Lecture 11

Hedonics

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AEM 4510

Roadmap

- What can we use to infer the demand for environmental goods?
- What do housing prices tell us?
- When do changes in house prices give us welfare measures

Hedonic valuation

Revealed preference approaches

There is no clear way to value changes in quantities of environmental goods

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There aren't any markets for them!

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Is there a way we can reveal the value of these goods?

Revealed preference approaches

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This change in price can tell us something about how people value the change in the environmental good

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What does this price change mean?

Hedonics: Property value models

Common market goods to use for revealed preference valuation are **properties**

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When people buy a home they are purchasing a bundle of goods:

- Rooms
- Bathrooms
- School quality
- Environmental quality

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Common market goods to use for revealed preference valuation are **properties**

When people buy a home they are purchasing a bundle of goods:

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Homes located in pristine areas are likely to be more valuable than identical homes located near toxic facilities

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Real estate is virtually ideal for measuring environmental changes

Real estate markets are often competitive and thick

Property purchases are large and consequential: buyers and sellers are likely to be well-informed

It is uncontroversial that property values should reflect local attributes

e.g. homes in better school districts are typically more expensive

BCA of Superfund

Superfund


The Love Canal Disaster: Toxic Was...
Watch later
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By 2005: $35 billion in federal funding has been spent at roughly 800 sites

Superfund

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How do we do it?

Superfund

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Main idea:

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How do their prices differ?

The hedonic method

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Ridker and Henning (1967) first applied method to environmental valuation in a study of the effect of air pollution on property values in St. Louis

It motivated the conceptual model of Rosen (1974) of how we might use hedonic prices to estimate peoples’ values for site-specific amenities

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Environmental quality (air quality, noise, etc)

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This good is characterized by a set of J property characteristics x

- parcel size, school quality, bedrooms, etc

It is also characterized by an environmental good q

The hedonic model

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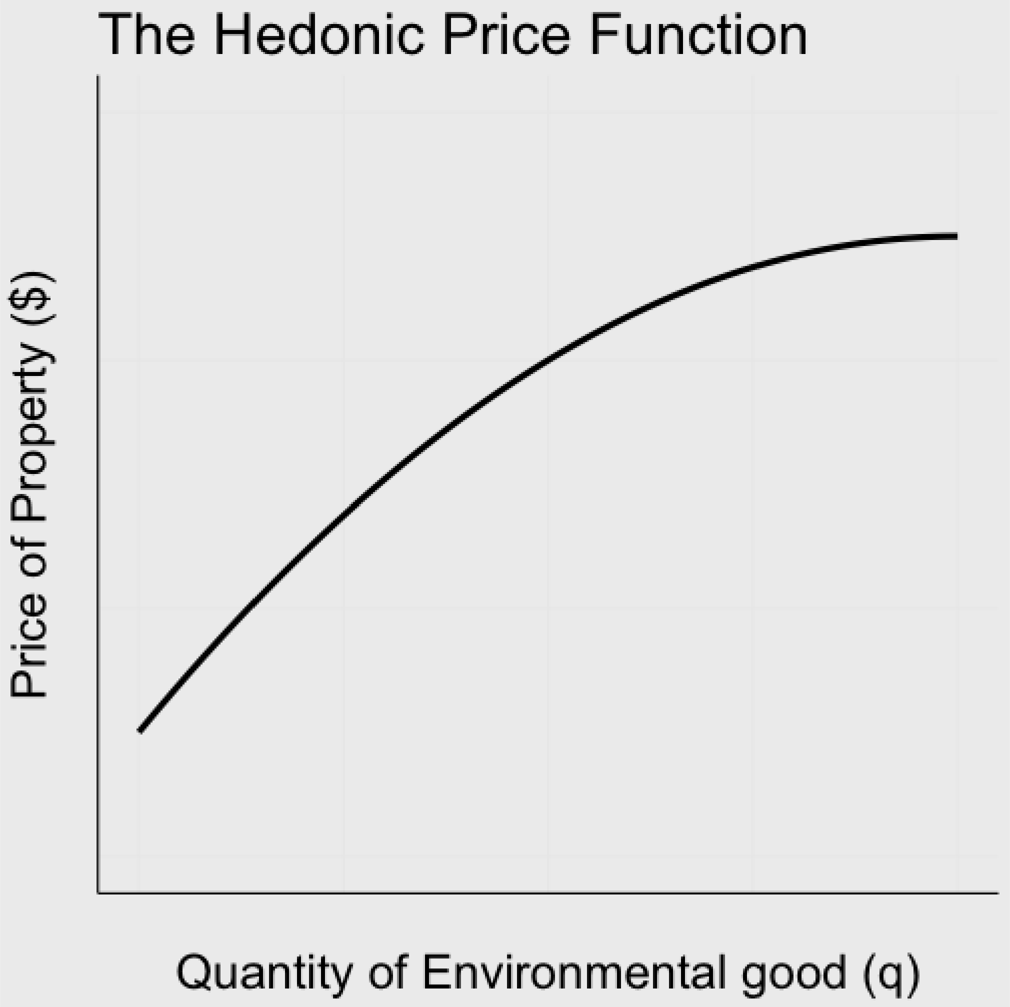
P arises in equilibrium from the interaction of all buyers in sellers in the market

Here we will assume the supply of houses is fixed in the short run so the price function arises from buyer behavior

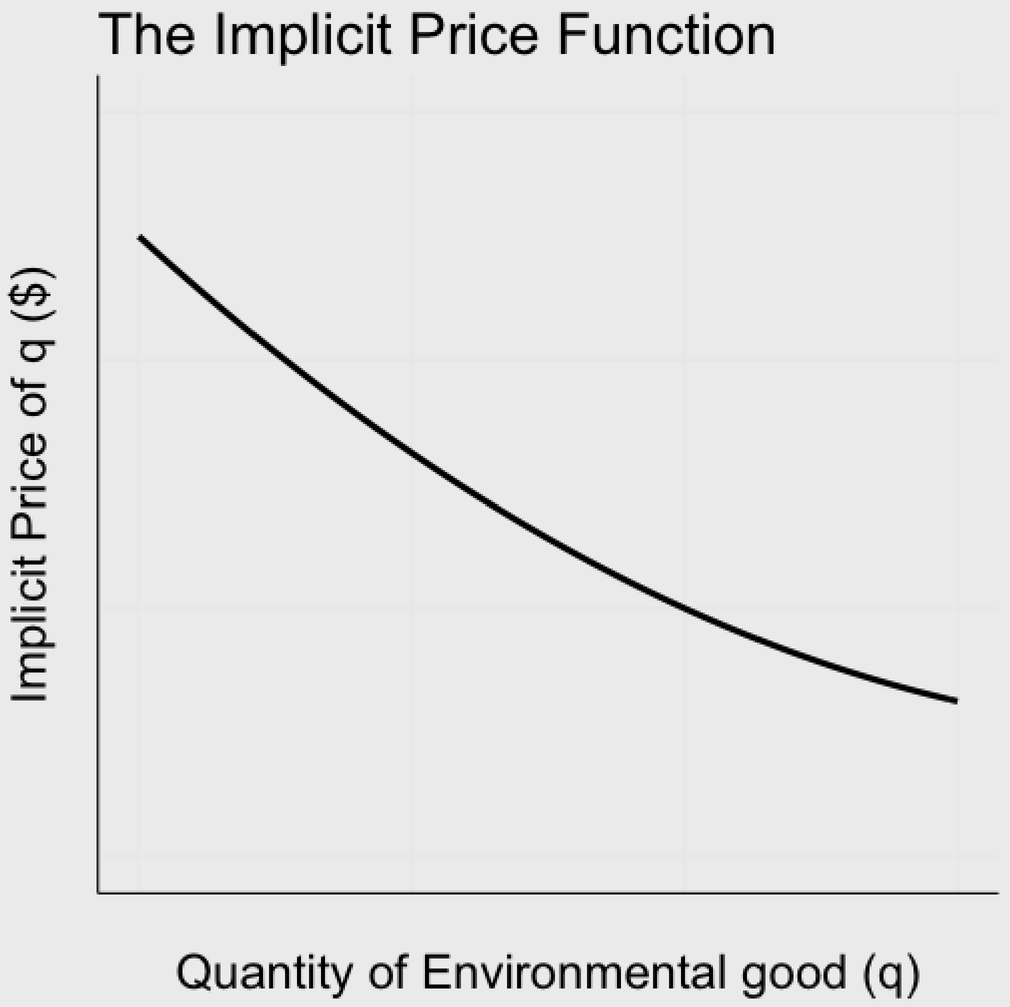
The hedonic model: the price function



The hedonic price function is $P(x, q)$

It's increasing in q (q is good) but at a decreasing rate (decreasing marginal utility)

The hedonic model: the price function



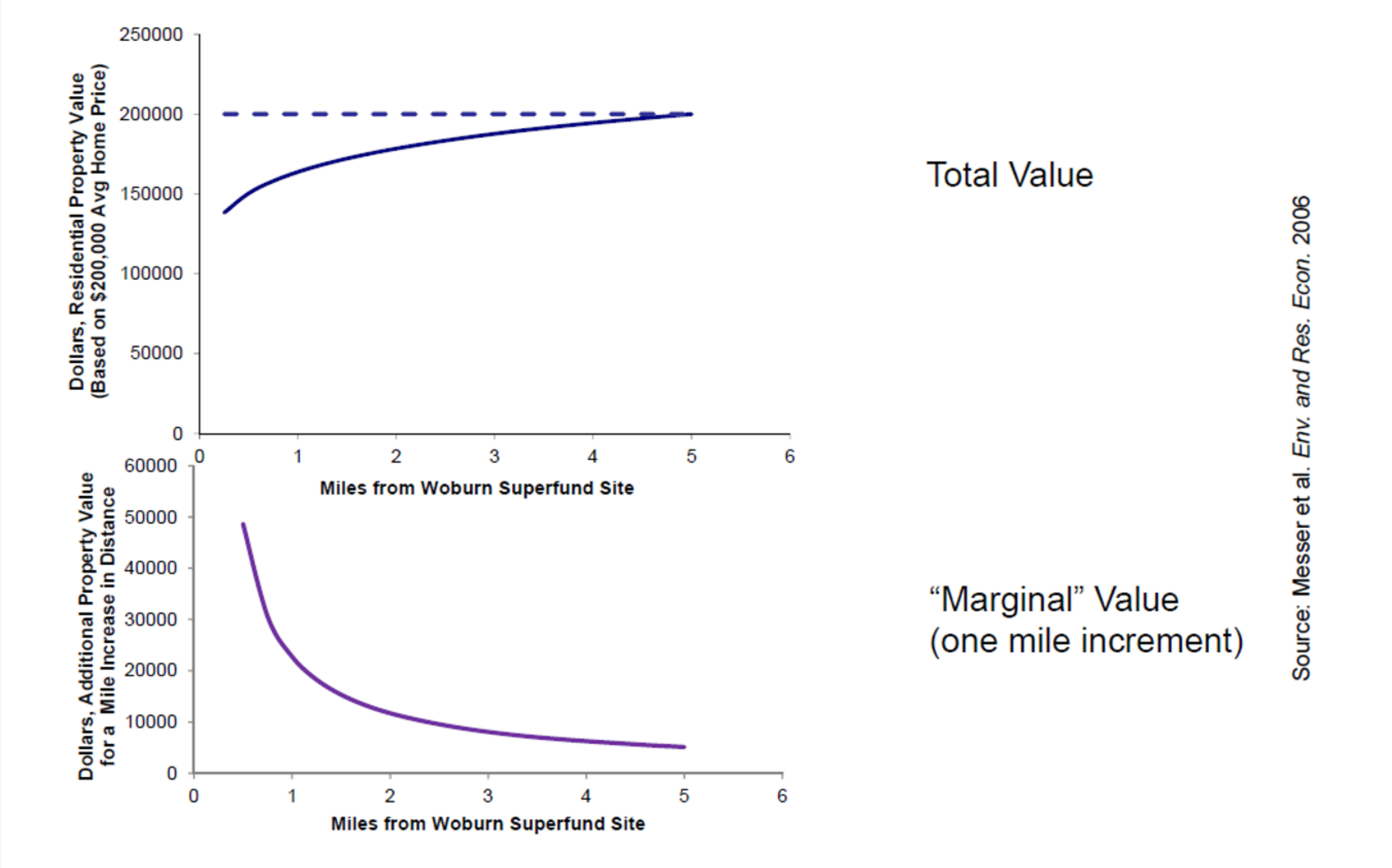
The implicit price function for q is $\frac{\partial P(x,q)}{\partial q}$

It tells us how the price changes in q

It's positive, but downward sloping

Effectively the q demand curve

Price function example



The hedonic model: consumer's choice problem

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Here we will assume that households are effectively just choosing (x, q) instead of a specific house with the following objective:

$$\max_{x,q,z} U(x, q, z; s) \quad s.t. \quad y = z + P(x, q)$$

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$$\max_{x,q,z} U(x, q, z; s) \quad s.t. \quad y = z + P(x, q)$$

- z is the numeraire good (spending on other private goods)
- y is income
- s is the set of the household's characteristics like family size

Unrealistic pieces of the model

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We won't touch on this in class because it's a bit more complicated, but economists know how to deal with these problems

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We are thus also implicitly assuming q varies across space so that households can sort into areas they prefer

- q is really picking up local environmental goods

What is $P(x, q)$

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For homeowners we are basically assuming they rent from themselves every year

The hedonic model: consumer's choice problem

$$\max_{x,q,z} U(x,q,z;s) \quad s.t. \quad y = z + P(x,q)$$

The FOCs for this problem are:

$$\begin{aligned}
\frac{\partial U}{\partial x_j} =& \lambda \frac{\partial P}{\partial x_j} \quad j = 1, \ldots, J \\
\frac{\partial U}{\partial q} =& \lambda \frac{\partial P}{\partial q} \\
\frac{\partial U}{\partial z} =& \lambda
\end{aligned}$$

Where λ is the Lagrange multiplier

Next, combine the last two FOCs

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gives us that

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What does this mean?

The hedonic model: consumer's choice problem

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At a utility-maximizing choice, a household equates their MRS between q and z and the marginal implicit cost of q

Let's give this some more context

The hedonic model: consumer's choice problem

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Recall that z is the numeraire good so we can think of it in terms of dollars

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Knowledge of the hedonic price function P is enough to tell us about household WTP for q!

The hedonic model: bid functions

Now let's dive deeper by looking at some reference utility level $\bar{u}$:

$$U(x, q, z; s) = \bar{u} \qquad \text{(indifference curve)}$$

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Next we will define something called a **bid function** $b(x, q, y, s, \bar{u})$ where:

$$U(x, q, y - b(x, q, y, s, \bar{u}); s) = \bar{u}$$

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The bid function b is the maximum amount the household is willing to pay for:

- A house with characteristics x, q
- Given income y and household characteristics s
- And achieving utility $\bar{u}$

The hedonic model: bid functions

$$U(x, q, z; s) = \bar{u}$$

We can also invert this to solve for z:[1]

$$z = U^{-1}(x, q, \bar{u}, s)$$

[1] We can do this because U is monotonically increasing in z

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Income, the bid function and z are related by:

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Now we have everything we need to derive a marginal WTP function for q

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The hedonic model: deriving MWTP

$$U(x, q, y - b(x, q, y, s, \bar{u}); s) = \bar{u}$$

Differentiate with respect to q to get:

$$\frac{\partial U}{\partial q} + \frac{\partial U}{\partial z}\frac{\partial b}{\partial q} = 0$$

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We can then rearrange to get:

$$\frac{\partial b}{\partial q} = \frac{\partial U}{\partial q} \bigg/ \frac{\partial U}{\partial z}$$

The hedonic model: deriving MWTP

Recall that the bid function is separable in income:

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Conditional on x, this defines our **compensated inverse demand function** for q!

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We can then use the bid function (which maps into prices) to understand the marginal WTP for q

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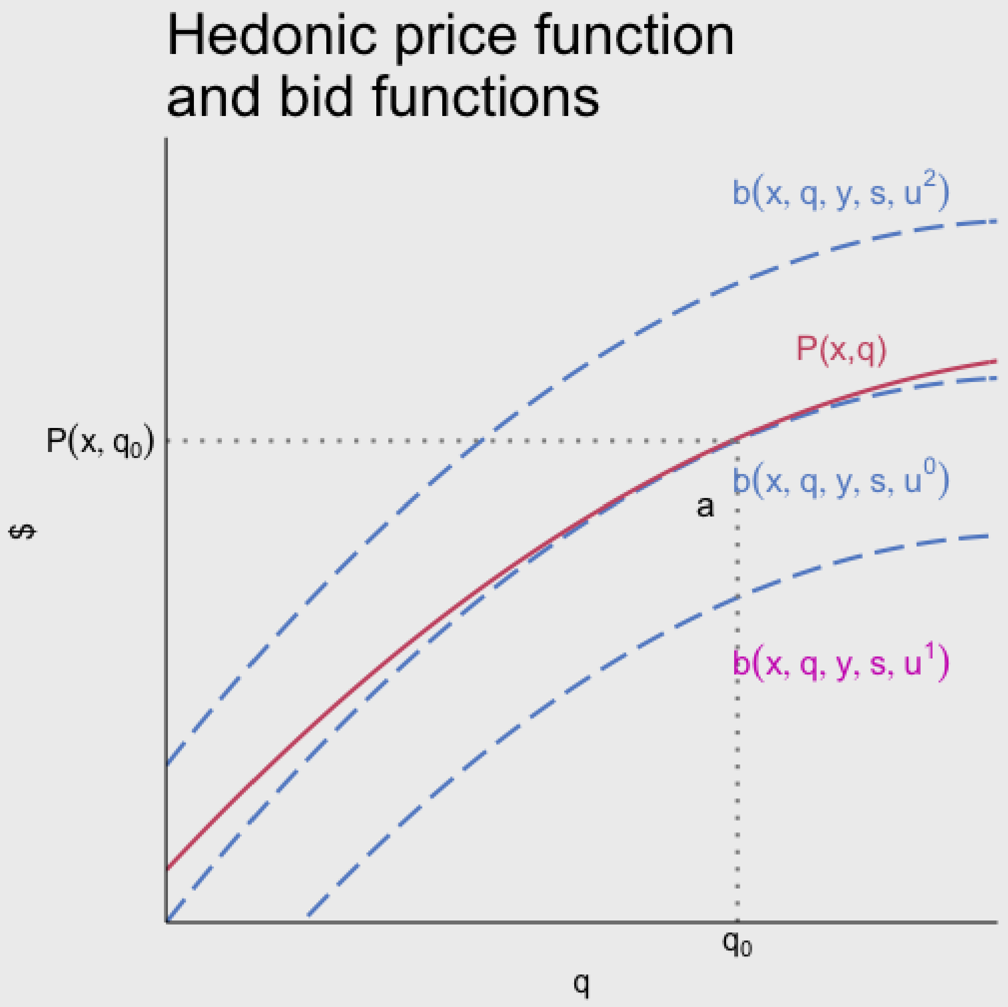
Our ultimate empirical goal is to estimate $\pi^q(x, q, s, \bar{u})$

Bid functions and housing prices

The red line is the hedonic price function

The blue lines are a single household's bid functions at different reference utility levels where $u_1 > u_0 > u_2$

Higher utility $\rightarrow$ lower bids because same level of q can be achieved with higher z

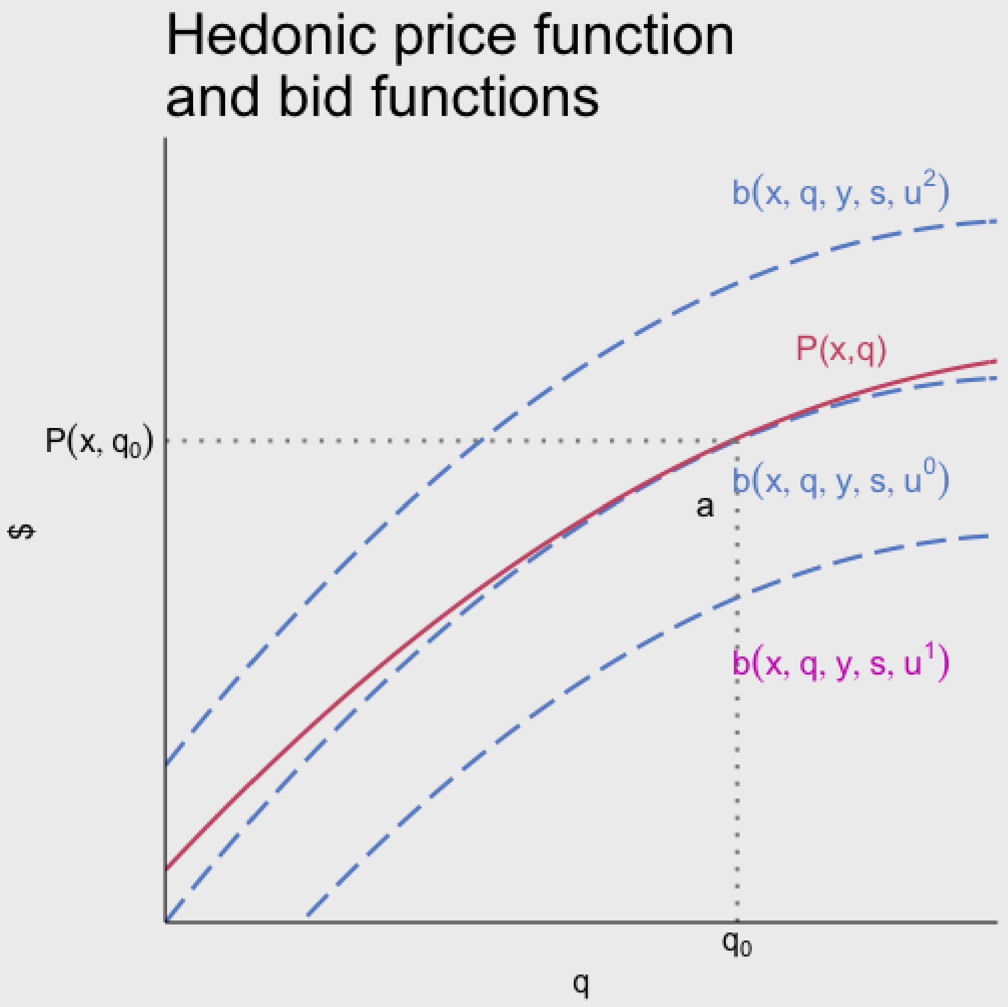


Bid functions and housing prices

Optimal choice is where the household's bid function is tangent to the hedonic price schedule: a

This gives us an observed consumption level q_0, observed price $P(x, q_0)$, and realized utility u^0

Different households will have different tangency points, different q and $P(x, q)$



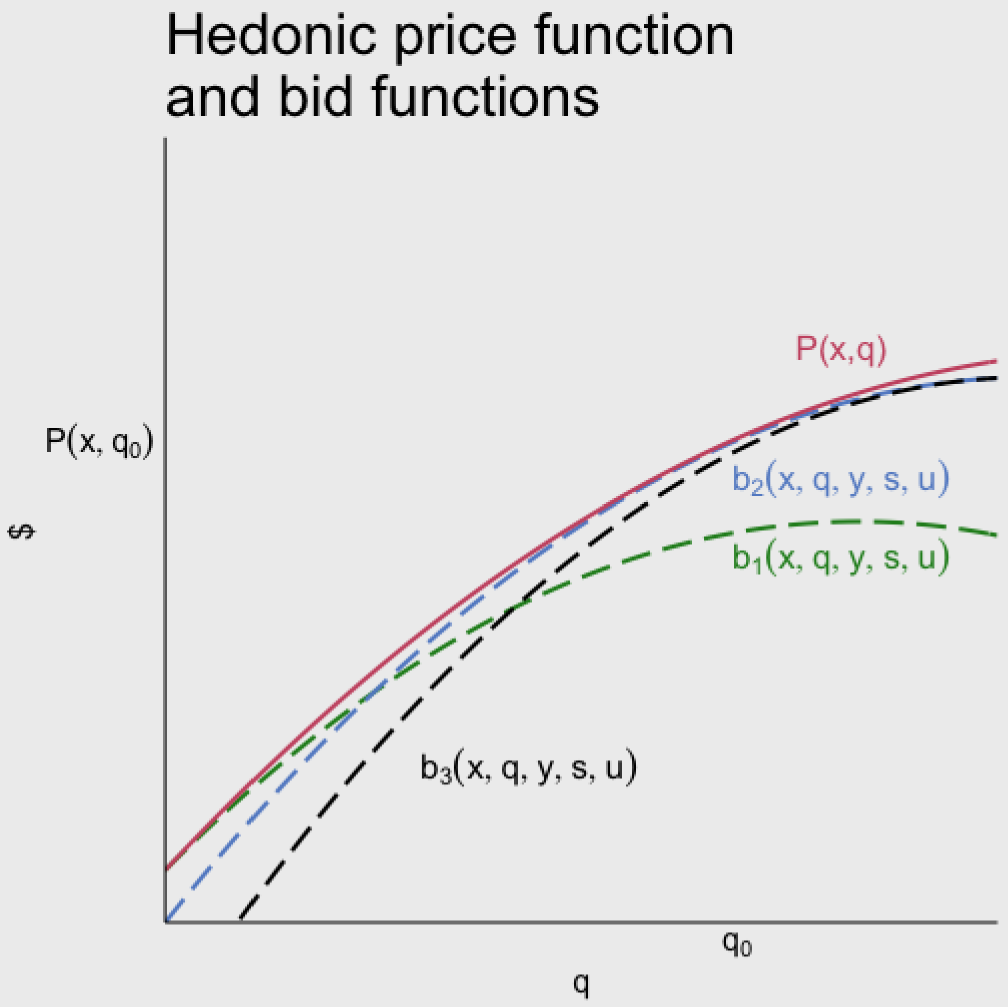
Bid functions and housing prices

The hedonic price function is the upper envelope of all the bid functions

i.e. all the bid functions are tangent to it

The other piece of the story is we need the landlord problem

It's almost identical to the buyer, but replace utility with profit



Hedonic price function and willingness to pay

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Their bid curve is only tangent at that one point, we don't see their whole bid curve

Housing prices and superfund clean up

Greenstone, Michael, and Justin Gallagher (2008). “Does Hazardous Waste Matter? Evidence from the Housing Market and the Superfund Program.” Quarterly Journal of Economics

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Main question: How does superfund site clean up affects the housing price in the adjacent areas?

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Main question: How does superfund site clean up affects the housing price in the adjacent areas?

How they do it: Compare housing market outcomes in the areas surrounding the first 400 hazardous sites chosen for Superfund clean-ups to the areas surrounding the 290 sites that narrowly missed qualifying for these clean-ups

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Cutoff is arbitrary (imposed by congressional budget constraints)

Housing prices and superfund clean up

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Because of funding limit, cutoff: HRS > 28.5 cleaned up, HRS < 28.5 are not

Some houses were treated, others were not

Cutoff is arbitrary (imposed by congressional budget constraints)

Unobserved differences between treated and untreated sites are likely to be small

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Minimizes any bias with things that might be correlated with clean up

Superfund location

Figure IIa
GEOGRAPHIC DISTRIBUTION OF HAZARDOUS WASTE SITES IN THE 1982 HRS SAMPLE
SITES WITH 1982 HRS SCORES EXCEEDING 28.5

Figure IIb
GEOGRAPHIC DISTRIBUTION OF HAZARDOUS WASTE SITES IN THE 1982 HRS SAMPLE
SITES WITH 1982 HRS SCORES BELOW 28.5

Regression

What do GG 2008 do?

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They regress:

$$log(2000medianhomeprice)_c = \theta 1(cleanedupin2000)_c + \beta X_c + \varepsilon_c$$

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$-\theta$ is telling us the **cost** of a superfund site to households

Superfund results: conventional approach

Conventional Estimates of the Association between NPL Status and House Prices with Data from the Entire United States

	(1)	(2)	(3)
A. All NPL sample, own Census tract observation			
1(NPL status by 2000)	0.040	0.046	0.067
	(0.012)	(0.011)	(0.009)
R^2	0.579	0.654	0.779
B. All NPL sample, 3-mile-radius circle sample observation			
1(NPL status by 2000)	0.030	0.060	0.106
	(0.011)	(0.013)	(0.011)
Ho: > 0.046, p-value	.061	.862	.999
R^2	0.580	0.652	0.776
C. Restrict NPL sites to those in 1982 HRS sample, own Census tract observation			
1(NPL status by 2000)	0.071	0.076	0.057
	(0.016)	(0.015)	(0.013)
R^2	0.581	0.655	0.780
D. Restrict NPL sites to those in 1982 HRS sample, 3-mile-radius circle sample observation			
1(NPL status by 2000)	0.046	0.143	0.191
	(0.015)	(0.021)	(0.021)
Ho: > 0.058, p-value	.215	.999	.999
R^2	0.580	0.653	0.777
1980 ln house price	Yes	Yes	Yes
1980 housing characteristics	No	Yes	Yes
1980 economic and demographic variables	No	No	Yes
State fixed effects	No	No	Yes

Superfund results: "quasi-experimental"

Quasi-Experimental Estimates of the Effect of NPL Status on House Prices, Samples Based on the 1982 HRS Sample Sites

					RD-Style Estimators		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
A. Own Census Tract							
1(NPL Status by 2000)	0.035	0.037	0.043	0.047	0.007	0.022	0.027
	(0.031)	(0.035)	(0.031)	(0.027)	(0.063)	(0.042)	(0.038)
B. Adjacent Census Tracts							
1(NPL Status by 2000)	0.071	0.066	0.012	0.015	-0.006	-0.002	0.001
	(0.031)	(0.035)	(0.029)	(0.022)	(0.056)	(0.035)	(0.035)
C. 2-Mile Radius from Hazardous Waste Sites							
1(NPL Status by 2000)	0.021	0.019	0.011	0.001	0.023	-0.018	-0.007
	(0.028)	(0.032)	(0.029)	(0.023)	(0.054)	(0.035)	(0.034)
Ho: > 0.138, P-Value	0.000	0.000	0.000	0.000	0.018	0.000	0.000

Superfund results

Superfund cleanups had economically and statistically insignificant effects on property values, rental rates, housing supply, population, who lives near the site

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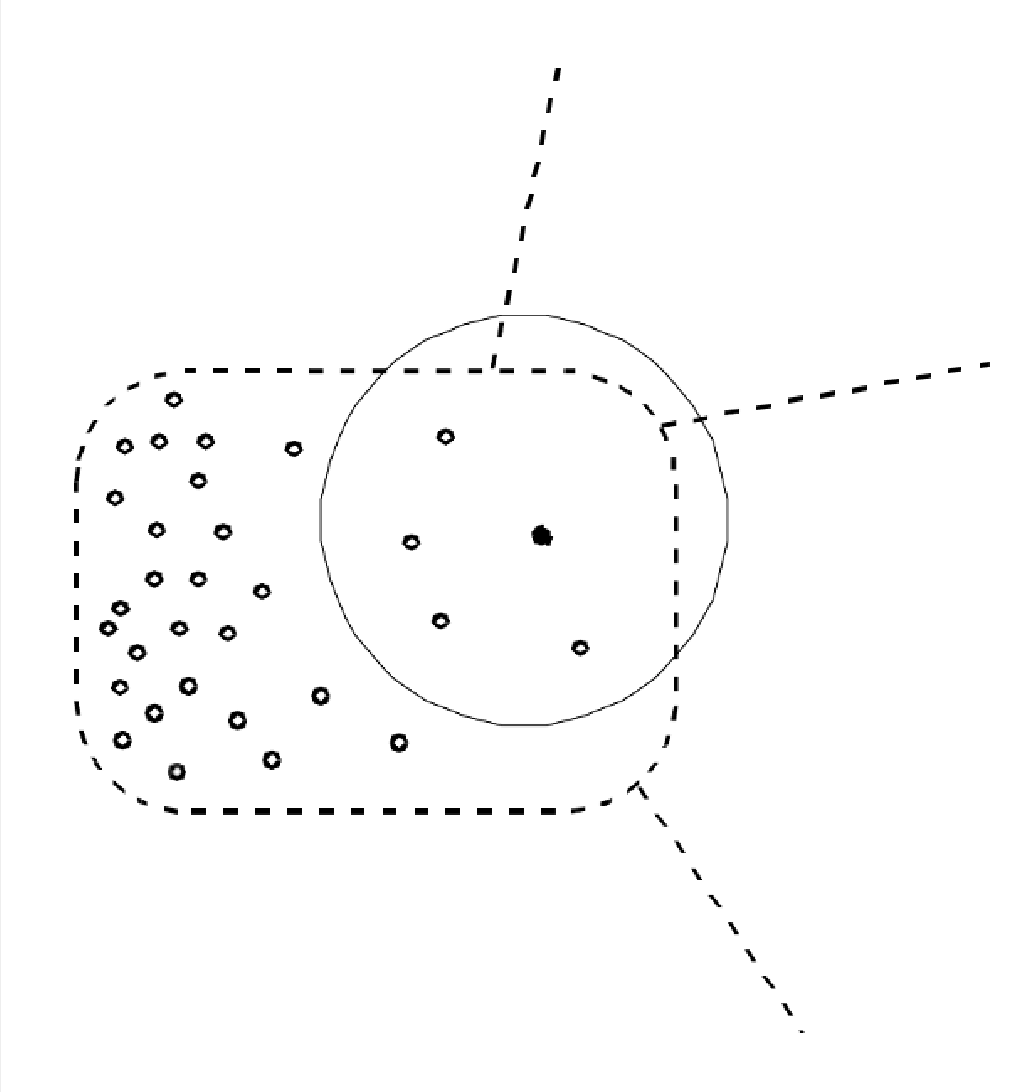
Why does granularity matter?

Superfund: zoom in

Superfund sites are a localized disamenity

Previous attempts to value cleanup looked at changes incensus tract median housing values and found no impacts

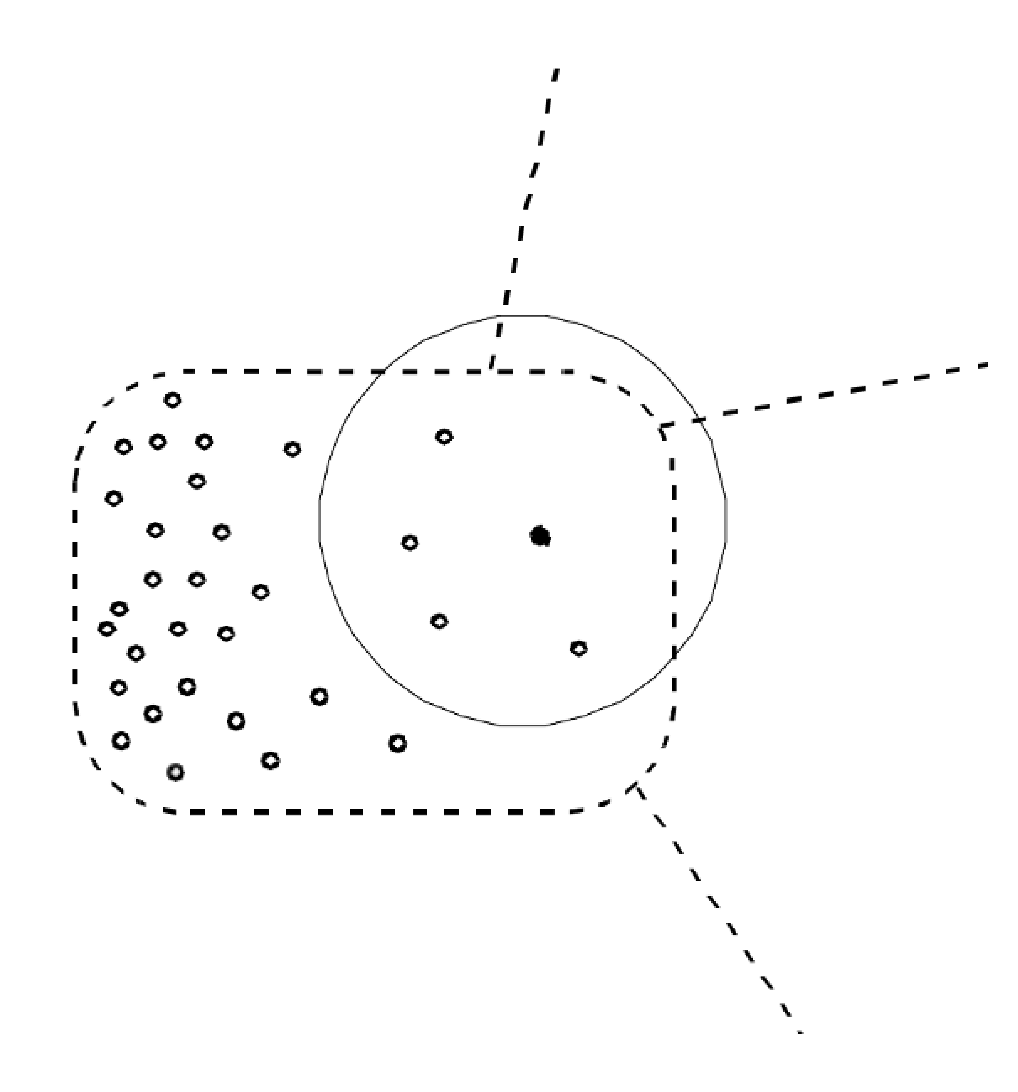
Need to look within census tracts



Superfund: zoom in

Consider changes in other percentiles of within-tract house value distribution:

deletion of a site raises tract-level housing values by 18.2% at the 10th percentile, 15.4% at the median, and 11.4% at the 60th percentile



Hedonics closing intuition: L.O. Taylor, 2003

Imagine the following hypothetical scenario in which there are two identical lakes each with 100 identical homes surrounding them

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All homes are lakefront, and all the characteristics of the homes themselves, the land, and the neighborhoods are identical across the properties

Hedonics closing intuition: L.O. Taylor, 2003

Imagine the following hypothetical scenario in which there are two identical lakes each with 100 identical homes surrounding them

All homes are lakefront, and all the characteristics of the homes themselves, the land, and the neighborhoods are identical across the properties

At the current equilibrium price of $200,000 per house, all 200 hundred homes on either lake are equally preferred.

Hedonics closing intuition: L.O. Taylor, 2003

Now let's imagine the clarity on one lake, Lake A, for example, is improved

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Now if any home on Lake A were offered at the original equilibrium price of \$200,000, consumers would uniformly prefer this house to any house on Lake B

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Now let's imagine the clarity on one lake, Lake A, for example, is improved

Now if any home on Lake A were offered at the original equilibrium price of \$200,000, consumers would uniformly prefer this house to any house on Lake B

In other words, at current prices, there would be excess demand on Lake A, and as such the price of these houses must rise to bring the market into equilibrium

Hedonics closing intuition: L.O. Taylor, 2003

The price differential that results from a change in water quality at Lake A is the implicit price that consumers are willing to pay for that incremental increase in water clarity.

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This willingness to pay for water clarity is directly revealed to us through the market prices of the homes.

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The price differential that results from a change in water quality at Lake A is the implicit price that consumers are willing to pay for that incremental increase in water clarity.

This willingness to pay for water clarity is directly revealed to us through the market prices of the homes.

For instance, if in the new equilibrium houses on Lake A sell for \$210,000, while house on Lake B sell for \$200,000, the "implicit price" associated with the increased water clarity is \$10,000.

Value of a statistical life (VSL)

This is a topic that makes non-economists uncomfortable

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But for policy analysis, there is no way around it

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VSL reflects willingness to pay for a reduction in the risk of death

VSL is more appropriately called the value of mortality risk

Value of a statistical life (VSL)

How do you get a credible estimate of the VSL?

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People can't just **tell** you it

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How?

See tradeoffs people make between cost and safety

Value of a statistical life (VSL)

Some examples:

Value of a statistical life (VSL)

Some examples:

Driving speed

Value of a statistical life (VSL)

Some examples:

Driving speed

Vehicle choice

Value of a statistical life (VSL)

Some examples:

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Wage-risk relationship

Value of a statistical life (VSL)

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Driving speed

Vehicle choice

Wage-risk relationship

There's lots of studies, and lots of different answers

VSL

> EPA recommends that the central estimate of $7.4 million ($2006), updated to the year of the analysis, be used in all benefits analyses that seek to quantify mortality risk reduction benefits regardless of the age, income, or other population characteristics of the affected population until revised guidance becomes available

VSL thought experiment

Suppose that individuals are willing to adopt a safety procedure, for which they have to give up 25 cents per hour, to reduce risk of on-the-job fatality by 1 in 10,000 (annual risk)

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Consider 10,000 independent workers

This procedure would result in one fewer person dying on average

VSL = $500*10,000 = 5 million dollars

Estimating a hedonic wage function

Just like our hedonic price function, we can estimate a hedonic wage function:

$$w_i = \alpha + \beta_1 H_i + \beta_2 X_i + \beta_3 p_i H_i + \gamma_1 p_i + \gamma_2 q_i + \gamma_3 q_i WC_i + \varepsilon_i$$

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w: wage

H: worker personal characteristics

X: job characteristics p: risk of death at the job

q: non-fatal risk at the job

WC: workers' compensation benefits for injury

ε: error term

$\frac{\partial w}{\partial p}$ is the wage-risk trade off for marginal changes in risk

VSL from the hedonic wage function

Suppose the coefficient on mortality risk was 0.4 where wages were in thousands of dollars and risk is deaths per 10,000 (WTP 400 dollars to reduce risk by 1/10,000)

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$$VSL = (0.4/10,000) * 1000) = 4 \text{ million dollars}$$

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This policy has a value of:

$$400 * 60,000 = 24 \text{ million dollars}$$

VSL estimates

Exhibit 7-3 Value of Statistcal Life Estimates (mean values in 1997 dollars)

Study	Method	Value of Statistical Life
Kneisner and Leeth (1991 - U.S.)	Labor Market	$0.7 million
Smith and Gilbert (1984)	Labor Market	$0.8 million
Dillingham (1985)	Labor Market	$1.1 million
Butler (1983)	Labor Market	$1.3 million
Miller and Guria (1991)	Contingent Valuation	$1.5 million
Moore and Viscusi (1988)	Labor Market	$3.0 million
Viscusi, Magat and Huber (1991)	Contingent Valuation	$3.3 million
Marin and Psacharopoulos (1982)	Labor Market	$3.4 million
Gegax et al. (1985)	Contingent Valuation	$4.0 million
Kneisner and Leeth (1991 - Australia)	Labor Market	$4.0 million
Gerking, de Haan and Schulze (1988)	Contingent Valuation	$4.1 million
Cousineau, Lecroix and Girard (1988)	Labor Market	$4.4 million
Jones-Lee (1989)	Contingent Valuation	$4.6 million
Dillingham (1985)	Labor Market	$4.7 million
Viscusi (1978, 1979)	Labor Market	$5.0 million
R.S. Smith (1976)	Labor Market	$5.6 million
V.K. Smith (1976)	Labor Market	$5.7 million
Olson (1981)	Labor Market	$6.3 million
Viscusi (1981)	Labor Market	$7.9 million
R.S. Smith (1974)	Labor Market	$8.7 million
Moore and Viscusi (1988)	Labor Market	$8.8 million
Kneisner and Leeth (1991 - Japan)	Labor Market	$9.2 million
Herzog and Schlottman (1987)	Labor Market	$11.0 million
Leigh and Folsom (1984)	Labor Market	$11.7 million
Leigh (1987)	Labor Market	$12.6 million
Garen (1988)	Labor Market	$16.3 million
Derived from EPA (1997) and Viscusi (1992).		