Lecture 2:
Value of Environmental Amenities
ECO 567A

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Syllabus

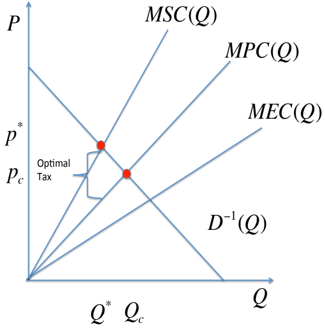
- Part I: Demand for Local Environmental Quality
  - Intro (Jan 10)
  - Demand I - Estimation (Jan 17)
  - Demand II - Sorting and Environmental Justice (Jan 24)
  - Amenities and Quant. Spatial Economic Models (Jan 31)
- Part II: Supply of Local Environmental Quality - Energy
  - Energy Production (Feb 7)
  - Energy Demand (Feb 14)
  - Energy Efficiency Innovation (Feb 21)
  - Trade and Pollution (March 7)
- Part III: Global Externalities
  - Climate Change (March 14)

Research Project

- Pick a question that interests you in Sustainable Development/Environment/Energy/Geography
- Brief literature review on what has been done, what are outstanding questions
- Develop empirical strategy to address the question (real world)
- Identify dataset
- Obtain dataset and describe

Last Week: Optimal Policy is Very Easy

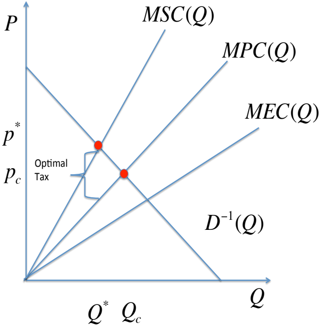
- $$\underbrace{\hat{\tau}}_{\text{Marg. Cost of Reg.}} = MSC(Q^*) - MPC(Q^*) = \underbrace{MEC(Q^*)}_{\text{Marg. Benef. of Reg.}}$$



Last Week: Optimal Policy is Very Easy

- $$\underbrace{\hat{\tau}}_{\text{Marg. Cost of Reg.}} = MSC(Q^*) - MPC(Q^*) = \underbrace{MEC(Q^*)}_{\text{Marg. Benef. of Reg.}}$$

- But what is $MEC(Q^*)$?



Forever More: Optimal Policy is Very Hard

- $$MEC(Q) = \underbrace{\frac{d\$}{dU} * \frac{dU}{dZ}}_{\text{MWTP Abatement}} * \underbrace{\frac{dZ}{dQ}}_{\text{Pollution associated with } Q}$$
- Marginal Willingness to Pay for Abatement (MWTP Abatement)
  "How much money would the average person pay to avoid a unit of pollution (Z) ?"
- Pollution associated with Q = "How much does the consumption/production of Q increase pollution?"

How to Estimate $MEC(Q)$ (or MWTPA)?

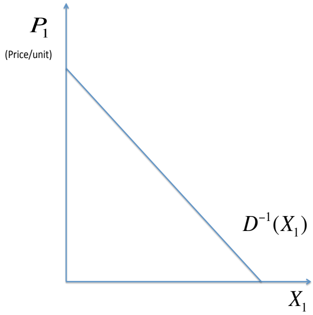
- Hedonic Method
- Accounting Method

Benefits of environment

- Direct utility effect (environmental services, biodiversity, behest, etc)
- Health effect
  - avoidance costs
  - medical costs (ex-post)
  - productivity effect
  - wage effect

Normally....

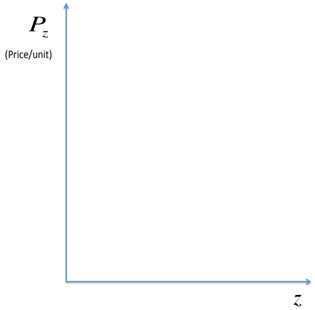
$$x_1^*, x_2^* = \underset{x_1, x_2}{\text{argmax}} \; U(x_1, x_2)$$
$$\text{s.t.} \;\; p_1 x_1 + p_2 x_2 \leq y$$



But with a missing market....

$$? = \underset{x,z}{\operatorname{argmax}} \; U(x,z)$$

$$\text{s.t.} \;\; p_x x + \underbrace{p_z}_{=0} z \leq y$$



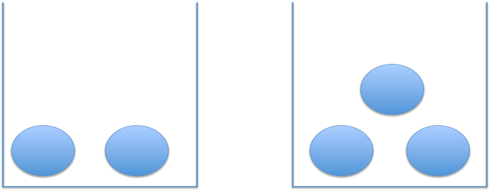
Hedonic Method

- Value of non-market amenities are capitalized in related goods

Hedonic Method

- Value of non-market amenities are capitalized in related goods

- Example: consider two baskets

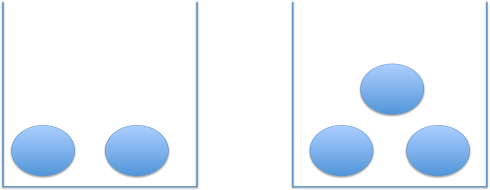


$P_{basket} = 7$ $\qquad$ $P_{basket} = 9$

Hedonic Method

- Value of non-market amenities are capitalized in related goods

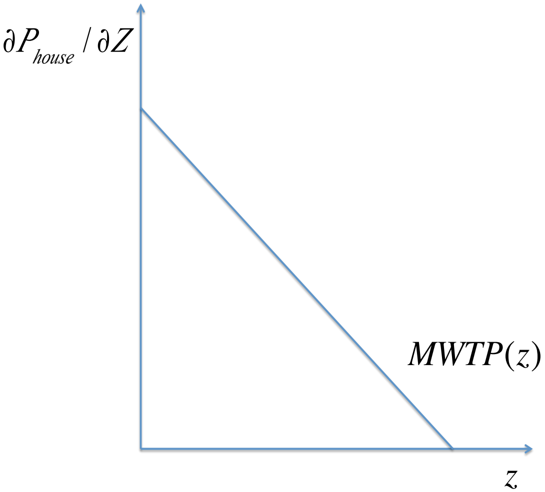
- Example: consider two baskets



$P_{basket} = 7$ $\qquad$ $P_{basket} = 9$

- Example: MWTP = 9-7=2

Hedonic Method



Hedonic Theory

- Define:
  - U = Utility
  - x = Consumption Good
  - z = amenity
  - y = income
  - θ = bid for house
- $U = U(x, z)$
- Agent's problem:

$$\theta = \underset{x,\theta}{\text{argmax}} \ \theta$$

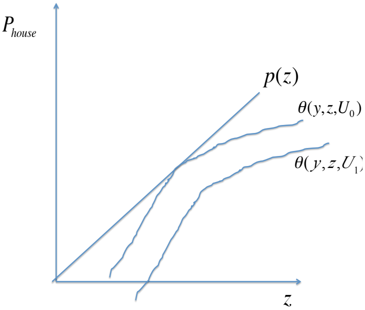
$$\text{s.t. } x + \theta \leq y$$

$$U(x, z) \geq \hat{U}$$

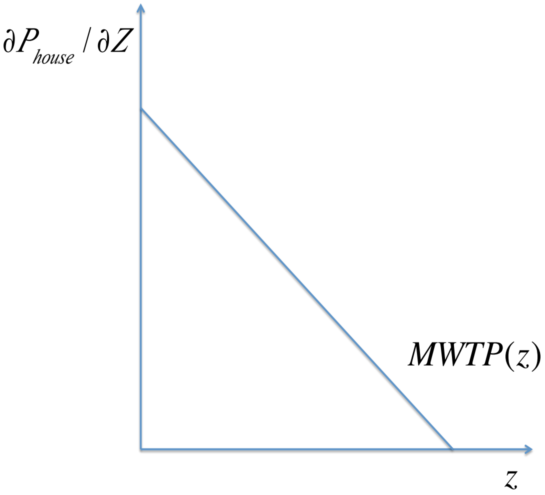
- $\Longrightarrow$ optimal bid function $\theta^*(y, z, \hat{U})$

Hedonic Theory

- optimal bid function $\theta^*(y, z, \hat{U})$
- $\frac{\partial}{\partial z}\theta^*(y, z, \hat{U}) = MWTP(z)$



Hedonic Method



Example: Davis (AER, 2004)

Research Question: What is the MWTP to avoid health risk?

- Certainly positive, but what is the magnitude? Need to know for optimal policy.
- Previous work focuses on labor outcomes. Davis provides first estimates of child risk. This is important because children are not observed in the labor market, so you can't use wages to answer the question

Example: Davis (AER, 2004)

- Identification problem
  - health risk is not randomly assigned
- Empirical Strategy
  - Look at change in housing prices in Nevada (1990 -2002) before vs after increase in incidence of pediatric leukemia
    - Control for time-invariant correlates with health risk
    - The change in health risk is unlikely to covary with other changes in determinants of health risk

Health Risk

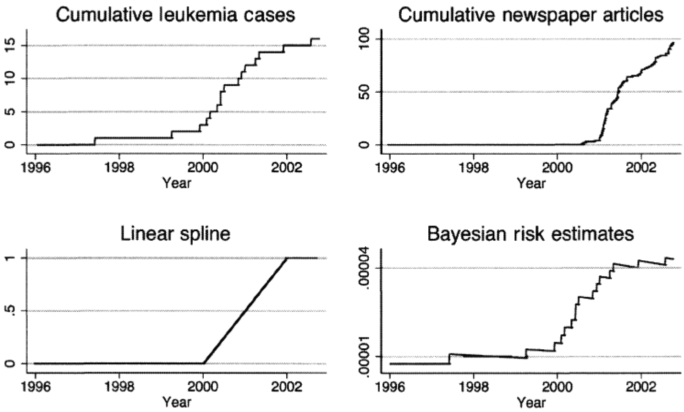
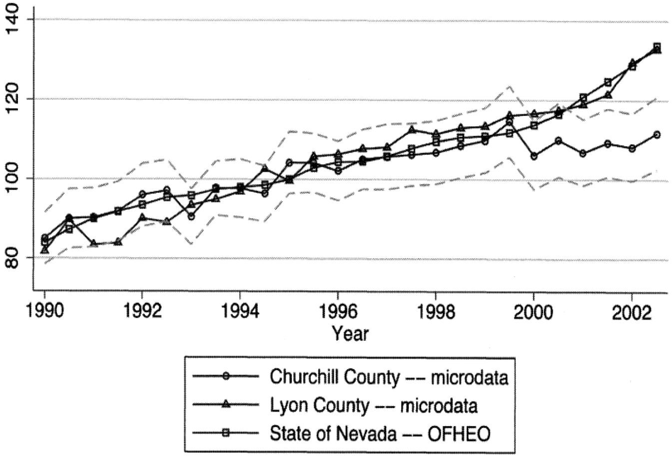


FIGURE 1. INCIDENCE RATES INCREASE AFTER 1999:
ALTERNATIVE MEASUREMENTS OF PEDIATRIC LEUKEMIA RISK FOR CHURCHILL COUNTY, NEVADA

Treatment vs Control Counties

	Churchill (n = 2495)	Lyon (n = 3683)
Housing characteristics:		
Mean sales price	$116,060	$119,723
	(52,791)	(55,060)
Mean lot size (acres)	1.42	1.16
	(3.97)	(6.21)
Mean interior floor space (square feet)	1493	1480
	(461)	(438)
Mean building age (years)	16.9	10.8
	(20.8)	(15.6)
Mean class (range 1–5)	1.75	2.16
	(.59)	(.76)
Demographic characteristics:		
Population	23,982	34,501
Persons per square mile	4.9	17.3
Percentage under 18	28.9	27.1
Percentage over 65	11.9	13.7
Percentage white	84.2	88.6
Percentage high-school graduates	85.1	81.5
Percentage college graduates	16.7	11.3
Homeownership rate	65.8	75.8
Percentage multi-unit	11.7	8.1
Percentage below poverty	8.7	10.4
Median household income	$40,808	$40,699

Housing Price Indices



Housing Price Indices Difference

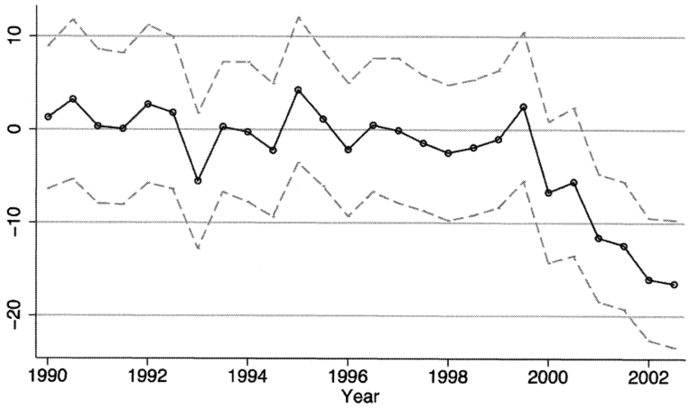


FIGURE 3. FALL IN HOUSING PRICES AFTER 1999:
PERCENTAGE DIFFERENCE BETWEEN CHURCHILL COUNTY HPI AND NEVADA HPI

Estimation

$$\ln Price_{jct} = \beta_1 X_{jct} + \beta_2 Risk_{ct} + \alpha_t + \alpha_c + \epsilon_{jct} \tag{1}$$

$$\ln Price_{jct} = \beta_1 X_{jct} + \beta_2 Risk_{ct} + \alpha_j + \alpha_t + \epsilon_{jct} \tag{2}$$

*Note this is not how Davis writes his estimation equation

Regression Estimates

TABLE 3—THE EFFECT OF HEALTH RISK ON HOUSING VALUES

	OLS (1)	OLS (2)	FE
Leukemia risk (linear spline)	−0.123	−0.156	−0.140
	(0.013)	(0.017)	(0.015)
Lot size (acres)	0.011	0.012	—
	(0.002)	(0.002)	
Lot size squared	−1.88E-05	−2.02E-05	—
	(3.20E-06)	(3.18E-06)	
Floor space (square feet, 100s)	0.054	0.044	—
	(0.001)	(0.001)	
Building age (years)	−0.009	−0.006	—
	(0.001)	(0.001)	
Building age squared	3.57E-05	1.20E-05	—
	(8.61E-06)	(8.42E-06)	
Churchill County dummy	—	0.068	—
		(0.009)	
Class dummies	no	yes	—
Year dummies	no	yes	yes
Month dummies	no	yes	yes
n	10204	10204	4922
R^2	0.60	0.63	0.05

Notes: The sample consists of sales of single-family residences from 1990 to 2002 from both counties. The dependent variable is sales price in logs. The linear spline is zero through 1999, rises by 1/24 each month during 2000 and 2001, and then takes the value of one. For the control county the linear spline is equal to zero for all periods. Standard errors are corrected for heteroskedasticity and correlated errors within county-month groups.

Interpreting Point Estimate

- Suppose the model is $y = \beta x + \epsilon$

  $\Longrightarrow$ 1 unit increase in x leads to $\beta \times 1$ unit increase in y, i.e., just β

- Suppose the model is $\ln y = \beta x + \epsilon$, or equivalently, $y = e^{\beta x + \epsilon}$

  $\Longrightarrow$ suppose x goes from 1 to 2 then the ratio $\frac{y(2)}{y(1)}$ is $\frac{e^{2\beta+\epsilon}}{e^{\beta+\epsilon}}$. Taking logs,

  $$\ln\left(\frac{y(2)}{y(1)}\right) = \beta$$

  and

  $$\frac{y(2) - y(1)}{y(1)} \approx d\ln y = \ln y(2) - \ln y(1) = \beta$$

  So a 1 unit change in x leads approximately to a β % change in y.

Implications of Results

- Perceived lifetime risk increased from 2.59 cases per 10,000 to 14.5 cases per 10,000 in Churchill
- Housing prices went down by 15% $\longrightarrow .15/(14.5 - 2.59)$ gives 1.25 % of the housing price per 1 in 10,000 change in perceived lifetime risk
- Value of statistical life is defined as the compensation a group would require to accept 1 expected case within the group
- MWTP = 1.25% * 116,000 / 2.64 $\approx$ 550 USD per individual
- Multiply by 10,000 $\Longrightarrow$ Implies a value of statistical life of around $ 5.5 million USD

Remaining Issues

- People who sort towards the health risk might have worse information

  $\Longrightarrow$ underestimate the true MWTP

- Spill over effects to control counties (controls also perceived as suffering increased risk)

  $\Longrightarrow$ underestimate the true MWTP

- Spill over effects to control counties (health risk in Churchill leads to higher demand in Lyon)

  $\Longrightarrow$ overestimate the true MWTP

Jayachandran (JHE, 2009)

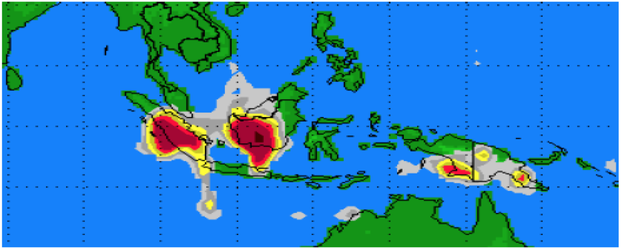
Research Question: What is the impact of air pollution on infant health?

- Does the impact differ by income?
- Does the impact differ by stage of pregnancy (pre-natal vs post-natal) ?

Jayachandran (JHE, 2009)

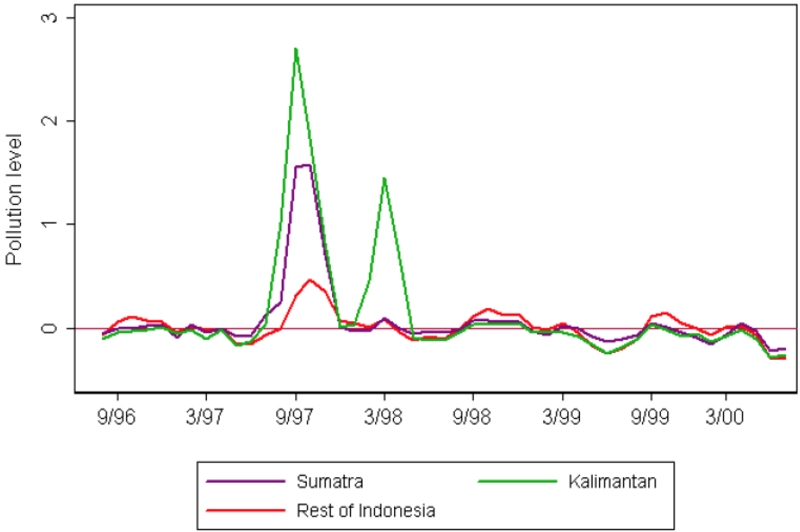
- Identification problem
  - Air pollution is endogenous to production, which will correlate with health outcomes
  - Air pollution is tough to measure, and usually changes gradually over time
- Empirical Strategy
  - Look at difference in cohort size based on geographical exposure to wild fires
  - measure smoke using satellite-based metrics of aerial optic depth

Example: Jayachandran (JHE, 2009)



November 4, 1997

Example: Jayachandran (JHE, 2009)



Data

- Pollution Data
  - Aerosol index from Earth Probe Total Ozone Mapping Spectrometer (TOMS)
  - Tracks airborne smoke and dust calculated from optical depth
  - Gridded product, 1 degree latitude by 1.25 degrees longitude grid
- Cohort size from 2000 Census
  - 3700 sub-districts
  - Individual-level information on date of birth
- Covariates like district-level income

Estimation

$$ln(cohortsize^{2000})_{jt} = \alpha_j + \alpha_t + \beta_1 Smoke_{jt} + \epsilon_{jt} \tag{3}$$

Main Effects

Dependent variable: Log cohort size

	Statistic used for smoke			
	Median	Median	Mean	% high-smoke days
	(1)	(2)	(3)	(4)
Smoke	-.0005		-.001	-.010
	(.006)		(.007)	(.020)
Prenatal Smoke ($Smoke_{t-1,2,3}$)	-.035 ***	-.032 ***	-.032 **	-.085 **
	(.012)	(.011)	(.013)	(.033)
Postnatal Smoke ($Smoke_{t+1,2,3}$)	-.014		-.016 *	-.042 *
	(.009)		(.010)	(.025)

Effects by Gender and Income

	By gender	By income (log consumption) of the district						
					<-------------------- one regression			--------------------->
					Top quartile	3rd quartile	2nd quartile	Bottom quart.
	(1)	(2)	(3)	(4)	(5)			
Smoke	-.008	-.060 ***	-.024	-.013	-.004	-.011	-.028	.002
	(.007)	(.021)	(.016)	(.017)	(.009)	(.010)	(.024)	(.045)
Prenatal Smoke	-.030 **	-.158 ***	-.129 ***	-.090 ***	-.058 ***	-.076 ***	-.094 **	-.121 **
	(.012)	(.037)	(.028)	(.015)	(.018)	(.017)	(.047)	(.061)
Postnatal Smoke	-.019 *	-.158 ***	-.047 *	-.035 **	-.025	-.040 ***	-.046	.009
	(.010)	(.027)	(.024)	(.019)	(.016)	(.014)	(.032)	(.052)
Male	.014 ***							
	(.003)							
Smoke * Male	.016 ***							
	(.005)							

Alternative hypotheses

Table 4
Alternative Hypotheses

Dependent variable: Log cohort size

	Control for predicted fertility	Excluding September 1997	SUSENAS and PODES subsample	Control for financial crisis	Excluding areas with fires	Control for fires	Control for rainfall
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Smoke	.001	.0001	.002	.002	.005	.004	.0001
	(.006)	(.009)	(.006)	(.006)	(.008)	(.006)	(.006)
Prenatal Smoke	-.035 ***	-.035 ***	-.032 ***	-.032 ***	-.035 ***	-.032 **	-.035 ***
	(.012)	(.013)	(.011)	(.011)	(.013)	(.014)	(.012)
Postnatal Smoke	-.014	-.013	-.012	-.012	.002	-.005	-.015
	(.009)	(.010)	(.009)	(.009)	(.011)	(.011)	(.009)
Ln(Predicted Births)	.875						
	(.696)						
Financial Crisis				-.049			
				(.038)			
Any Fires						-.004	
						(.010)	
Prenatal Any Fires						.007	
						(.017)	
Postnatal Any Fires						-.004	
						(.014)	
Intense Fires						-.028 *	
						(.016)	
Prenatal Intense Fires						-.017	
						(.025)	
Postnatal Intense Fires						-.021	
						(.029)	
Rainfall							-.004
							(.007)

Summary of Results

- Fires lead to a 1% reduction in cohort size, or 16,000 children
- Effects strongest for pre-natal exposure
- Effects strongest for poorer districts

Further Questions

- Are there any policies that can mitigate the effect?
- What are the long term effects on “treated” people? Income? Health?
- What are the long term equilibrium effects of reduced cohort size?

Currie et al (AER, 2015)

Research Question: What is the impact of toxic pollutants on infant health?

- While criteria pollutants are regulated, toxic pollutants are not. We need to know the magnitudes for policy.

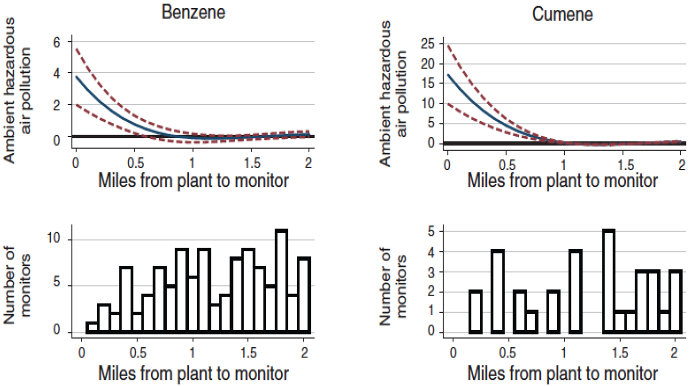
Currie et al (AER, 2015)

- Identification problem
  - Toxic pollutants come from manufacturing firms. But these firms generate benefits to wages
- Empirical Strategy
  - Look at changes in health outcomes before and after plants open for places very near vs slightly further away
  - This comparison holds wage effects constant

Data

- 1600 toxic plant locations with year of opening
- Hazardous Air Pollutant monitors from EPA
  - 1998 - 2005
  - 84 different pollutants
  - approx. 100 monitors
- Health Data
  - All births in 5 states between 1990 - 2002
  - Birth outcomes like low birth weight
  - Mothers residential address

Pollution Effects



Pollution Index

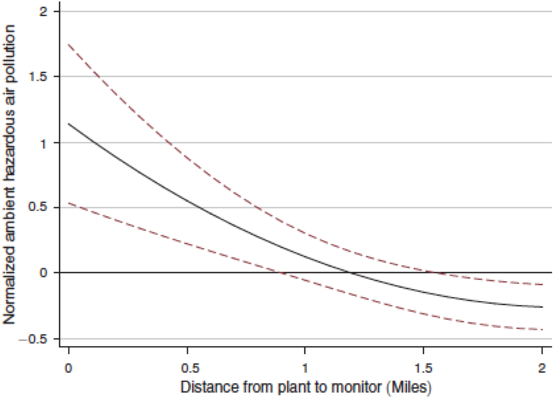


FIGURE 2. THE EFFECT OF TOXIC PLANTS ON AMBIENT HAZARDOUS AIR POLLUTION, ALL POLLUTANTS

Health Effects

TABLE 4—THE EFFECT OF TOXIC PLANTS ON LOW BIRTHWEIGHT

	0–0.5 Miles		0.5–1 Miles		0–1 Miles	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Estimated effect of plant operation						
1(Plant Operating) × Near	0.0010	0.0012	0.0014**	0.0015**	0.0013**	0.0014**
	(0.0010)	(0.0012)	(0.0006)	(0.0006)	(0.0006)	(0.0007)
Observations	88,958	88,958	88,958	88,958	88,958	88,958
Plant count	3,438	3,438	3,438	3,438	3,438	3,438
Panel B. Estimated effect of plant openings and closings						
1(Plant Opened) × Near	0.0025	0.0022	0.0024***	0.0027***	0.0024**	0.0024***
	(0.0019)	(0.0018)	(0.0009)	(0.0010)	(0.0009)	(0.0008)
1(Plant Closed) × Near	−0.0002	−0.0007	−0.0009	−0.0009	−0.0007	−0.0009
	(0.0016)	(0.0016)	(0.0009)	(0.0010)	(0.0009)	(0.0009)
H_0: Opening = −Closing (p-value)	0.44	0.56	0.32	0.28	0.22	0.24
Observations	88,958	88,958	88,958	88,958	88,958	88,958
Plant count	3,438	3,438	3,438	3,438	3,438	3,438
Plant × Distance-bin FE	X	X	X	X	X	X
State × Year FE	X		X		X	
Plant × Year FE		X		X		X

Summary of Results

- Opening a plant increase the average incidence of low birth weight by .24 - .37 percentage points, on a base rate of 7% , implies 3.3-5.1% increase in incidence
- Are these net of defensive measures?

Summary

- MWTP is like the inverse demand function for a conventional good
- Two ways to estimate it
  - Hedonic method: assumes valuation of amenities is capitalized in housing value
  - Accounting method: estimate impacts on individual channels (health)
- In both cases, endogeneity of amenities is a concern

References

- Currie, Janet, et al. "Environmental health risks and housing values: evidencefrom 1,600 toxic plant openings and closings." The American economicreview 105.2 (2015): 678-709.
- Davis, Lucas W. "The effect of health risk on housing values: Evidence from a cancer cluster." The American Economic Review 94.5 (2004): 1693-1704.
- Jayachandran, Seema. "Air quality and early-life mortality evidence from Indonesia's wildfires." Journal of Human resources 44.4 (2009): 916-954.