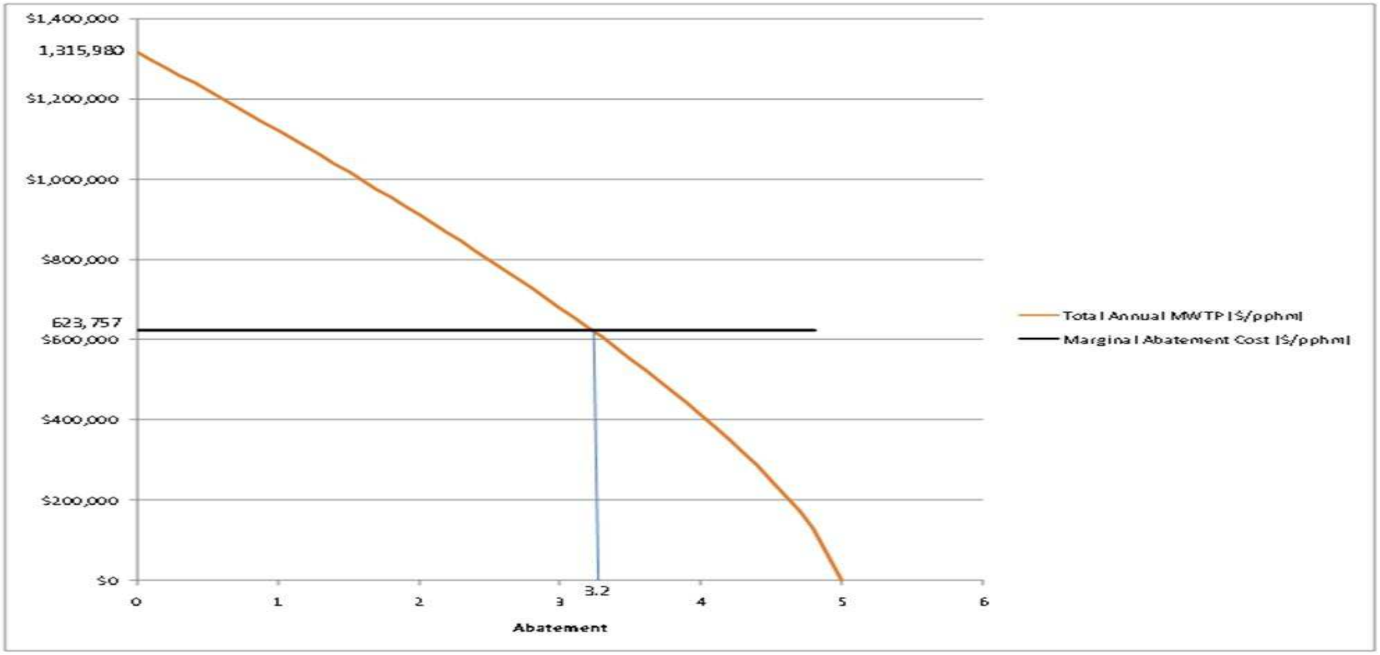
Convert to annual willingness to pay for abatement relative to baseline of 5 pphm (AMWTP for abatement a is AMWTA for $NOX = 5 - a$)

Pollution Abatement

- Your Portland Cement facility has 3 kilns and emits 2700 tons of NOx per year. You are under pressure to reduce emissions by 80% to 540 tons.
- Emissions affect nitrous oxide concentrations in census tracts containing a total of 10,000 homes and with median home values of 23,000. Concentrations in these tracts are 5 pphm.
- Estimate: 1000 tons/year of NOx from your facility contributes 1.81 pphm nitrous oxide
- Marginal abatement cost for NOX for cement production is \$1,129/ton*
  - ▷ $\text{MAC}\,\frac{\$}{\text{pphm}} = 1,129\,\frac{\$}{\text{ton}}\,\frac{1000}{1.81}\,\frac{\text{ton}}{\text{pphm}} = 623,757\,\frac{\$}{\text{pphm}}$

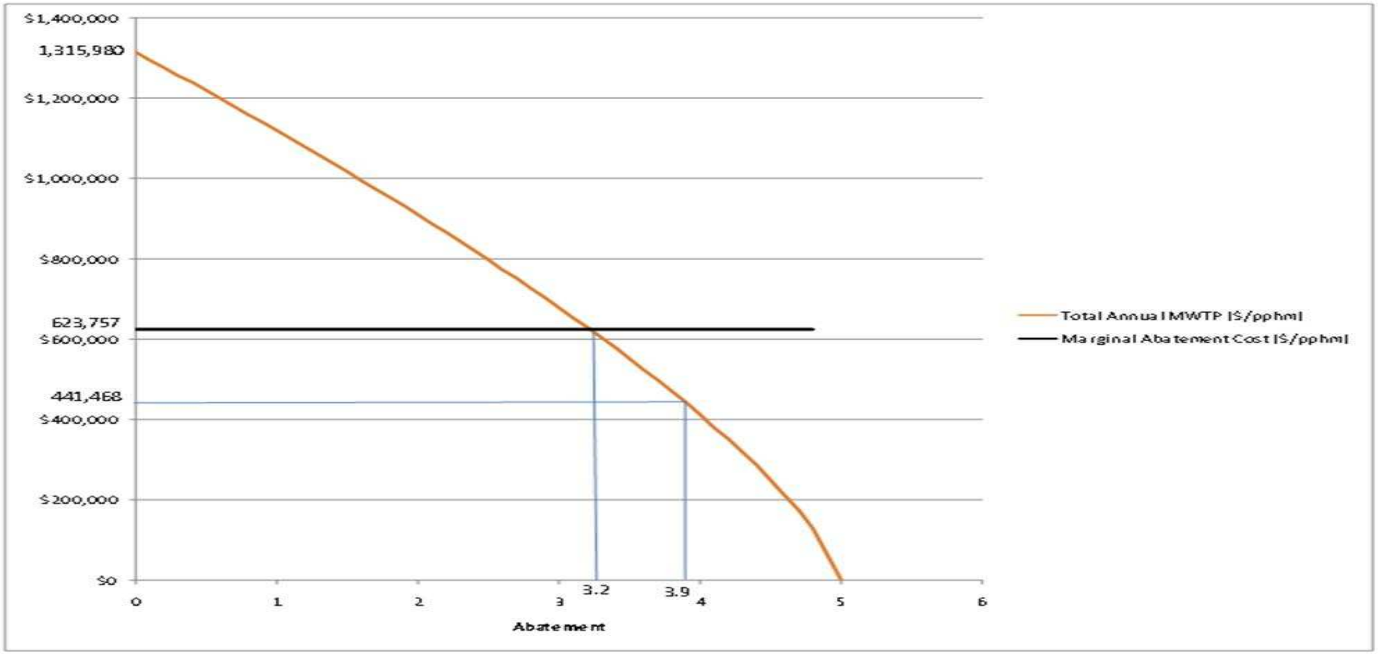
*See http://ec.europa.eu/environment/air/pdf/task2_nox.pdf. For example, Selective Catalytic Reduction units could be installed.

Efficient Pollution Abatement



- Efficient abatement = 3.2 pphm = 1768 tons (65% reduction)
- Annual abatement cost = 3.2 pphm $\cdot$ 623, 757 \$/pphm = \$1, 996, 022
- Annual consumer benefit $\approx \$1,996,022 + \frac{1}{2} \cdot 3.2 \cdot (1,315,980 - 623,757) = \$1,996,022 + \$1,107,557$
- Annual surplus $= \$1,107,557$
- Discounted surplus $= \frac{1}{1-.91}\ \$1,107,557 \approx \$12$ million

Abatement of 80%



- Abatement of 80% implies $A = 3.9$ pphm
- Annual abatement cost = 3.9 pphm $\cdot$ 623,757 \$/pphm = \$2,432,652
- Annual consumer benefit $\approx 3.9 \cdot 441,468 + \frac{1}{2} \cdot 3.9 \cdot (1,315,980 - 441,468) = \$1,721,725 + \$1,705,298$
- Annual surplus = \$994,371
- Discounted surplus $= \frac{1}{1-.91}$ \$994,371 $\approx$ \$11 million

Summary: Hedonic Market Method

1. Fit a hedonic regression, which is often in log linear form

$$\log P = b_0 + b_1 \log z_1 + ... + b_N \log z_N + b_X \log X$$

   - X is the pollutant. May be entered as X or $\sqrt{X}$or X^2 instead of $\log X$, whatever gives the best R^2

2. Extract $MWTA$ from the hedonic regression for each observation

$$MWTA = -\frac{\partial P}{\partial X}$$

   - Computed $MWTA$ will vary by attributes and level of pollutant

3. Remove the variability in $MWTA$ with a demand regression

$$\log MWTA = a_0 + a_1 \log X + a_2 \log(\text{income})$$

   - Use $MWTA = \exp(a_0 + a_1 \log X + a_2 \log(\text{income}))$ as the final estimate of $MWTA$.

4. Choose a benchmark and convert to $MWTP$ for abatement.

Criticisms of Residential Hedonic Regressions

- As with any regression, the regressors should be independent of the error term
  - ▷ E.g. both income and pollution are higher in urban areas. A national hedonic regression might reach the conclusion that wealthy people prefer pollution.
- The two-step regression procedure – hedonic, demand – is problematic statistically
  - ▷ Known as the generated regressor problem in statistics
  - ▷ Attempts to correct for the problem using simultaneous equations methods may reveal that hedonic models are poorly identified

Other Measurement Approaches

- Revealed preference
- Stated preference (contingent valuation)
- Value of a statistical life

Revealed vs. Stated Preference

- Revealed Preference (Indirect)
  - ▷ Economic choices about substitutes for or complements of the nonmarket good tell us something about its value
  - ▷ Based on real economic behavior
- Stated Preference (Direct)
  - ▷ Individuals responses to survey questions directly state their monetary values of nonmarket goods
  - ▷ Based on hypothetical economic behavior or laboratory behavior

Contingent Valuation (Direct Methods)

- Individuals are asked to make willingness-to-pay responses when placed in contingent situations
- Framing of environmental quality characteristic or health outcome to be evaluated
- Design of survey (in person, phone, mail, ...)
- Sample selection
- Analysis of results
- Many obvious problems, but may be the best approach in some cases

Contingent Valuation History

- First proposed in theory by S.V. Ciriacy-Wantrup (1947)

- First application by Robert K. Davis (1963) to estimate the value hunters and tourists placed Maine Woods

  - ▷ Harvard Ph.D. dissertaion

  - ▷ Results correlated well with travel cost method.

- The Exxon Valdez oil spill in Prince William Sound was the first case where contingent valuation surveys were used in a quantitative assessment of damages.

- Usage has increased from that point on.

Contingent Valuation Concerns

- Strategic behavior
- Protest answers
- Response bias
- Respondents ignoring income constraints

Contingent Valuation Example

- Present results from in-class homework.

NOAA 1993 Recommendations

National Oceanic and Atmospheric Administration

- Personal interviews be used to conduct the survey, as opposed to telephone or mall-stop methods.
- Surveys be designed in a yes or no referendum format put to the respondent as a vote on a specific tax to protect a specified resource.
- Respondents be given detailed information on the resource in question and on the protection measure they were voting on. This information should include threats to the resource (best and worst-case scenarios), scientific evaluation of its ecological importance and possible outcomes of protection measures.
- Income effects be carefully explained to ensure respondents understood that they were to express their willingness to pay to protect the particular resource in question, not the environment generally.
- Subsidiary questions be asked to ensure respondents understood the question posed.

Source: Wikipedia

A Freshwater Quality Questionnaire

1.How many people in this household are under 18 years of age?

2. During the last 12 months, did you or any member of your household boat, fish, swim, wade, or water-ski in a freshwater river, lake, pond, or stream?

Here are the national water pollution goals:

Goal C — 99 percent of freshwater is at least boatable,

Goal B — 99 percent of freshwater is at least fishable,

Goal A — 99 percent of freshwater is at least swimmable.

3. What is the highest amount you would be willing to pay each year:

a. To achieve Goal C?

b. To achieve Goal B?

c. To achieve Goal A?

4. Considering the income classes listed in the accompanying card, what category best describes the total income that you and all the members of the household earned in 20__?

Source: R. C. Cameron and R. T. Carson, *Using Surveys to Value Public Goods: The Contingent Valuation Method*

Exxon Valdez

- Richard T. Carson, Robert C. Mitchell, Michael Hanemann, Raymond J. Kopp, Stanley Pressr, and Paul A. Ruud (2003) "Contingent Valuation and Lost Passive Use: Damages from the Exxon Valdez Oil Spill" *Environmental and Resource Economics* 25: 257286

- Go through Exxon-Valdez slides by Padraic Tremblay at http://www.docfoc.com in class

Contingent Valuation Results

Selected Willingness to Pay Estimates for Health Outcomes

Outcome	Valuation (2008 US$)		
	U.S. EPA	Canada	Europe
Reduced mortality, implied VSL	7,874,975	4,757,797	4,921,859
WTP to avoid a case of chronic bronchitis	426,561	305,155	168,984
WTP to avoid a case of chronic asthma	41,015	-	-
WTP to avoid an ER visit	318	655	358
WTP to avoid a "restricted activity day"	62	84	120

Source : Various sources as reported in Field and Field (2009), Table 7.3.

Converted from 1990 dollars using the CPI (U.S. All items, CUUR0000SA0) , www.bls.gov.

Contingent Valuation Results

Examples of Benefit Estimation Studies Carried Out by Environmental Economists in Various Countries

Country and Study	Results
Germany (Holm-Muller et al, 1991)	
WTP to have an improvement in air quality (CV method)	75-190 DM/person/month
Israel (Shechter and Kim, 1991)	
WTP for a 50% reduction in air pollution in Haifa	
Indirect means (hedonic)	$66.2/household/yr
Direct means (CV)	$25.1/household/yr
Netherlands (van der Linden and Oosterhuis, 1987)	
WTP to prevent further deterioration of the Dutch forests and heath (CV method)	22.83 DFL/person/month
Norway (Heiberg and Him, 1989)	
WTP for improved water quality in the inner Oslo fjord (CV method)	
Users	942 NOK/household/yr
Nonusers	522 NOK/household/yr
Sweden (Aakerman, 1988)	
WTP for a reduction in the risk of getting lung cancer from radon exposure	4300 SEK/household
United Kingdom (Green and Tunstall, 1991)	
WTP for an improvement in river water quality (CV method)	£12.08/person/year

Source : Sources given above as reported in Field and Field (2009), Table 18.3.

Revealed Preference (Indirect Methods)

- Averting behavior (defensive expenditures)
  - ▷ Based on substitutes for the nonmarket good
- Weak complementarity
  - ▷ Based on complements of the nonmarket good
- Hedonic market methods
  - ▷ Based on market responses in the presence of the non-market good

Averting Behavior for Drinking Water

- Boil tap water, purchase bottled water, install filtering systems, draw spring or underground water

- Um, Kwak, and Kim (2002): water in Pusan, South Korea
  - ▷ WTP for water that is "drinkable without any treatment" = \$4.10 to \$6.10 per month per household (1998\$)

Analytical Intuition

- Damage depends on pollution x and defensive spending z: $D(x, z)$
  - ▷ As an example, think of $D(x, z)$ as cancer risk
  - ▷ z (e.g. drinking filtered water) has a price but abatement a of x does not
- Willingness to spend money on z implicitly tells us about $MWTP_a$ for abatement

Averting Behavior Analytics

- The consumer's problem

  $$\min_{x,z} D(x,z) \text{ subject to } (MWTP_a)(BM - x) + (P_z)z = \text{budget}$$

- From the consumer's problem (think of it as a firm minimizing cost), we know ratio of marginal damages equals the ratio of the "prices"

  $$\frac{D_x(x,z)}{D_z(x,z)} = \frac{-(MWTP_a)}{P_z}$$

- Thus,

  $$MWTP_a = -P_z \frac{D_x(x,z)}{D_z(x,z)}$$

  ▷ Assuming $MWTP_a$ is constant.

Why This is Powerful Stuff

- Aversion equation (repeated from previous slide)

$$MWTP_a = -P_z \frac{D_x(x,z)}{D_z(x,z)} = P_z \frac{D_x(x,z)}{-D_z(x,z)} = P_z \frac{D_x(x,z)}{B_z(x,z)}$$

- $D_x(x,z)$ is the marginal damage to health from pollution
  - ▷ Observable – requires information from other scientists

- $B_z(x,z) = -D_z(x,z)$ is the marginal benefit to health from averting behavior
  - ▷ Observable – requires information from other scientists

Averting Behavior Analytics

In words:

> The value of reducing cancer risk in drinking water by one more unit is the price of water purification times the increase in cancer risk from having more pollution divided by the decrease in cancer risk from having more water purification.

Weak Complementarity

- Averting behavior exploits the substitutability of market goods for nonmarket goods

- Weak complementarity exploits the complementarity of market goods with nonmarket goods
  - ▷ Specifically, we look at how an improvement in environmental quality increases the purchased good

Complementarity Examples

- Travel cost method – time and travel cost expenses incurred to visit a site represent the "price" of access to the site

- 1970s study of recreational value of Hell Canyon (Oregon/Idaho) – estimated \$900,000

- 1984 study of average annual benefits to all Maryland beach users of the improvements in water quality – estimated \$35 million

- 1990 study of WTP for river-based recreation near Denver, Colorado – \$26 per day (times 2 million people)

Value of a Statistical Life

- Another application of hedonic regression
  - ▷ Wages compensate individuals for the bundle of services they provide
  - ▷ Each service has a hedonic price
- Use the wage premia in risky professions to infer the dollar value of a death
- Value of a statistical life is the change in wage divided by the change in probability of death

Example: Value of a Statistical Life

- Consider two workers with equal skills. Construction workers in high rise and low rise
  - ▷ low rise, 45K per year, Pr(death) $= 0.0001$ per year
  - ▷ high rise, 50K per year, Pr(death) $= 0.001$ per year

$$VSL = \frac{50,000 - 45,000}{0.001 - 0.0001} = \frac{5000}{0.0099} \approx \$5,050,000$$

- If risk is lifetime and wage is annual, must make the appropriate conversion

VSL Estimates

Implied Value of a Statistical Life as Estimated in Recent Labor Market Studies

Study	Value of a Statistical Life (2008 US$)		
Moore and Viscusi (1990)	25,900,832		
Kniesner and Leeth (1991)	871,663		
Gegax, Gerking, and Schulze (1991)	2,614,988		
Leigh (1991)	8,841,149	-	19,052,054
Berger and Gabriel (1991)	10,708,998	,	13,573,032
Leigh (1995)	10,086,382	-	20,919,902
Dorman and Hagstrom (1998)	10,833,521	-	25,278,215
Lott and Manning (2000)	1,867,848	,	3,735,697

Source : Sources given above as reported in Field and Field (2009), Table 7.2.

Converted from 2000 dollars using the CPI (U.S. All items, CUUR0000SA0) , www.bls.gov.

Cost per Life Saved

Average Cost of US Regulations to Reduce Risk of Death

Regulation	Initial annual risk	Expected annual lives saved	Cost per expected life saved (2008 $)
Unvented space heaters	2.7 in 10^5	63.000	206,380
Airplane cabin fire protection	6.5 in 10^8	15.000	412,760
Auto passive restraints/belts	9.1 in 10^5	1,850.000	619,141
Underground construction	1.6 in 10^3	8.100	619,141
Servicing wheel rims	1.4 in 10^5	2.300	1,031,901
Aircraft seat cushion flammability	1.6 in 10^7	37.000	1,238,281
Aircraft floor emergency lighting	2.2 in 10^8	5.000	1,444,661
Crane suspended personnel platform	1.8 in 10^3	5.000	2,476,562
Concrete and masonry construction	1.4 in 10^5	6.500	2,889,322
Benzene/fugitive emissions	2.1 in 10^5	0.310	5,778,645
Grain dust	2.1 in 10^4	4.000	10,938,149
Radionuclides/uranium mines	1.4 in 10^4	1.100	14,240,232
Benzene in workplace	8.8 in 10^4	3.800	35,291,010
Ethylene oxide in workplace	4.4 in 10^5	2.800	52,833,324
Arsenic/copper smelter	9.0 in 10^4	0.060	54,690,746
Uranium mill tailings, active	4.3 in 10^4	2.100	109,381,492
Asbestos in workplace	6.7 in 10^5	74.700	184,297,495
Arsenic/glass manufacturing	3.8 in 10^5	0.250	293,059,846
Radionuclides/DOE facilities	4.3 in 10^6	0.001	433,398,364
Benzene/ethylbenzenol styrene	2.0 in 10^6	0.006	996,816,237
Formaldehyde in workplace	6.8 in 10^7	0.010	148,593,724,735

Source: Viscusi (1996), pp. 124-125, as reported in Kolstad (2000), Table 8.2.

Converted from 1984 dollars using the CPI (U.S. All items, CUUR0000SA0), www.bls.gov

Shortcomings of VSL

- Heterogeneous risk preferences

- Cultural values of the profession
  - ▷ Fishing
  - ▷ Firefighting
  - ▷ Police officer
  - ▷ Soldier

Second Measurement Example

- WTP for clean-up of a hazardous waste dump in Acton, Mass.

- The book "A Civil Action" by Jonathan Harr is based on this case.

- The movie "A Civil Action" starring John Travolta as Jan Schlichtmann and Robert Duvall as Jerome Facher is also based on this case.