Lecture 11

Hedonics

Ivan Rudik
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 **directly** value changes in quantities of environmental goods

Revealed preference approaches

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

Why?

Revealed preference approaches

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

Why?

There aren't any markets for them!

Revealed preference approaches

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

Why?

There aren't any markets for them!

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

Revealed preference approaches

One way to circumvent this problem is to look at private goods that interact with the environmental good

Revealed preference approaches

One way to circumvent this problem is to look at private goods that interact with the environmental good

If there are changes in the environmental good,

Revealed preference approaches

One way to circumvent this problem is to look at private goods that interact with the environmental good

If there are changes in the environmental good, holding everything else fixed,

Revealed preference approaches

One way to circumvent this problem is to look at private goods that interact with the environmental good

If there are changes in the environmental good, holding everything else fixed, that should be reflected in *some way* in changes in the price of the related private good

Revealed preference approaches

One way to circumvent this problem is to look at private goods that interact with the environmental good

If there are changes in the environmental good, holding everything else fixed, that should be reflected in *some way* in changes in the price of the related private good

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

Revealed preference approaches: example

There is no market for orcas

Revealed preference approaches: example

There is no market for orcas

Suppose there's a massive decline in orcas off the Washington coast, what happens?

Revealed preference approaches: example

There is no market for orcas

Suppose there's a massive decline in orcas off the Washington coast, what happens?

We will likely see demand for sightseeing tours go down (MB of these tours went down!)

Revealed preference approaches: example

There is no market for orcas

Suppose there's a massive decline in orcas off the Washington coast, what happens?

We will likely see demand for sightseeing tours go down (MB of these tours went down!)

This drops the price of tours

Revealed preference approaches: example

There is no market for orcas

Suppose there's a massive decline in orcas off the Washington coast, what happens?

We will likely see demand for sightseeing tours go down (MB of these tours went down!)

This drops the price of tours

A non-market good had an effect on a market price

Revealed preference approaches: example

There is no market for orcas

Suppose there's a massive decline in orcas off the Washington coast, what happens?

We will likely see demand for sightseeing tours go down (MB of these tours went down!)

This drops the price of tours

A non-market good had an effect on a market price

What does this price change mean?

Hedonics: Property value models

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

Hedonics: Property value models

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

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

- Rooms
- Bathrooms
- School quality
- **Environmental quality**

Hedonics: Property value models

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

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

- Rooms
- Bathrooms
- School quality
- **Environmental quality**

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

Hedonics: Property value models

Real estate is virtually ideal for measuring environmental changes

Hedonics: Property value models

Real estate is virtually ideal for measuring environmental changes

Real estate markets are often competitive and thick

Hedonics: Property value models

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

Hedonics: Property value models

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

Hedonics: Property value models

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 Waste in the Ne...
Share
Watch on YouTube

Superfund

Congress passes Comprehensive Environmental Response, Compensation, and Liability Act (“Superfund”) in 1980

Superfund

Congress passes Comprehensive Environmental Response, Compensation, and Liability Act (“Superfund”) in 1980

Located and analyzed hazardous waste sites nation-wide

Superfund

Congress passes Comprehensive Environmental Response, Compensation, and Liability Act ("Superfund") in 1980

Located and analyzed hazardous waste sites nation-wide

Since then, the EPA has identified more than 47,000 hazardous waste sites that potentially require some sort of cleanup action

Superfund

Congress passes Comprehensive Environmental Response, Compensation, and Liability Act ("Superfund") in 1980

Located and analyzed hazardous waste sites nation-wide

Since then, the EPA has identified more than 47,000 hazardous waste sites that potentially require some sort of cleanup action

By 2005: $35 billion in federal funding has been spent at roughly 800 sites

Superfund

Superfund site cleanups are not cheap

Superfund

Superfund site cleanups are not cheap

Even before the budget crisis in Washington, there were many calls for an evaluation of the costs and the benefits of the program

Superfund

Superfund site cleanups are not cheap

Even before the budget crisis in Washington, there were many calls for an evaluation of the costs and the benefits of the program

The costs requiring a careful accounting of all the resources that go into a cleanup, and the benefits necessitating a **non-market valuation** exercise: superfund cleanups do not trade in the marketplace

Superfund

Superfund site cleanups are not cheap

Even before the budget crisis in Washington, there were many calls for an evaluation of the costs and the benefits of the program

The costs requiring a careful accounting of all the resources that go into a cleanup, and the benefits necessitating a **non-market valuation** exercise: superfund cleanups do not trade in the marketplace

How do we do it?

Superfund

Recognize that the houses surrounding a remediated site trade in the marketplace

Superfund

Recognize that the houses surrounding a remediated site trade in the marketplace

This provides one of the most simple and straightforward ways in which to look for estimates of the benefits of a Superfund cleanup: **through change in property values**

Superfund

Recognize that the houses surrounding a remediated site trade in the marketplace

This provides one of the most simple and straightforward ways in which to look for estimates of the benefits of a Superfund cleanup: **through change in property values**

Main idea: Take two otherwise very similar houses: one in a neighborhood surrounding a site that has been cleaned up and one in a neighborhood surrounding a site that has not

Superfund

Recognize that the houses surrounding a remediated site trade in the marketplace

This provides one of the most simple and straightforward ways in which to look for estimates of the benefits of a Superfund cleanup: **through change in property values**

Main idea: Take two otherwise very similar houses: one in a neighborhood surrounding a site that has been cleaned up and one in a neighborhood surrounding a site that has not

How do their prices differ?

The hedonic method

The hedonic pricing approach derives from the characteristics theory of value first proposed by Lancaster (1966)

The hedonic method

The hedonic pricing approach derives from the characteristics theory of value first proposed by Lancaster (1966)

This seeks to explain the value of a commodity as a bundle of valuable characteristics

The hedonic method

The hedonic pricing approach derives from the characteristics theory of value first proposed by Lancaster (1966)

This seeks to explain the value of a commodity as a bundle of valuable characteristics

One or more of these characteristics may be environmental

The hedonic method

The hedonic pricing approach derives from the characteristics theory of value first proposed by Lancaster (1966)

This seeks to explain the value of a commodity as a bundle of valuable characteristics

One or more of these characteristics may be environmental

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

The hedonic method

The hedonic pricing approach derives from the characteristics theory of value first proposed by Lancaster (1966)

This seeks to explain the value of a commodity as a bundle of valuable characteristics

One or more of these characteristics may be environmental

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

The hedonic method

What might housing prices depend on?

The hedonic method

What might housing prices depend on?

Site characteristics (parcel size, bedrooms, etc)

The hedonic method

What might housing prices depend on?

Site characteristics (parcel size, bedrooms, etc)

Neighboorhood characteristics (school district, crime, public transit, etc)

The hedonic method

What might housing prices depend on?

Site characteristics (parcel size, bedrooms, etc)

Neighboorhood characteristics (school district, crime, public transit, etc)

Environmental quality (air quality, noise, etc)

The hedonic model

Property value approaches are called **hedonics**

The hedonic model

Property value approaches are called **hedonics**

Suppose that we have some quality-differentiated good (i.e. a home)

The hedonic model

Property value approaches are called **hedonics**

Suppose that we have some quality-differentiated good (i.e. a home)

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

- parcel size, school quality, bedrooms, etc

The hedonic model

Property value approaches are called **hedonics**

Suppose that we have some quality-differentiated good (i.e. a home)

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

Property value approaches are called **hedonics**

Suppose that we have some quality-differentiated good (i.e. a home)

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

Lets get some intuition for how housing markets reveal the value of environmental goods

Hedonics intuition: L.O. Taylor, 2003

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

Hedonics 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

Hedonics 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 intuition: L.O. Taylor, 2003

Suppose the clarity on one lake, Lake A, for example, is improved

Hedonics intuition: L.O. Taylor, 2003

Suppose the clarity on one lake, Lake A, for example, is improved

This increases the benefit of buying a Lake A home

Hedonics intuition: L.O. Taylor, 2003

Suppose the clarity on one lake, Lake A, for example, is improved

This increases the benefit of buying a Lake A home

If prices have not changed, consumers would all want to buy lake A houses

Hedonics intuition: L.O. Taylor, 2003

Suppose the clarity on one lake, Lake A, for example, is improved

This increases the benefit of buying a Lake A home

If prices have not changed, consumers would all want to buy lake A houses

In other words: at current prices, there is excess demand on Lake A

Hedonics intuition: L.O. Taylor, 2003

Suppose the clarity on one lake, Lake A, for example, is improved

This increases the benefit of buying a Lake A home

If prices have not changed, consumers would all want to buy lake A houses

In other words: at current prices, there is excess demand on Lake A

Lake A prices **increase** to bring the market back into equilibrium

Hedonics intuition: L.O. Taylor, 2003

The new equilibrium price difference is the **implicit price** that consumers are willing to pay for that change in water clarity

Hedonics intuition: L.O. Taylor, 2003

The new equilibrium price difference is the **implicit price** that consumers are willing to pay for that change in water clarity

This WTP for water clarity is directly revealed to us through the market prices of the homes

Hedonics intuition: L.O. Taylor, 2003

The new equilibrium price difference is the **implicit price** that consumers are willing to pay for that change in water clarity

This WTP for water clarity is directly revealed to us through the market prices of the homes

If Lake A houses sell for 210,000, while Lake B houses sell for 200,000, the "implicit price" of increased water clarity is 10,000 dollars

Hedonics intuition: L.O. Taylor, 2003

The new equilibrium price difference is the **implicit price** that consumers are willing to pay for that change in water clarity

This WTP for water clarity is directly revealed to us through the market prices of the homes

If Lake A houses sell for 210,000, while Lake B houses sell for 200,000, the "implicit price" of increased water clarity is 10,000 dollars

Real world considerations:

Hedonics intuition: L.O. Taylor, 2003

The new equilibrium price difference is the **implicit price** that consumers are willing to pay for that change in water clarity

This WTP for water clarity is directly revealed to us through the market prices of the homes

If Lake A houses sell for 210,000, while Lake B houses sell for 200,000, the "implicit price" of increased water clarity is 10,000 dollars

Real world considerations: houses aren't going to be perfectly comparable, etc

Hedonics intuition: L.O. Taylor, 2003

The new equilibrium price difference is the **implicit price** that consumers are willing to pay for that change in water clarity

This WTP for water clarity is directly revealed to us through the market prices of the homes

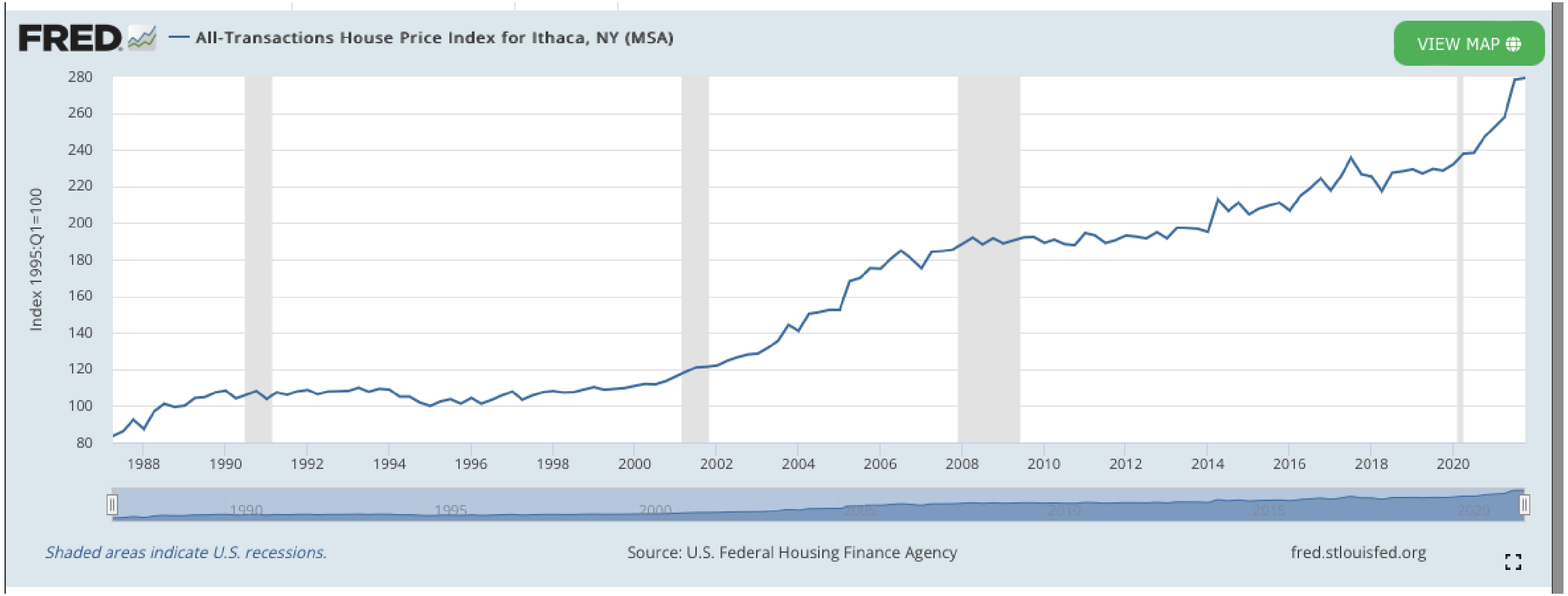
If Lake A houses sell for 210,000, while Lake B houses sell for 200,000, the "implicit price" of increased water clarity is 10,000 dollars

Real world considerations: houses aren't going to be perfectly comparable, etc

Sidebar: think about US cities in the last 20 years and urban residential prices

Housing prices in Ithaca are increasing fast, why?

Study shows Ithaca home prices rising far faster than nation's



Another Dyson professor's house

The hedonic model

The price of a house is determined by a **hedonic price curve** $P(x, q)$

The hedonic model

The price of a house is determined by a **hedonic price curve** $P(x, q)$

P tells us the market value of the home based on its characteristics x and local environmental quality q

The hedonic model

The price of a house is determined by a **hedonic price curve** $P(x, q)$

P tells us the market value of the home based on its characteristics x and local environmental quality q

For a particular house k its price is $p_k = P(x_k, q_k)$

The hedonic model

The price of a house is determined by a **hedonic price curve** $P(x, q)$

P tells us the market value of the home based on its characteristics x and local environmental quality q

For a particular house k its price is $p_k = P(x_k, q_k)$

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

The hedonic model

The price of a house is determined by a **hedonic price curve** $P(x, q)$

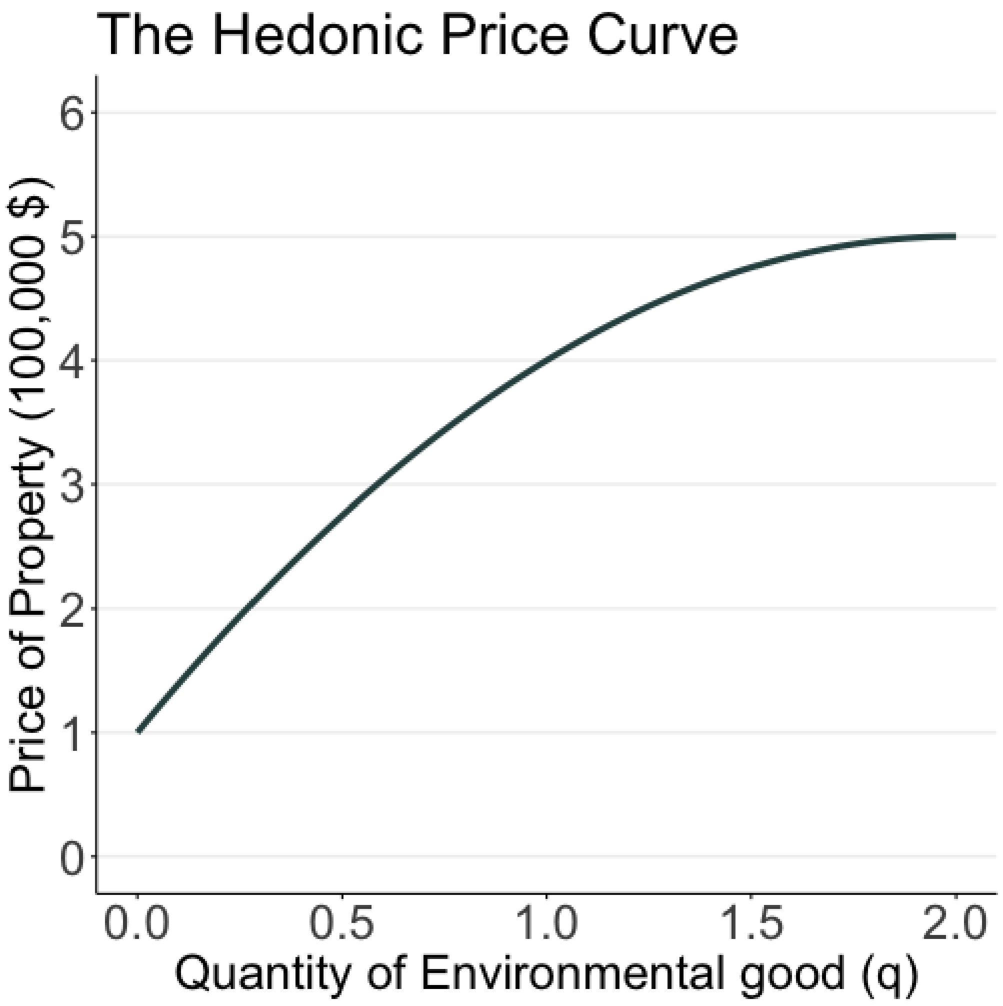
P tells us the market value of the home based on its characteristics x and local environmental quality q

For a particular house k its price is $p_k = P(x_k, q_k)$

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 curve arises solely from buyer behavior

The hedonic model: the price curve



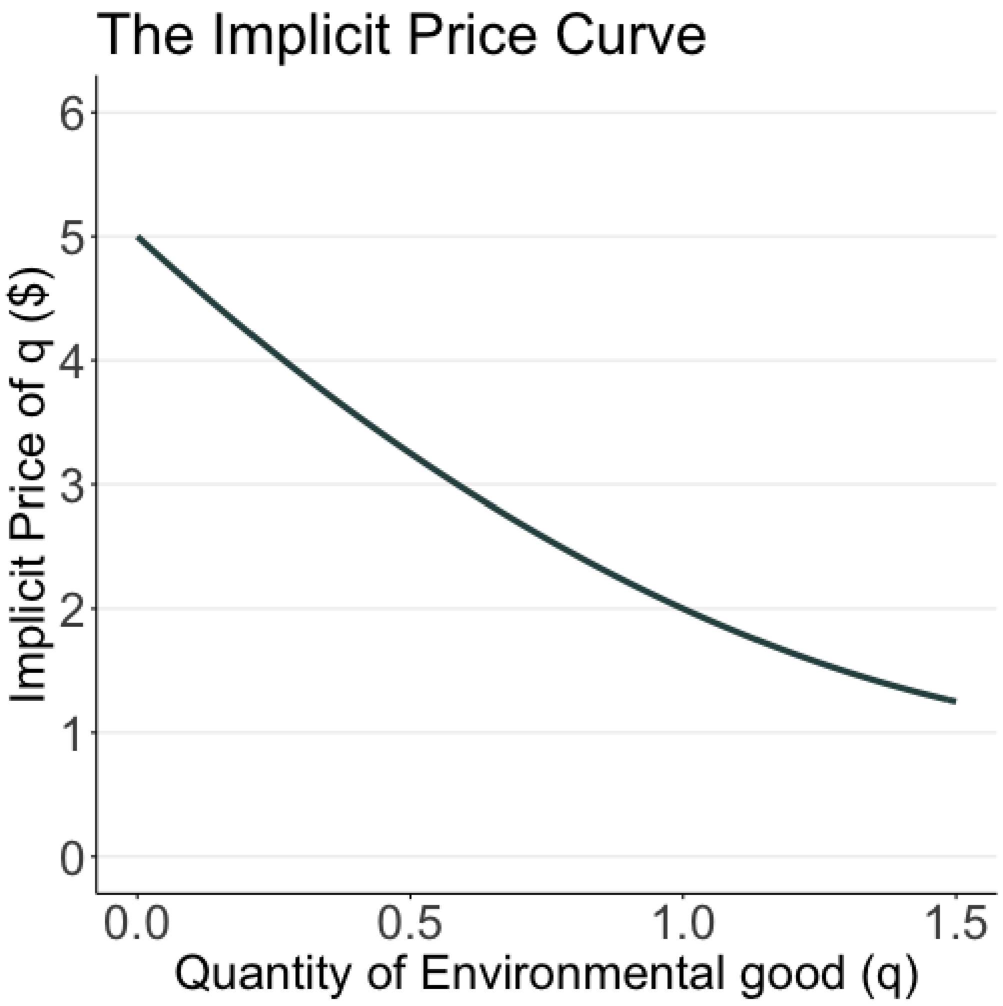
The hedonic price curve is $P(x, q)$

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

This is holding x fixed

Analogous to regular demand curves holding income fixed

The hedonic model: the price curve



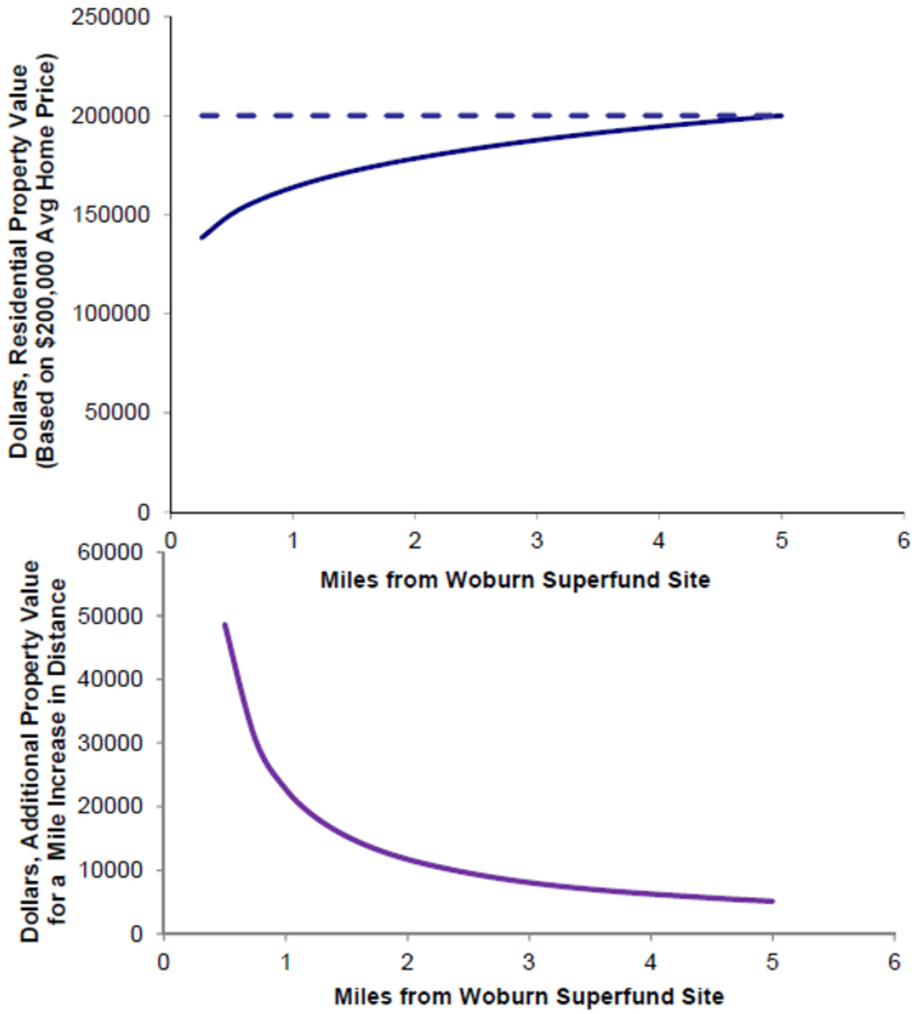
The implicit price curve for q is $\frac{\partial P(x,q)}{\partial q}$

It tells us how the price changes in q

It's positive, but downward sloping

This is effectively the environmental good demand curve

Price curve example



Total Value

“Marginal” Value
(one mile increment)

Source: Messer et al. *Env. and Res. Econ.* 2006

The hedonic model: consumer's choice problem

Households buy a single property given their budget constraint and their preferences for housing characteristics

The hedonic model: consumer's choice problem

Households buy a single property given their budget constraint and their preferences for housing characteristics

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

The hedonic model: consumer's choice problem

Households buy a single property given their budget constraint and their preferences for housing characteristics

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

$$\max_{x,q,z} U(x, q, z; s) \quad \text{subject to:} \quad \underbrace{y = z + P(x, q)}_{\text{budget constraint}}$$

The hedonic model: consumer's choice problem

Households buy a single property given their budget constraint and their preferences for housing characteristics

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

$$\max_{x,q,z} U(x, q, z; s) \quad \text{subject to:} \quad \underbrace{y = z + P(x, q)}_{\text{budget constraint}}$$

- 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, ages, etc

Unrealistic pieces of the model

One unrealistic part of this model is that we are assuming household characteristics are continuous

Unrealistic pieces of the model

One unrealistic part of this model is that we are assuming household characteristics are continuous

Many housing characteristics are discrete (bedrooms, bathrooms, etc)

Unrealistic pieces of the model

One unrealistic part of this model is that we are assuming household characteristics are continuous

Many housing characteristics are discrete (bedrooms, bathrooms, etc)

Another is that you just can't purchase some sets of x (i.e. a huge lot in downtown Manhattan with a farm)

Unrealistic pieces of the model

One unrealistic part of this model is that we are assuming household characteristics are continuous

Many housing characteristics are discrete (bedrooms, bathrooms, etc)

Another is that you just can't purchase some sets of x (i.e. a huge lot in downtown Manhattan with a farm)

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

Choosing q

Another thing to note: the consumer *chooses* q

Choosing q

Another thing to note: the consumer *chooses* q

The idea is that mobile households can move to get their desired level of the environmental good

Choosing q

Another thing to note: the consumer *chooses* q

The idea is that mobile households can move to get their desired level of the environmental good

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 $P(x, q)$

In the model we are thinking of $P(x, q)$ as the annual **rental rate**, not the purchase price

What is $P(x, q)$

In the model we are thinking of $P(x, q)$ as the annual **rental rate**, not the purchase price

This allows us to mesh more cleanly with annual income and view the problem as an annual choice

What is $P(x, q)$

In the model we are thinking of $P(x, q)$ as the annual **rental rate**, not the purchase price

This allows us to mesh more cleanly with annual income and view the problem as an annual choice

This clearly works well for renting households

What is $P(x, q)$

In the model we are thinking of $P(x, q)$ as the annual **rental rate**, not the purchase price

This allows us to mesh more cleanly with annual income and view the problem as an annual choice

This clearly works well for renting households

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

The hedonic model: consumer's choice problem

$$\max_{x,q,z} U(x,q,z;s) \quad \text{subject to:} \quad y = z + P(x,q)$$

Plug in the constraint for z to get:

$$\max_{x,q} U(x,q,\underbrace{y - P(x,q)}_{z};s)$$

The hedonic model: consumer's choice problem

$$\max_{x,q,z} U(x,q,z;s) \quad \text{subject to:} \quad y = z + P(x,q)$$

Plug in the constraint for z to get:

$$\max_{x,q} U(x,q,\underbrace{y - P(x,q)}_{z};s)$$

The FOCs for this problem are:

The hedonic model: consumer's choice problem

$$\max_{x,q,z} U(x,q,z;s) \quad \text{subject to:} \quad y = z + P(x,q)$$

Plug in the constraint for z to get:

$$\max_{x,q} U(x,q,\underbrace{y - P(x,q)}_{z};s)$$

The FOCs for this problem are:

$$\frac{\partial U}{\partial x_j} = \frac{\partial U}{\partial z}\frac{\partial P}{\partial x_j} \quad j = 1,\ldots,J \quad \text{(house characteristics)}$$

$$\frac{\partial U}{\partial q} = \frac{\partial U}{\partial z}\frac{\partial P}{\partial q} \quad \text{(environmental good)}$$

The hedonic model: consumer's choice problem

$$\frac{\partial U}{\partial q} = \frac{\partial U}{\partial z} \frac{\partial P}{\partial q}$$

gives us that

$$\frac{\partial P}{\partial q} = \frac{\partial U}{\partial q} \Bigg/ \frac{\partial U}{\partial z}$$

The hedonic model: consumer's choice problem

$$\frac{\partial U}{\partial q} = \frac{\partial U}{\partial z} \frac{\partial P}{\partial q}$$

gives us that

$$\frac{\partial P}{\partial q} = \frac{\partial U}{\partial q} \Bigg/ \frac{\partial U}{\partial z}$$

What does this mean?

The hedonic model: consumer's choice problem

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

The hedonic model: consumer's choice problem

$$\underbrace{\frac{\partial P}{\partial q}}_{\text{implicit cost of q}} = \frac{\partial U}{\partial q} \Bigg/ \frac{\partial U}{\partial z}$$

The hedonic model: consumer's choice problem

$$\underbrace{\frac{\partial P}{\partial q}}_{\text{implicit cost of q}} = \underbrace{\frac{\partial U}{\partial q} \Bigg/ \frac{\partial U}{\partial z}}_{\text{q-z MRS}}$$

The hedonic model: consumer's choice problem

$$\underbrace{\frac{\partial P}{\partial q}}_{\text{implicit cost of q}} = \underbrace{\frac{\partial U}{\partial q} \Big/ \frac{\partial U}{\partial z}}_{\text{q-z MRS}}$$

At a utility-maximizing choice,

The hedonic model: consumer's choice problem

$$\underbrace{\frac{\partial P}{\partial q}}_{\text{implicit cost of q}} = \underbrace{\frac{\partial U}{\partial q} \Bigg/ \frac{\partial U}{\partial z}}_{\text{q-z MRS}}$$

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

The hedonic model: consumer's choice problem

$$\underbrace{\frac{\partial P}{\partial q}}_{\text{implicit cost of q}} = \underbrace{\frac{\partial U}{\partial q} \Big/ \frac{\partial U}{\partial z}}_{\text{q-z MRS}}$$

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

Recall from intro/intermediate micro: the MRS tells us how the household trades off q and z while keeping utility constant

The hedonic model: consumer's choice problem

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

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

The hedonic model: consumer's choice problem

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

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

This means that the MRS is the WTP for q: the reduction in income needed to compensate for an additional unit of q, while maintaining the same level of utility

The hedonic model: consumer's choice problem

$$\frac{\partial P}{\partial q} = \frac{\partial U}{\partial q} \Big/ \frac{\partial U}{\partial z}$$

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

This means that the MRS is the WTP for q: the reduction in income needed to compensate for an additional unit of q, while maintaining the same level of utility

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

The hedonic model: consumer's choice problem

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

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

This means that the MRS is the WTP for q: the reduction in income needed to compensate for an additional unit of q, while maintaining the same level of utility

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

How prices change in the environmental good tells us about WTP

The hedonic model: bid functions

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

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

The hedonic model: bid functions

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

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

This equation just defines some indifference curve

The hedonic model: bid functions

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

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

This equation just defines some indifference curve

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

The hedonic model: bid functions

The bid function $b(x, q, y, s, \bar{u})$ is the **WTP** of the household for:

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

By definition how WTP changes in q is the q-z MRS:

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

The hedonic model: deriving MWTP

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

By assuming q is a part of a larger bundle of house characteristics, we are able to characterize its demand through its relationship to the housing market

The hedonic model: deriving MWTP

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

By assuming q is a part of a larger bundle of house characteristics, we are able to characterize its demand through its relationship to the housing market

Our ultimate empirical goal is to estimate $\frac{\partial b}{\partial q}$, which is a kind of demand curve

The hedonic model: deriving MWTP

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

By assuming q is a part of a larger bundle of house characteristics, we are able to characterize its demand through its relationship to the housing market

Our ultimate empirical goal is to estimate $\frac{\partial b}{\partial q}$, which is a kind of demand curve

It's called a **Hicksian** demand curve, whereas our regular demand curves are **Marshallian**

The hedonic model: deriving MWTP

The difference is that with **Marshallian** demand curves, we are holding **income** constant on the curve, income changes are demand shifters, utility changes as you move along the curve

The hedonic model: deriving MWTP

The difference is that with **Marshallian** demand curves, we are holding **income** constant on the curve, income changes are demand shifters, utility changes as you move along the curve

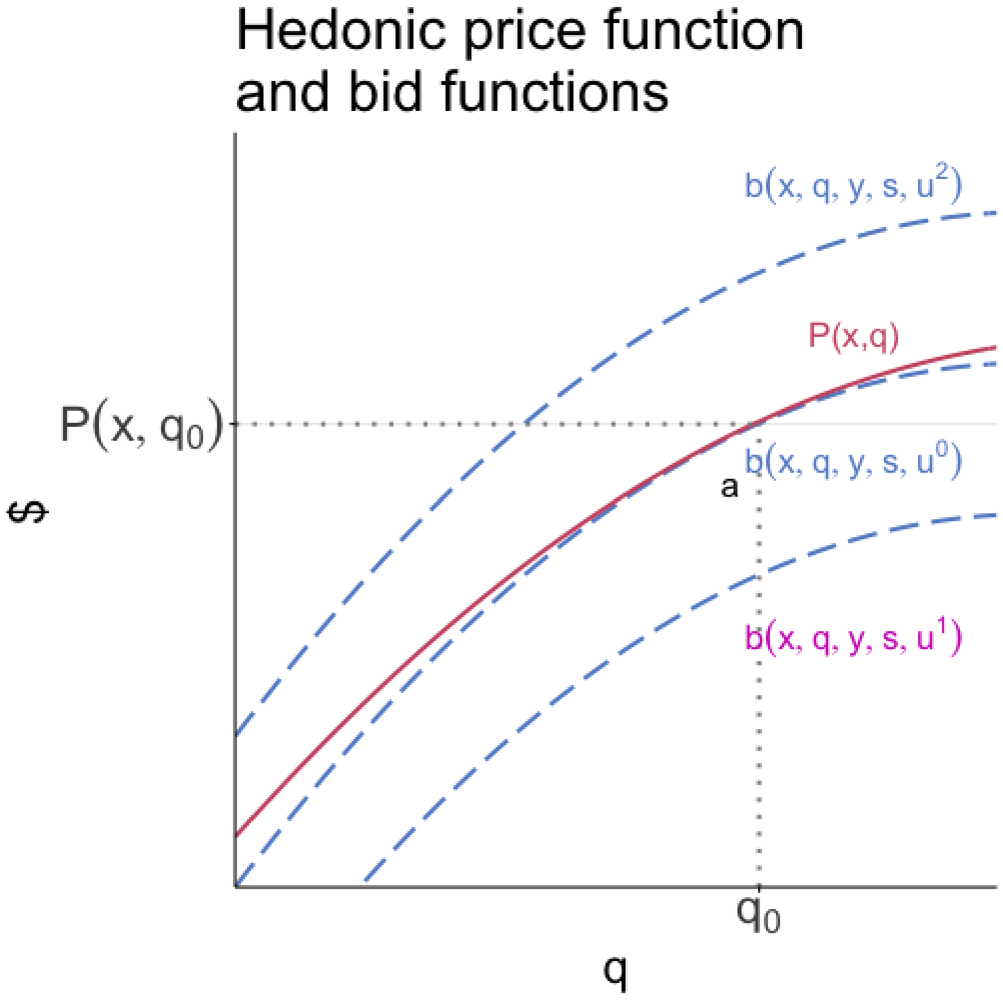
With **Hicksian** demand curves, we are holding **utility** constant, income can change along the curve, utility changes are demand shifters

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

Moving to the bottom-right increases utility

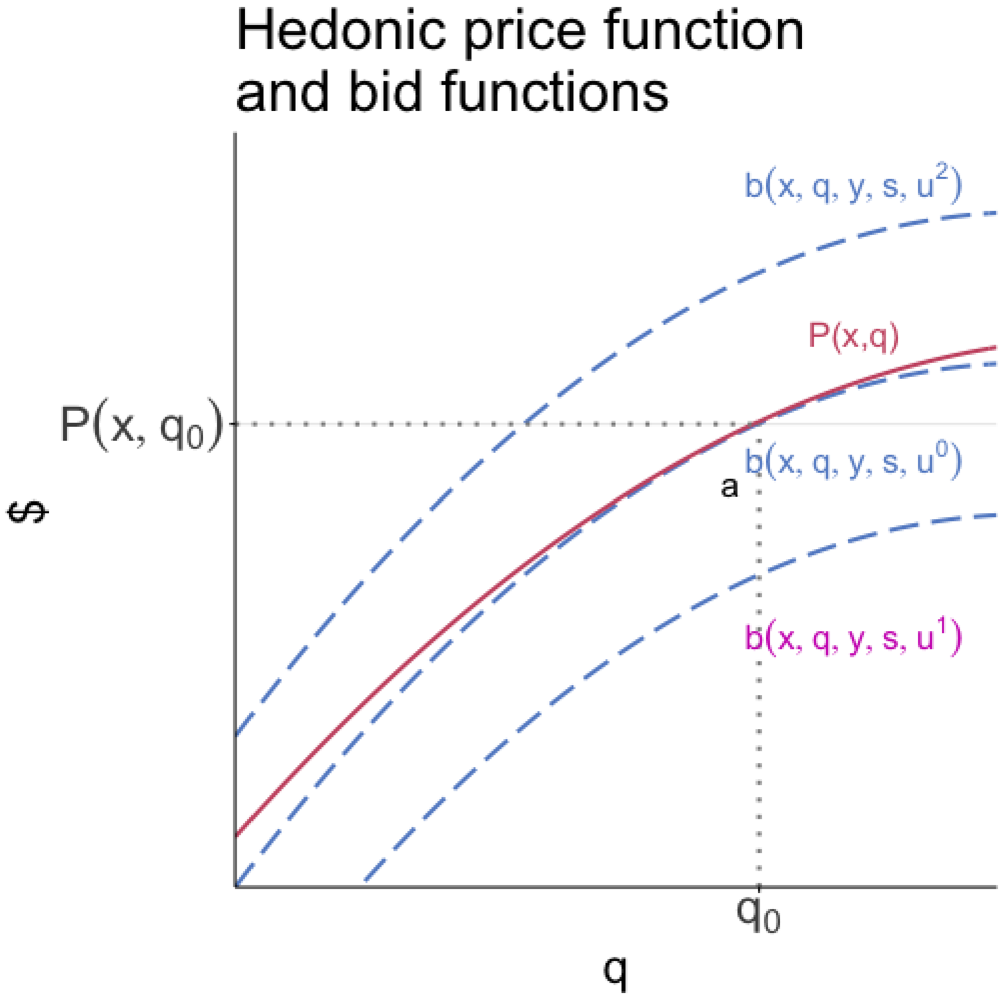


Bid functions and housing prices

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 $P(x, q)$



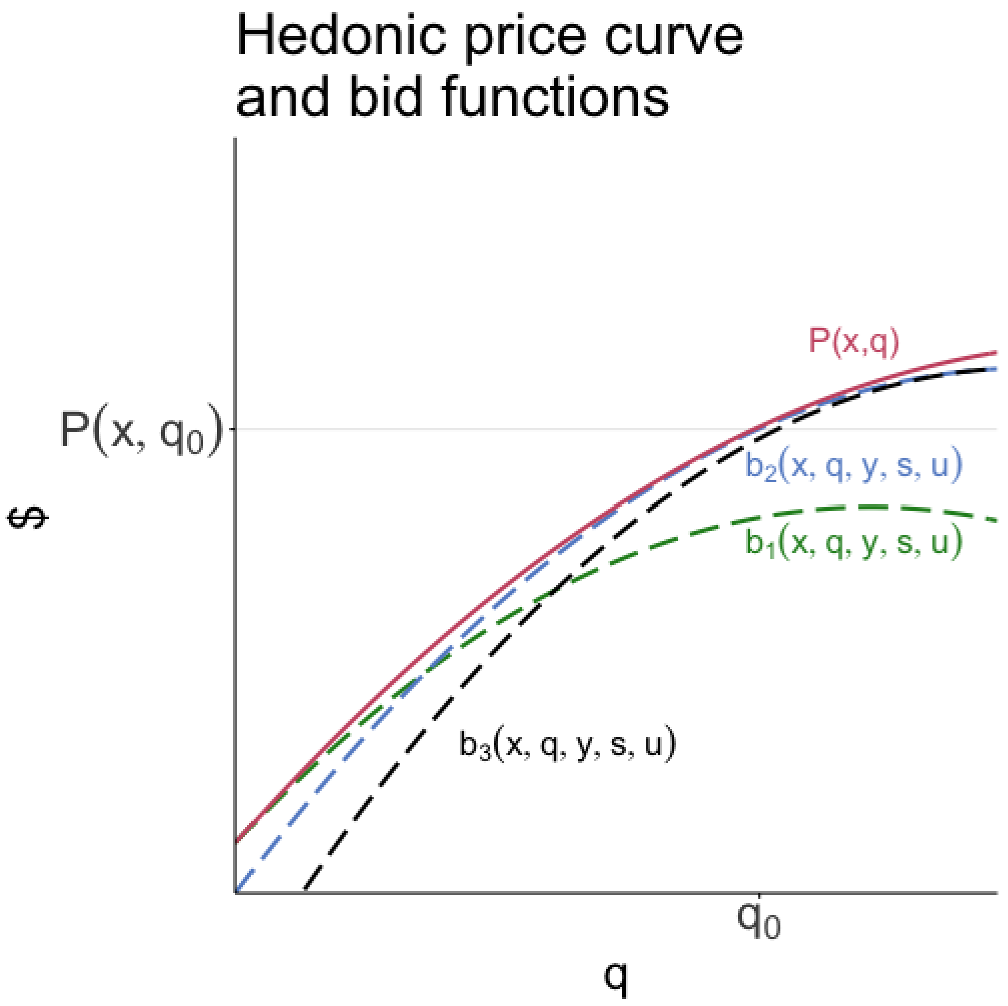
Bid functions and housing prices

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 curve and willingness to pay

The hedonic price curve shows how a house varies with attributes (such as air quality)

Hedonic price curve and willingness to pay

The hedonic price curve shows how a house varies with attributes (such as air quality)

The slope gives the marginal price of the attributes

Hedonic price curve and willingness to pay

The hedonic price curve shows how a house varies with attributes (such as air quality)

The slope gives the marginal price of the attributes

At a given point on the curve, the slope also gives the marginal WTP of the consumer who purchase that level of attributes

Hedonic price curve and willingness to pay

The hedonic price curve shows how a house varies with attributes (such as air quality)

The slope gives the marginal price of the attributes

At a given point on the curve, the slope also gives the marginal WTP of the consumer who purchase that level of attributes

But we don't know the whole marginal WTP schedule for **that person**, why?

Hedonic price curve and willingness to pay

The hedonic price curve shows how a house varies with attributes (such as air quality)

The slope gives the marginal price of the attributes

At a given point on the curve, the slope also gives the marginal WTP of the consumer who purchase that level of attributes

But we don’t know the whole marginal WTP schedule for **that person**, why?

Their bid curve is only tangent at that one point, we don't see their whole bid curve, people don't buy 1,000 houses to trace out the whole curve

Estimating the effect of ozone

Let's work through an example where we estimate the effect of ozone

You have a dataframe `house_data` available on RStudio Cloud:

```
house_data
```

```
## # A tibble: 757 × 7
##    house_num ozone num_bedrooms num_bathrooms sq_feet log_price   price
##        <int> <dbl>        <int>         <dbl>   <dbl>     <dbl>   <dbl>
##  1         1  9.60            4             3    577.      12.7 341991.
##  2         2  4.49            4             3   1111.      12.7 334851.
##  3         3 15.6             4             1    820.      12.0 159567.
##  4         6 10.2             3             2    886.      12.7 325459.
##  5         8 30.8             4             3   4909.      12.9 399579.
##  6         9 14.7             2           1.5    798.      11.9 152339.
##  7        10  3.80            4           1.5    946.      12.5 278165.
##  8        11  5.62            4             1   1912.      12.2 206147.
##  9        12  8.62            3           1.5    720.      12.3 226051.
```

Estimating the effect of ozone

We want to understand the effect of ozone on housing prices: how much does a unit increase in ozone cost?

Estimating the effect of ozone

We want to understand the effect of ozone on housing prices: how much does a unit increase in ozone cost?

Let's take a look at the summary statistics of our dataset first:

```
summary(house_data)
```

```
##    house_num          ozone            num_bedrooms   num_bathrooms      sq_feet          log_price
##  Min.   :   1.0   Min.   :  0.8242   Min.   :1.00   Min.   :1.000   Min.   :  501.4   Min.   :10.47
##  1st Qu.: 245.0   1st Qu.:  7.9529   1st Qu.:1.00   1st Qu.:1.500   1st Qu.:  892.3   1st Qu.:12.10
##  Median : 491.0   Median : 15.3680   Median :2.00   Median :2.000   Median : 1395.0   Median :12.49
##  Mean   : 494.4   Mean   : 23.1940   Mean   :2.49   Mean   :1.977   Mean   : 2055.0   Mean   :12.51
##  3rd Qu.: 745.0   3rd Qu.: 28.6273   3rd Qu.:4.00   3rd Qu.:2.500   3rd Qu.: 2415.5   3rd Qu.:12.92
##  Max.   :1000.0   Max.   :192.8742   Max.   :4.00   Max.   :3.000   Max.   :21001.0   Max.   :14.49
```

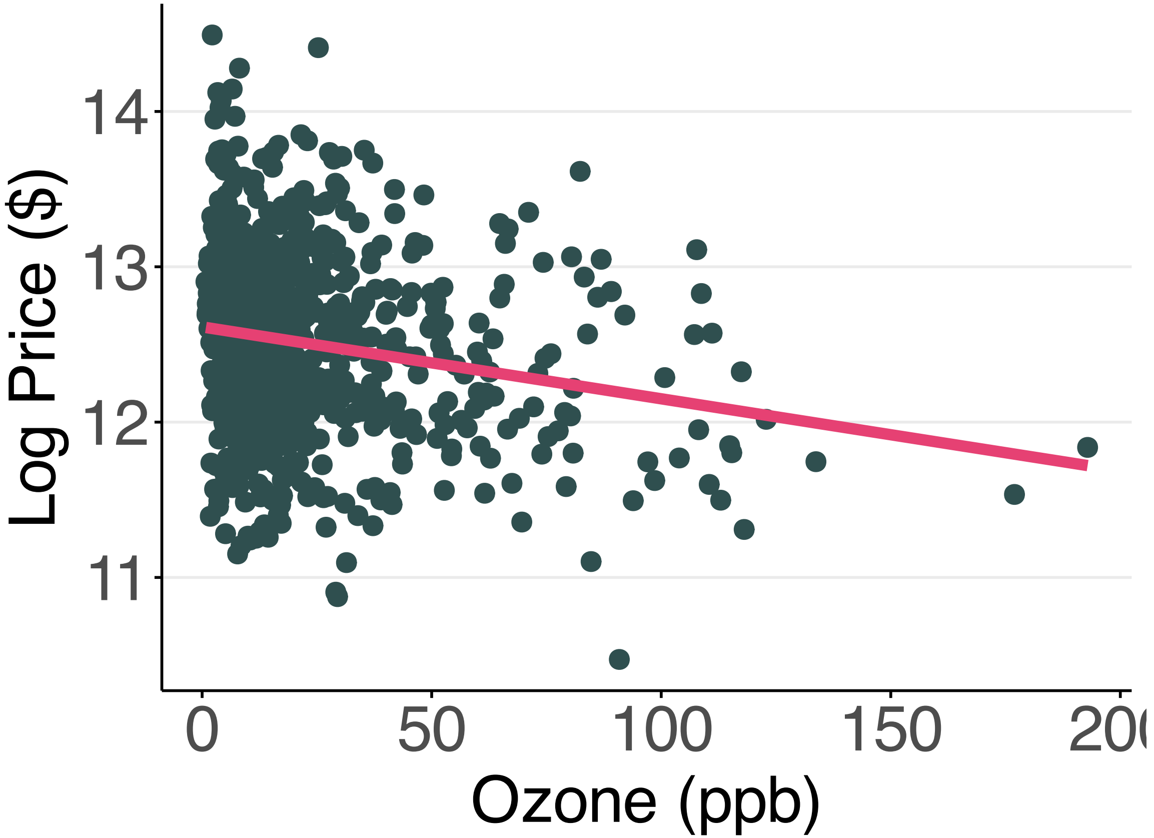
Estimating the effect of ozone

Now let's plot the relationship between log house prices and ozone to see what the data actually look like:

```
ggplot(house_data, aes(x = ozone, y = log_price)) +   # start plot
  geom_point(size = 3, color = "darkslategray") +                       # plot points
  geom_smooth(formula = y ~ x, se = F, method = "lm", size = 2, color = red_pink) +
  theme_regular +                                    # apply theme
  labs(x = "Ozone (ppb)", y = "Log Price ($)")      # assign labels
```

Estimating the effect of ozone

Now let's plot the relationship between log house prices and ozone to see what the data actually look like:



Estimating the effect of ozone

Now it's time to do the regression (try one out):

Estimating the effect of ozone

Now it's time to do the regression (try one out):

```
lm(log_price ~ num_bedrooms + num_bathrooms + sq_feet + ozone, house_data) %>%
  broom::tidy()
```

```
## # A tibble: 5 × 5
##   term          estimate  std.error statistic  p.value
##   <chr>            <dbl>      <dbl>     <dbl>    <dbl>
## 1 (Intercept)   11.7       0.0722       163.   0
## 2 num_bedrooms   0.136     0.0163         8.39 2.45e-16
## 3 num_bathrooms  0.161     0.0256         6.29 5.54e-10
## 4 sq_feet        0.0000971 0.00000900    10.8  2.46e-25
## 5 ozone         -0.00432   0.000767      -5.63 2.52e- 8
```

A 1 unit increase in ozone decreases housing values by 0.466%!

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

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

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

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

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

Housing prices and superfund clean up

Each site is given a Hazardous Ranking System (HRS) Score (0-100)

Housing prices and superfund clean up

Each site is given a Hazardous Ranking System (HRS) Score (0-100)

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

Housing prices and superfund clean up

Each site is given a Hazardous Ranking System (HRS) Score (0-100)

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

Cutoff is **arbitrary** (imposed by congressional budget constraints)

Housing prices and superfund clean up

Each site is given a Hazardous Ranking System (HRS) Score (0-100)

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

Cutoff is **arbitrary** (imposed by congressional budget constraints)

Places right below 28.5 probably aren't systematically different than those right above 28.5

Housing prices and superfund clean up

Each site is given a Hazardous Ranking System (HRS) Score (0-100)

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

Cutoff is **arbitrary** (imposed by congressional budget constraints)

Places right below 28.5 probably aren't systematically different than those right above 28.5

Key idea: Any differences between housing values in these locations is most likely due to Superfund clean up, not other factors

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?

Regression

What do GG 2008 do?

They regress:

$$\log(2000 \text{ median home price})_c = \theta \underbrace{1(\text{cleaned up in } 2000)_c}_{= 1 \text{ if true}, \, = 0 \text{ otherwise}} + \beta \underbrace{X_c}_{\text{controls}} + \varepsilon_c$$

Regression

What do GG 2008 do?

They regress:

$$\log(2000\text{ median home price})_c = \theta \underbrace{1(\text{cleaned up in }2000)_c}_{=1\text{ if true, }=0\text{ otherwise}} + \beta \underbrace{X_c}_{\text{controls}} + \varepsilon_c$$

They are interested in θ which tells us the percent change in a census tract median home price if it was cleaned up

Regression

What do GG 2008 do?

They regress:

$$\log(2000\text{ median home price})_c = \theta \underbrace{1(\text{cleaned up in }2000)_c}_{=1\text{ if true, }=0\text{ otherwise}} + \beta \underbrace{X_c}_{\text{controls}} + \varepsilon_c$$

They are interested in θ which tells us the percent change in a census tract median home price if it was cleaned up

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

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

Last three columns are the important ones

Superfund results

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

Superfund results

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

Suggests the mean benefits of Superfund cleanup are small

Superfund results

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

Suggests the mean benefits of Superfund cleanup are small

Some recent and more granular studies (Timmins and Gamper) dispute these findings: http://www.nber.org/papers/w16655.pdf

Superfund results

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

Suggests the mean benefits of Superfund cleanup are small

Some recent and more granular studies (Timmins and Gamper) dispute these findings: http://www.nber.org/papers/w16655.pdf

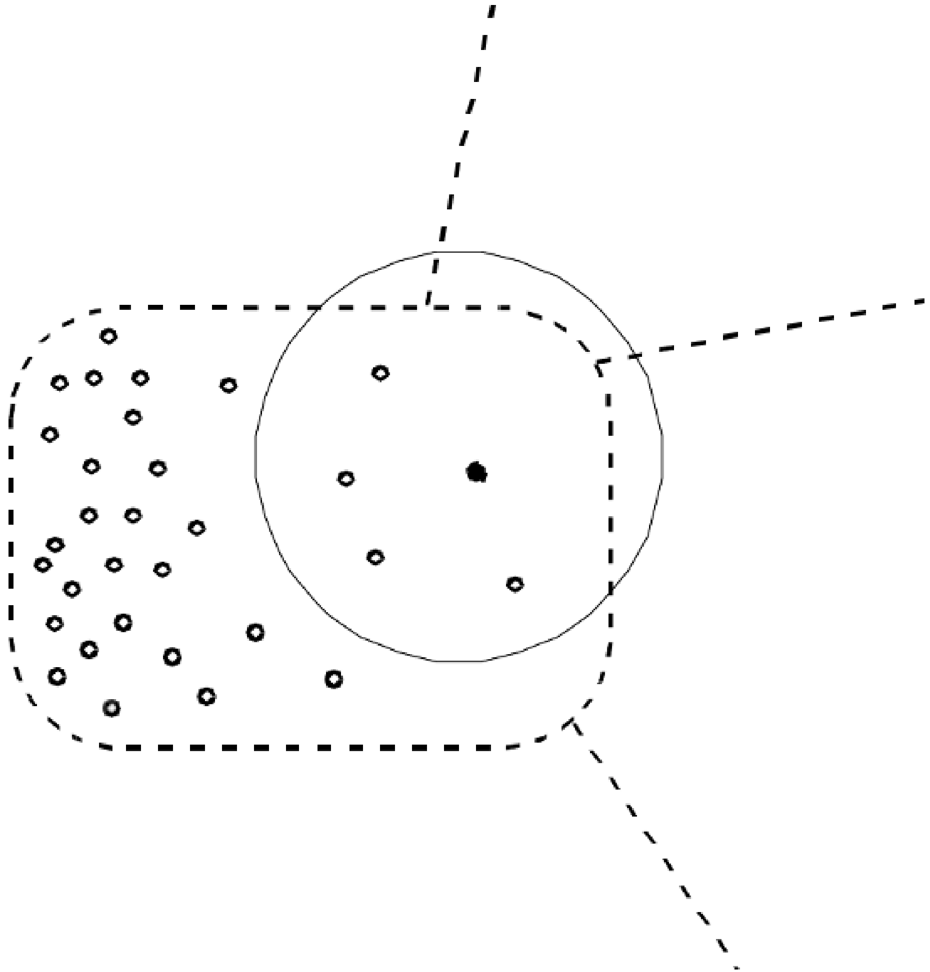
Why does granularity matter?

Superfund: zoom in

Superfund sites are a localized disamenity

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

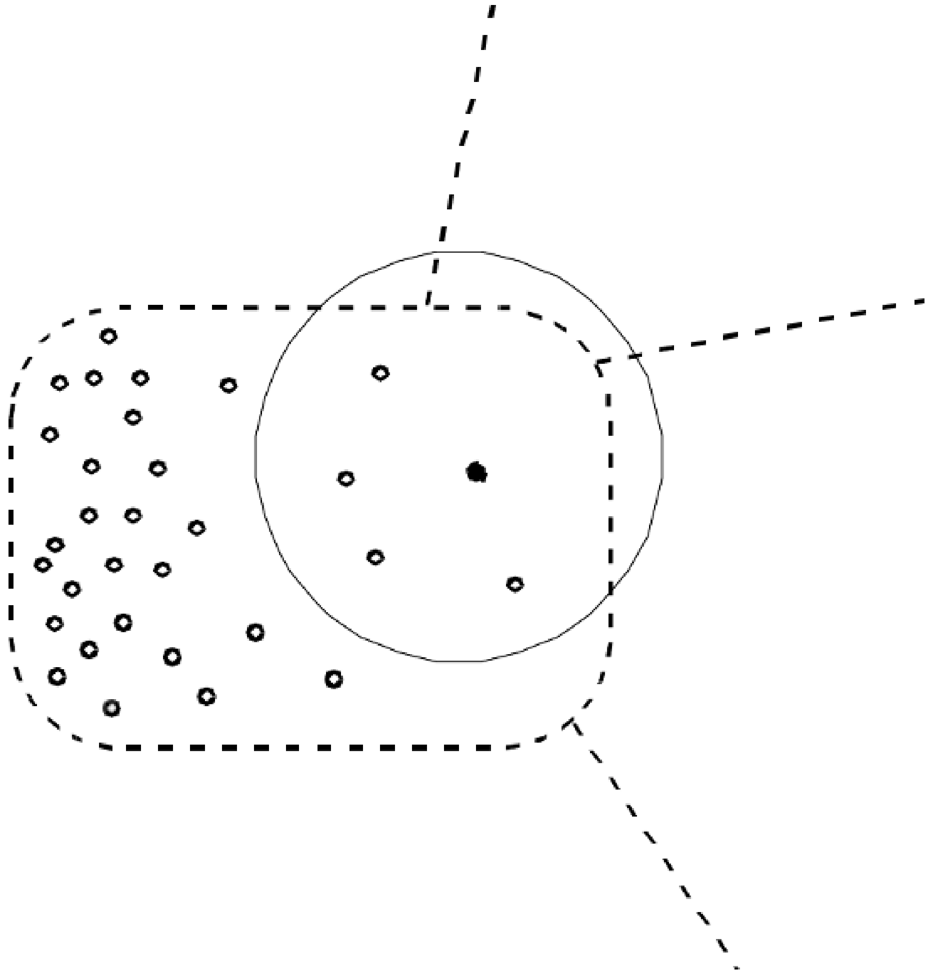
Need to look **within** census tracts



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



Value of a statistical life (VSL)

How much should society spend, at the margin, to save a 'statistical life'?

Value of a statistical life (VSL)

How much should society spend, at the margin, to save a 'statistical life'?

A statistical life is a probabilistic concept

Value of a statistical life (VSL)

How much should society spend, at the margin, to save a 'statistical life'?

A statistical life is a probabilistic concept

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

Value of a statistical life (VSL)

How much should society spend, at the margin, to save a 'statistical life'?

A statistical life is a probabilistic concept

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?

Value of a statistical life (VSL)

How do you get a credible estimate of the VSL?

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

Value of a statistical life (VSL)

How do you get a credible estimate of the VSL?

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

But we can observe it from behavior

Value of a statistical life (VSL)

How do you get a credible estimate of the VSL?

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

But we can observe it from behavior

How?

Value of a statistical life (VSL)

How do you get a credible estimate of the VSL?

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

But we can observe it from behavior

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:

Driving speed

Vehicle choice

Wage-risk relationship

Value of a statistical life (VSL)

Some examples:

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)

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)

This translates into 2000 hours per year $\times$ 0.25 dollars per hour = \$500 per year

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)

This translates into 2000 hours per year $\times$ 0.25 dollars per hour = \$500 per year

Consider 10,000 independent workers

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)

This translates into 2000 hours per year $\times$ 0.25 dollars per hour = \$500 per year

Consider 10,000 independent workers

This procedure would result in one fewer person dying on average

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)

This translates into 2000 hours per year $\times$ 0.25 dollars per hour = \$500 per year

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

We can estimate a **hedonic wage function:**

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

Estimating a hedonic wage function

We can estimate a **hedonic wage function:**

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

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

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

VSL from the hedonic wage function

Suppose:

- Wages were in thousands of dollars
- Risk is deaths per 10,000 people
- Coefficient on mortality risk p is $\gamma_1 = 0.4$

VSL from the hedonic wage function

Suppose:

- Wages were in thousands of dollars
- Risk is deaths per 10,000 people
- Coefficient on mortality risk p is $\gamma_1 = 0.4$

This implies an average WTP (reduced wage) of

VSL from the hedonic wage function

Suppose:

- Wages were in thousands of dollars
- Risk is deaths per 10,000 people
- Coefficient on mortality risk p is $\gamma_1 = 0.4$

This implies an average WTP (reduced wage) of 400 dollars to reduce risk by 1 in 10,000

VSL from the hedonic wage function

WTP (reduced wage) of 400 dollars to reduce risk by 1/10,000

VSL from the hedonic wage function

WTP (reduced wage) of 400 dollars to reduce risk by 1/10,000

This means that the VSL is:

VSL from the hedonic wage function

WTP (reduced wage) of 400 dollars to reduce risk by 1/10,000

This means that the VSL is:

$$VSL = \underbrace{(0.4 \times 1000)}_{\substack{\text{WTP to reduce} \\ \text{risk by 1 in 10000}}} \times 10,000) = 4 \text{ million dollars}$$

VSL from the hedonic wage function

WTP (reduced wage) of 400 dollars to reduce risk by 1/10,000

This means that the VSL is:

$$VSL = \underbrace{(0.4 \times 1000)}_{\substack{\text{WTP to reduce} \\ \text{risk by 1 in 10000}}} \times 10,000) = 4 \text{ million dollars}$$

Suppose a policy reduces mortality risk by 1/10,000 for 60,000 people (saves 6 lives on average)

VSL from the hedonic wage function

WTP (reduced wage) of 400 dollars to reduce risk by 1/10,000

This means that the VSL is:

$$VSL = \underbrace{(0.4 \times 1000)}_{\substack{\text{WTP to reduce} \\ \text{risk by 1 in 10000}}} \times 10,000) = 4 \text{ million dollars}$$

Suppose a policy reduces mortality risk by 1/10,000 for 60,000 people (saves 6 lives on average)

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).		