Housing Prices, Pollution, and Trends in the Value of a Statistical Life

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Summary

1. The Value of a Statistical Life (VSL)
2. Portney's Approach
3. Gregor's Study
4. Portney's VSL for Allegheny County
5. Smith & Huang's Meta-Study
6. iHAPSS MROD Data
7. VSL for Multiple Cities
8. Geographical variations in VSL
9. Conclusion

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Historical approaches and ranges of values

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Slightly more modern, multi-city MWTP

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Portney's Approach – MWTP Data

Unpublished 1972 Pennsylvania State University Ph. D. dissertation by Robert L. Spore

Gives

$$\frac{dV}{dQ}$$

where

V = home sale price
Q = level of pollution (dust or SO_2)

Portney infers dV/dQ of \$59* per *μg/m³* TSP

15% change in dustfall → 15% change in TSP → 18 *μg/m³* change in TSP

* 2007 dollars

Portney's Approach – MROD Data

EPA report by John Gregor (1977)

Gregor says there are three ways to get MROD data:

- Experiment
- Episodic studies
- Epidemiological studies

Are there increases in death due to pollution-related causes when the level of pollution increases?

Dependent Variables	Independent Variables
Cardio/respiratory deaths	Education (proxy for income, insurance)
Other deaths	Population density
Total deaths	Temperature
	Precipitation
	TSP
	SO_2

John Gregor, 1977, *Intra-Urban Mortality and Air Quality: An Economic Analysis of the Costs of Pollution Induced Mortality*, EPA-600/5-77-009

Gregor's Study

Data from 1968-1972
By race, sex and age group
9% non-White in Allegheny County

1970 Census	Population	% non-White
Pittsburgh	520,117	20.7%
Allegheny County - county overall - excluding Pittsburgh	1,605,016	 9.3% 3.8%

2000 Census	Population	% non-White
Pittsburgh	334,563	32.4%
Allegheny County - county overall - excluding Pittsburgh	1,281,666	 15.7% 9.8%

Gregor's Results

White Population Only	Sex	Deaths per 100,000 per μg/m³ per annum
Under 45	Male	0.500
	Female	0.349
45 – 64	Male	4.014
	Female	1.570
65 and over	Male	10.291
	Female	9.541

For a household consisting of a 40-year-old couple with one male child

$$MROD_{household} = \frac{0.500 + 0.349 + 0.500}{100{,}000} = 1.349 \times 10^{-5}$$

Portney's Results

Household MWTP is the annual cost of dV/dQ. Portney assumed a 10% interest rate, so

$$MWTP = \rho \frac{dV}{dQ} = 0.10 * \$59 = \$5.90$$

Thus, for a household consisting of a 40-year-old couple with one male child

$$VSL_{household} = \frac{MWTP}{MROD_{household}} = \frac{\$5.90}{1.349 \times 10^{-5}} = \$437\text{k}$$

Note that, for a household consisting of a single 40-year-old male

$$VSL_{male<45} = \frac{MWTP}{MROD_{male<45}} = \frac{\$5.90}{0.500 \times 10^{-5}} = \$1.18\text{M}$$

Gregor's Results Revisited

White Population Only	Sex	Deaths per 100,000 per μg/m³ per annum	% Population
Under 45	Male	0.500	31.66%
	Female	0.349	32.81%
45 – 64	Male	4.014	11.76%
	Female	1.570	13.06%
65 and over	Male	10.291	4.48%
	Female	9.541	6.22%

Weighted average = 2.000 deaths per 100,000 per μg/m³ per annum

$$VSL_{random} = \frac{\$5.90}{2.000 \times 10^{-5}} = \$295\text{k}$$

Smith-Huang Meta-Study

37 hedonic housing studies between 1964 and 1978 yielding dV/dQ. Developed an econometric model of dV/dQ with independent variables:

- TSP
- Income
- Vacancy
- # of neighborhood characteristics in hedonic model
- # of air pollution variables in hedonic model
- Actual price flag
- Linear model flag
- Semilog model flag
- Log-linear model flag
- OLS estimator flag
- Census 1960 vs. Census 1970
- Year
- Unpublished flag
- Inverse mills ratio

Meta-model: MWTP for Pittsburgh $124.50 per $\mu g/m^3$

iHAPPS MROD Data – Background

TSP and daily mortality in Philadelphia – Joel Schwartz & Douglas Dockery, 1992.

Health Effects Institute

PEEP (Particle Epidemiology Evaluation Project) – Jon Samet and Scott Zegler, 1994 - 1997. Philadelphia.

NMMAPS (National Morbidity, Mortality, and Air Pollution Study) – 1996 - 2000. 20, then 90 cities.

- co-pollutant correlation *(TSP, SO_2, O_3)*
- measurement error
- exposure error
- mortality displacement

Time-series issues

- TSP → PM10 *(14 cities)*

Joined by Schwartz, Dockery, and Francesca Dominici

iHAPPS MROD Data

NMMAPS grew into iHAPSS - the Internet-based Health and Air Pollution Surveillance System, which was funded by HEI and hosted at Johns Hopkins

Eventually included the 100 largest US cities.

Log-linear model of mortality as a function of DOW, time, temp over multiple time-scales, humidity over multiple time scales, age, with multiple time-scale smoothing.

For Pittsburgh:

$$MROD = 0.2189/100 \times \frac{746}{100{,}000} = 1.633 \times 10^{-7} \text{ per } \mu g/m^3 \text{ PM}_{10}$$
$$= 0.60 \times 1.633 \times 10^{-7} = 9.80 \times 10^{-8} \text{ per } \mu g/m^3 \text{ TSP}$$

Samet et al. 2000. *Fine Particulate Air Pollution and Mortality in 20 U.S. Cities.* NEJM, 343: 1742-1749.

Smith-Huang Meta-Study

18 studies over 9 metropolitan areas for which there are iHAPSS data:

Boston, Chicago, Kansas City, Los Angeles, Milwaukee, New York, San Francisco, St Louis, and Washington

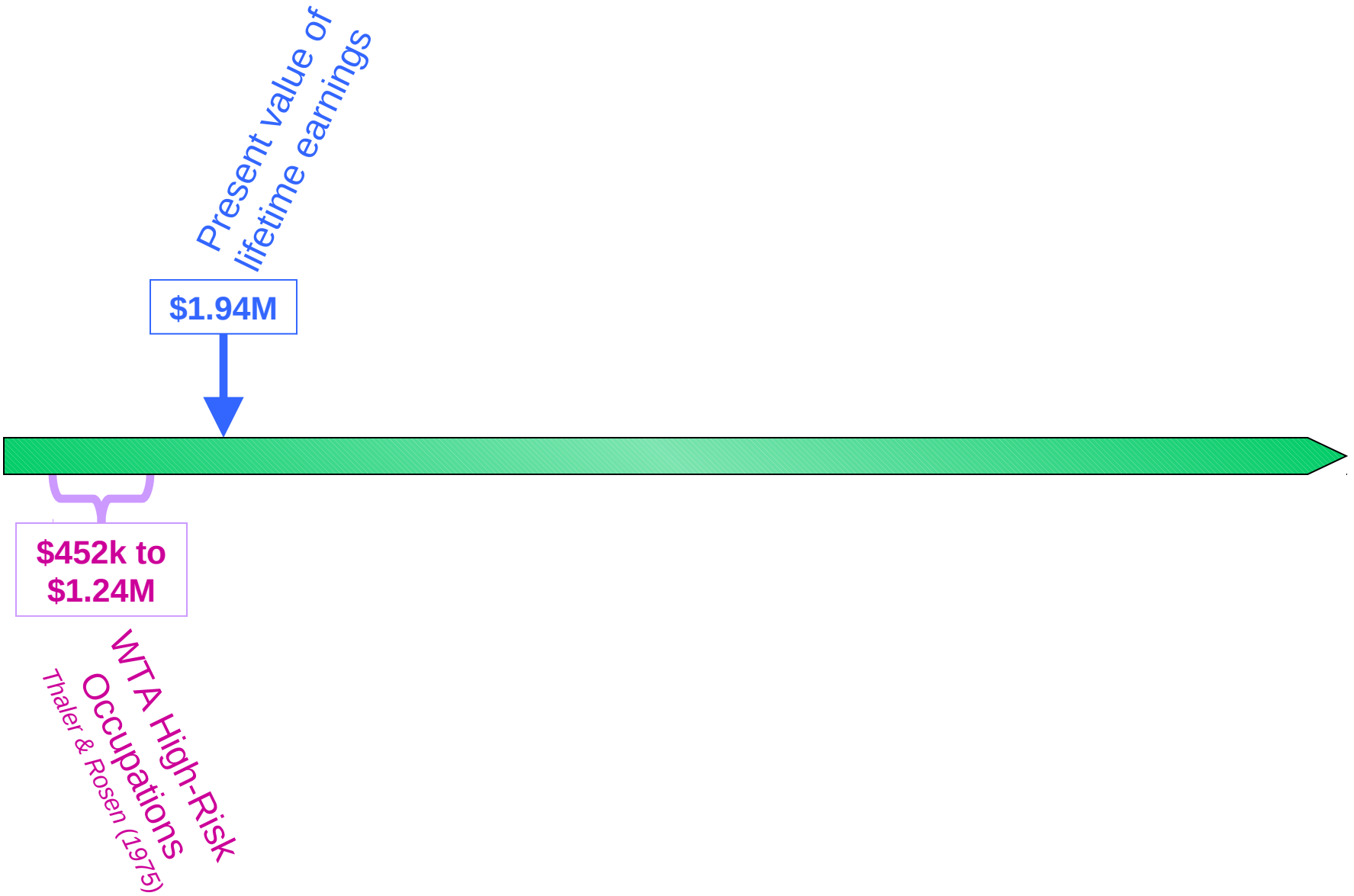
4 Composite studies

Brookshire et al (1979) Los Angeles and Orange counties
Palmquist (1982) Minneapolis, Houston, Dallas, San Francisco, Miami, Los Angeles, Portland, Chicago, Philadelphia, Atlanta, Anaheim, Washington, Cincinnati, San Bernardino, Indianapolis, St. Louis, Baltimore, Detroit, Denver, Tacoma
Palmquist (1983) Chicago, Los Angeles, Philadelphia, San Bernardino, Portland, Denver, Detroit, Dallas, Washington, Indianapolis
Palmquist (1984) Miami, Houston, Atlanta, Denver, Seattle, Louisville, Oklahoma City

The Value of a Statistical Life (VSL)

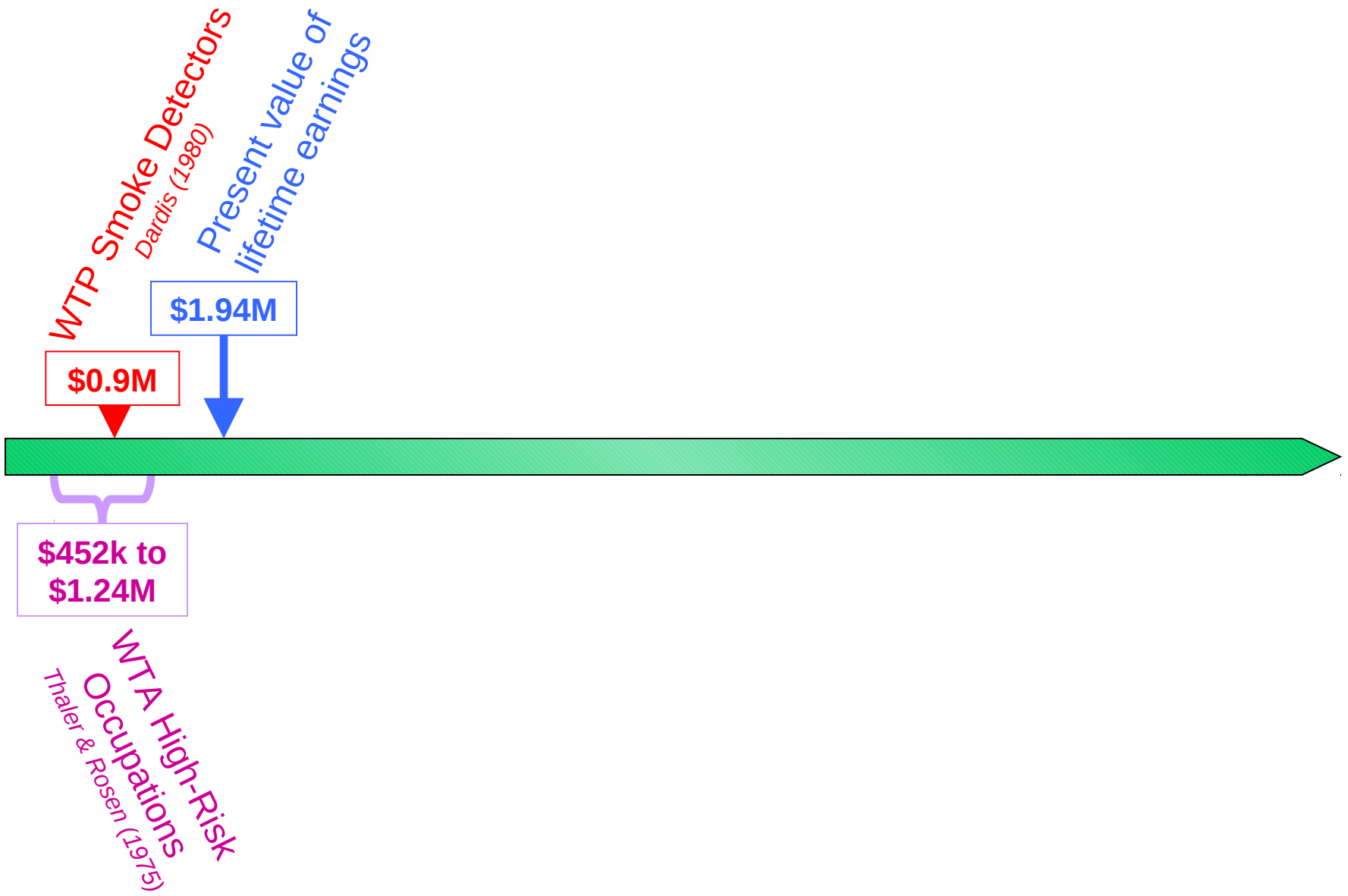
2007 dollars

The Value of a Statistical Life (VSL)



2007 dollars

The Value of a Statistical Life (VSL)



2007 dollars

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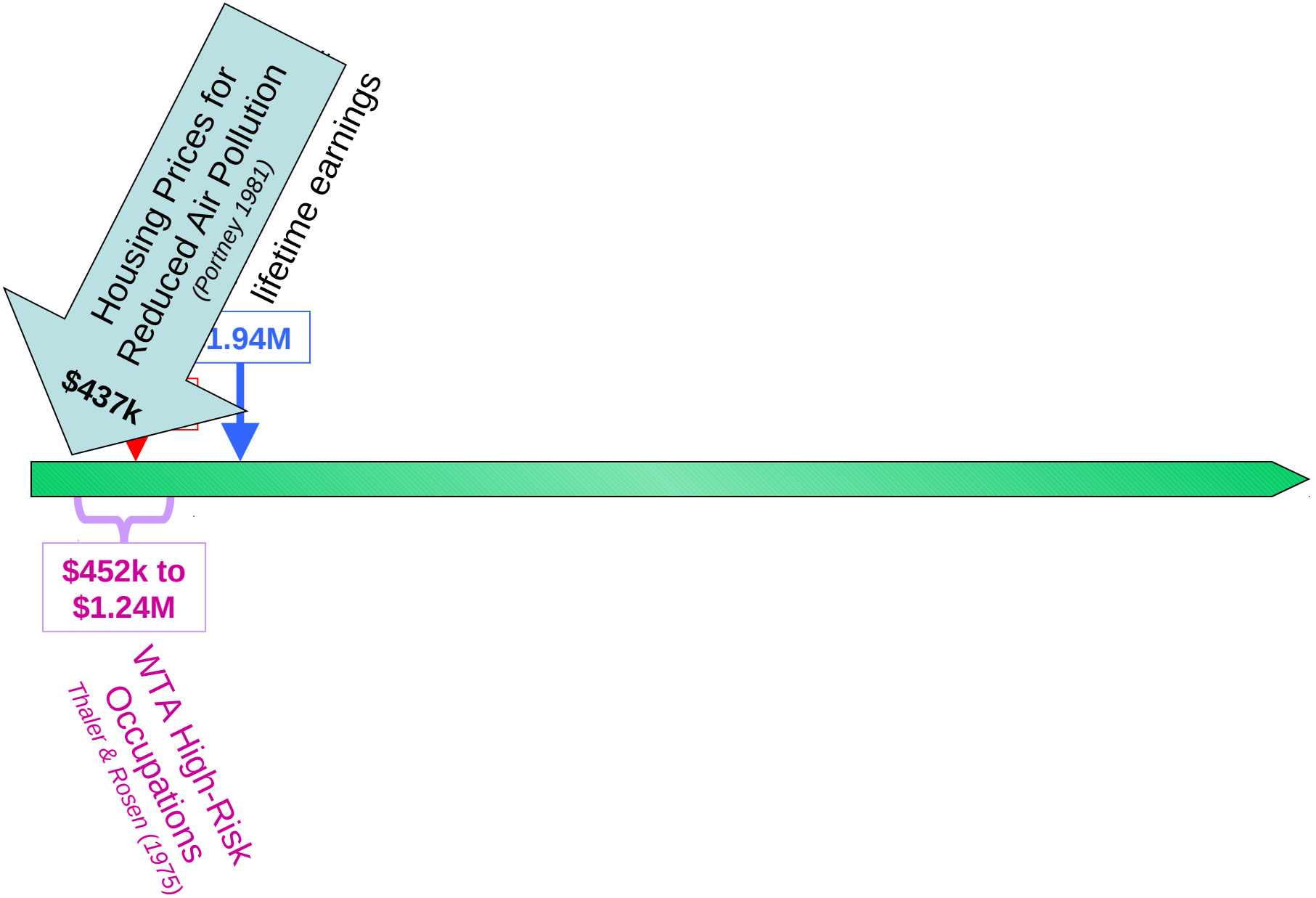

2007 dollars

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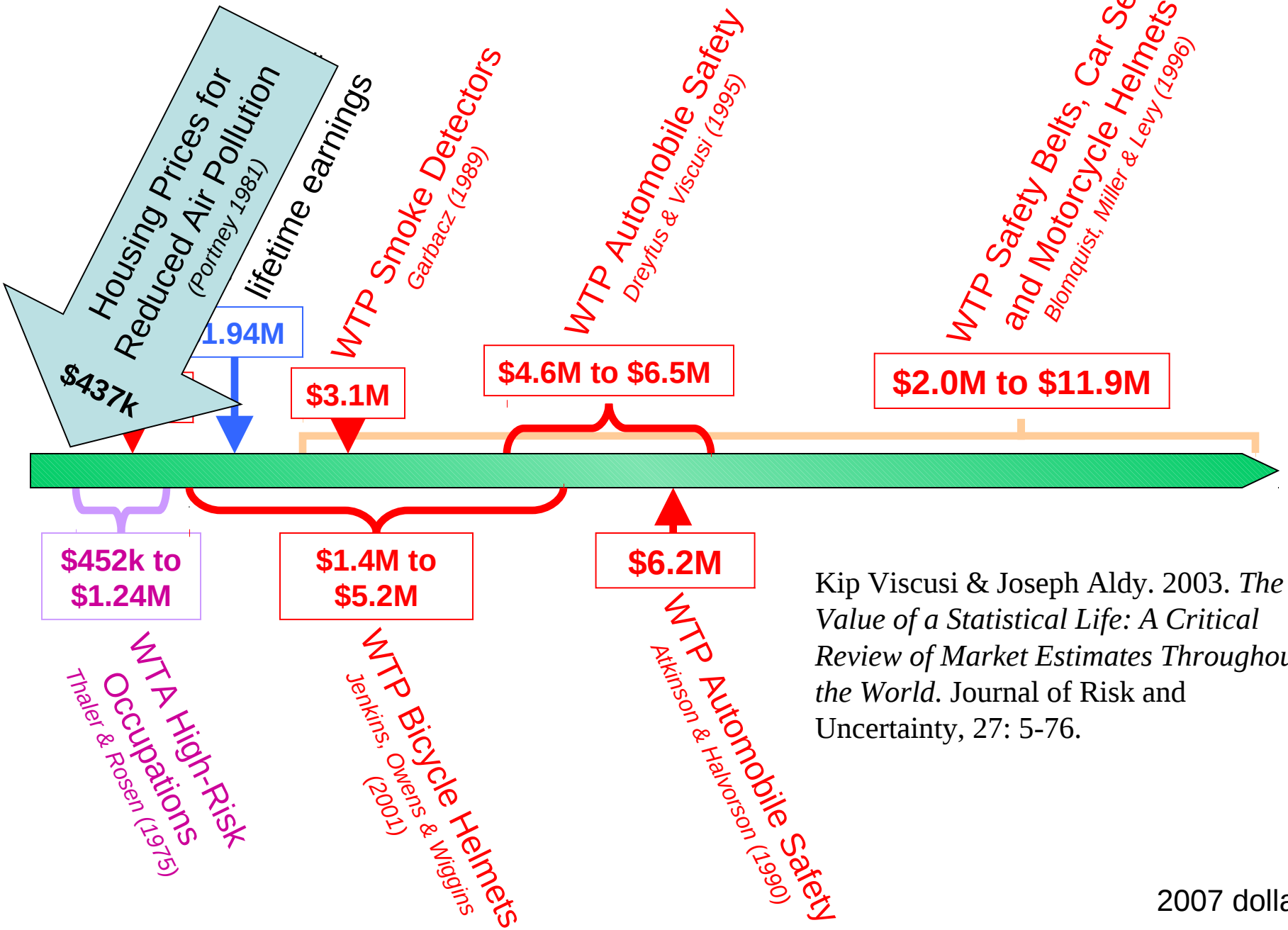


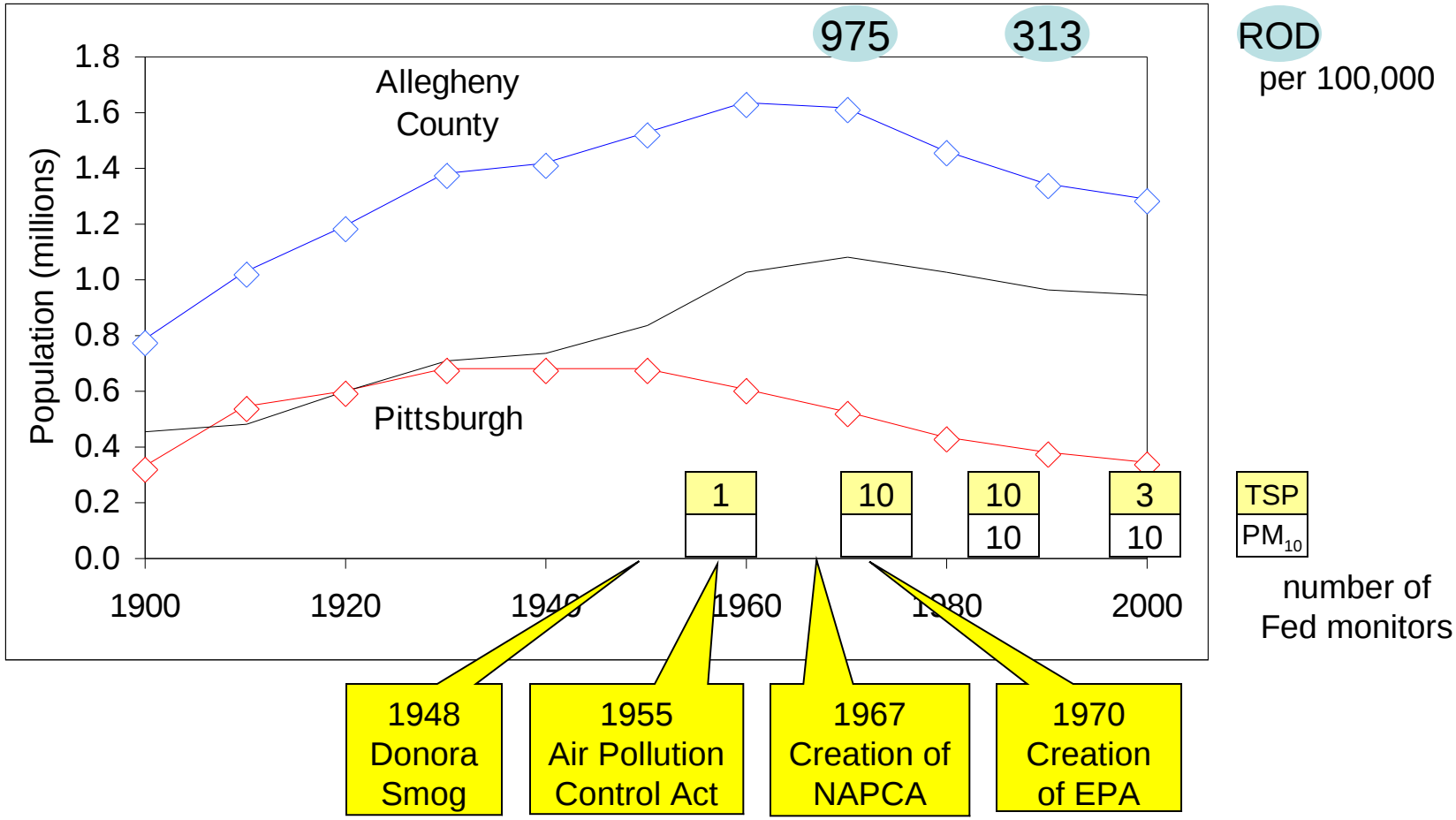
Kip Viscusi & Joseph Aldy. 2003. *The Value of a Statistical Life: A Critical Review of Market Estimates Throughout the World*. Journal of Risk and Uncertainty, 27: 5-76.

2007 dollars

Portney's Approach – Historical Context

1930 -1970 Flight to the suburbs

1970 -2008 Flight from the Rust Belt



Paul R. Portney, 1981, *Housing prices, health effect and valuing reductions in risk of death.* JEEM 8(72)

Portney's Approach

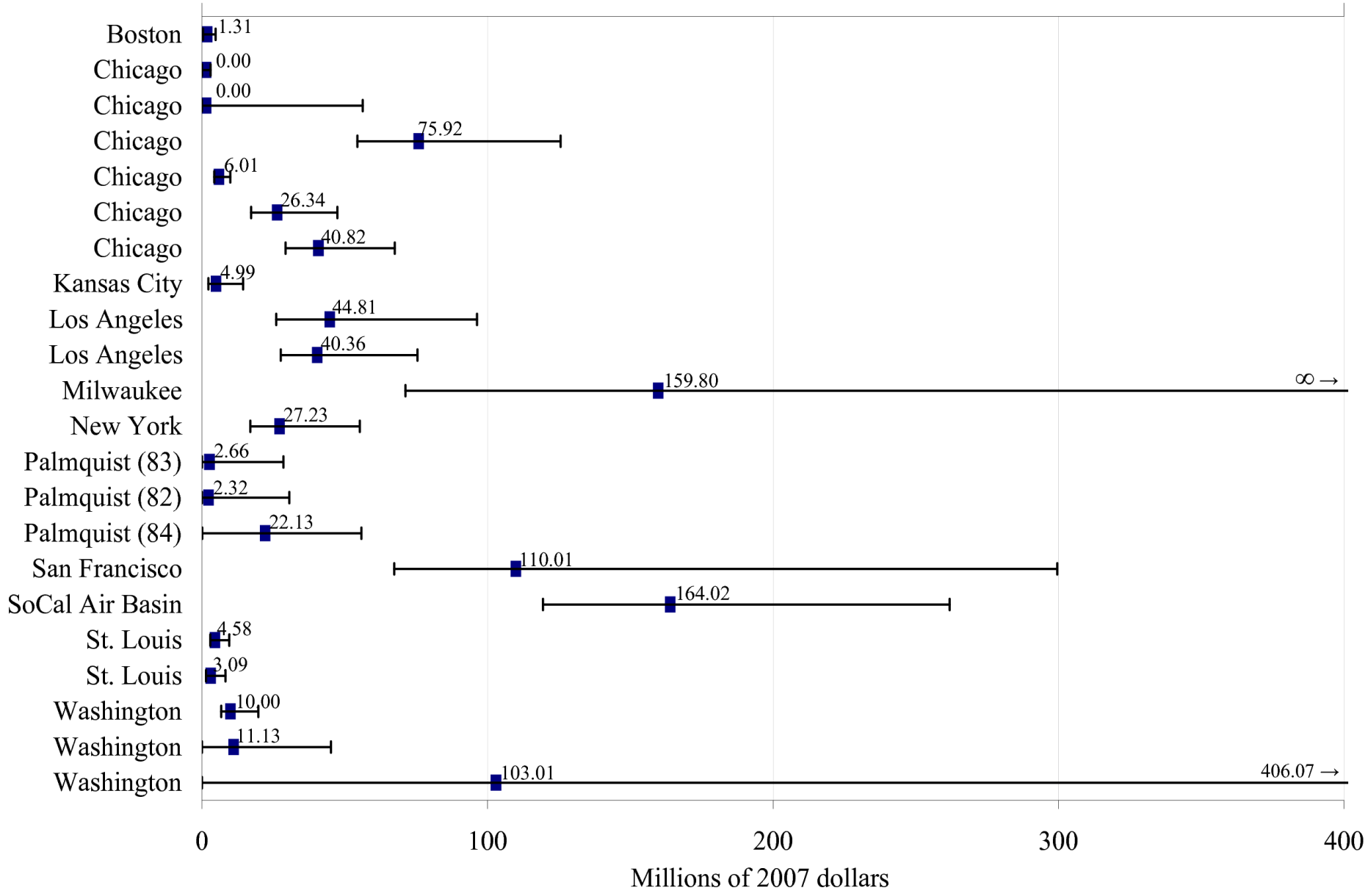
The marginal risk of death (MROD) is the increase in the risk of death resulting from a 1 $\mu g/m^3$ increase in total suspended particles (TSP).

Or, MROD is the **decrease** in the risk of death resulting from a 1 $\mu g/m^3$ **reduction** in TSP. Inverting this gives us the population for which one statistical life is saved.

The home purchase decision of a household reflects the WTP for reduced ROD for **all** members of household. That is, they want to decrease the probability that **any** member of the household die from air pollution.

$$\frac{1}{MROD_{household}} = \text{Number of households in which one statistical life is saved}$$

VSL for Multiple Cities



VSL for Multiple Cities – Econometric Models

Model 1

$$VSL = b_0 + b_1 (\text{median household income})$$

Model 2

$$VSL = b_0 + b_2 (\text{population})$$

Model 3

$$VSL = b_0 + b_3 (\text{risk of death})$$

Model 4

$$VSL = b + b_1 (\text{median household income}) + b_2 (\text{population}) + b_3 (\text{risk of death})$$

VSL for Multiple Cities – Zero Intercept Econometric Models

Model 5

$$VSL = b_1 (\text{median household income})$$

Model 6

$$VSL = b_2 (\text{population})$$

Model 7

$$VSL = b_3 (\text{risk of death})$$

Model 8

$$VSL = b_1 (\text{median household income}) + b_2 (\text{population}) + b_3 (\text{risk of death})$$

VSL for Multiple Cities – Results

Model	1	2	3	4
Constant std.err.	−69.247 80.731	44.458 13.653***	66.139 47.755	−80.379 182.500
Income ($millions) std.err.	2090.734 1549.279			2558.065 2298.650
Population (millions) std.err.		−0.756 1.050		−1.274 1.229
ROD (per 100,000) std.err.			−41.066 69.566	−5.018 112.008
R^2 adjusted R^2	0.084 0.038	0.025 −0.024	0.017 −0.032	0.147 0.005

Model	5	6	7	8
Income ($millions) std.err.	773.677 205.134***			1601.538 736.942**
Population (millions) std.err.		1.237 1.030		−1.462 1.128
ROD (per 100,000) std.err.			52.623 16.578***	−48.865 50.231
R^2 adjusted R^2	0.404 0.375	0.064 0.020	0.324 0.292	0.459 0.374

** 95 percent confidence
*** 99 percent confidence

VSL for Multiple Cities – Discussion

Whence the multiplier 774?

Mean Homeowner Income

Mean Income 31.2% higher than Median Income

Homeowner Income 11.7% higher than Median Income

} 46.6%

Value of Leisure

$1.66M present value lifetime earnings based on median income implying a VSL of $16M to $33M. (Keeler 2001)

Together

The range is $23M to $48 assuming homeowner mean income.
1990 U.S. metropolitan median income was $53,584 (2007 dollars)
Multiplier between 438 and 903.

Future Value

9.37% over 48 years

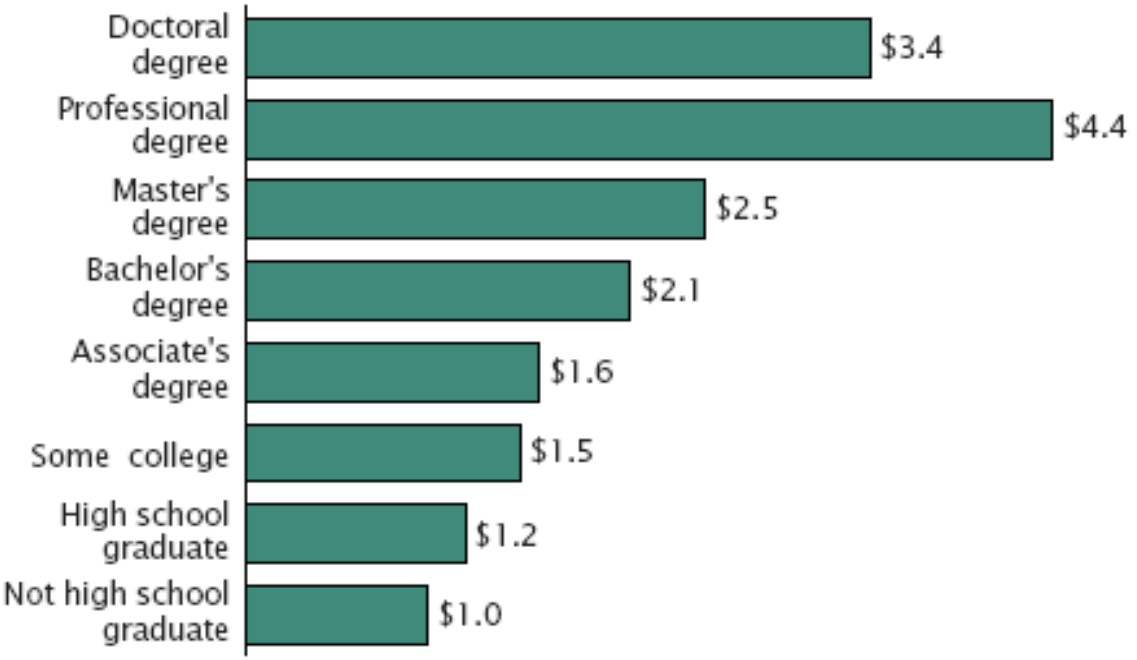
Appendices

Present Value of Lifetime Earnings

Figure 3.

Synthetic Work-Life Earnings Estimates for Full-Time, Year-Round Workers by Educational Attainment Based on 1997-1999 Work Experience

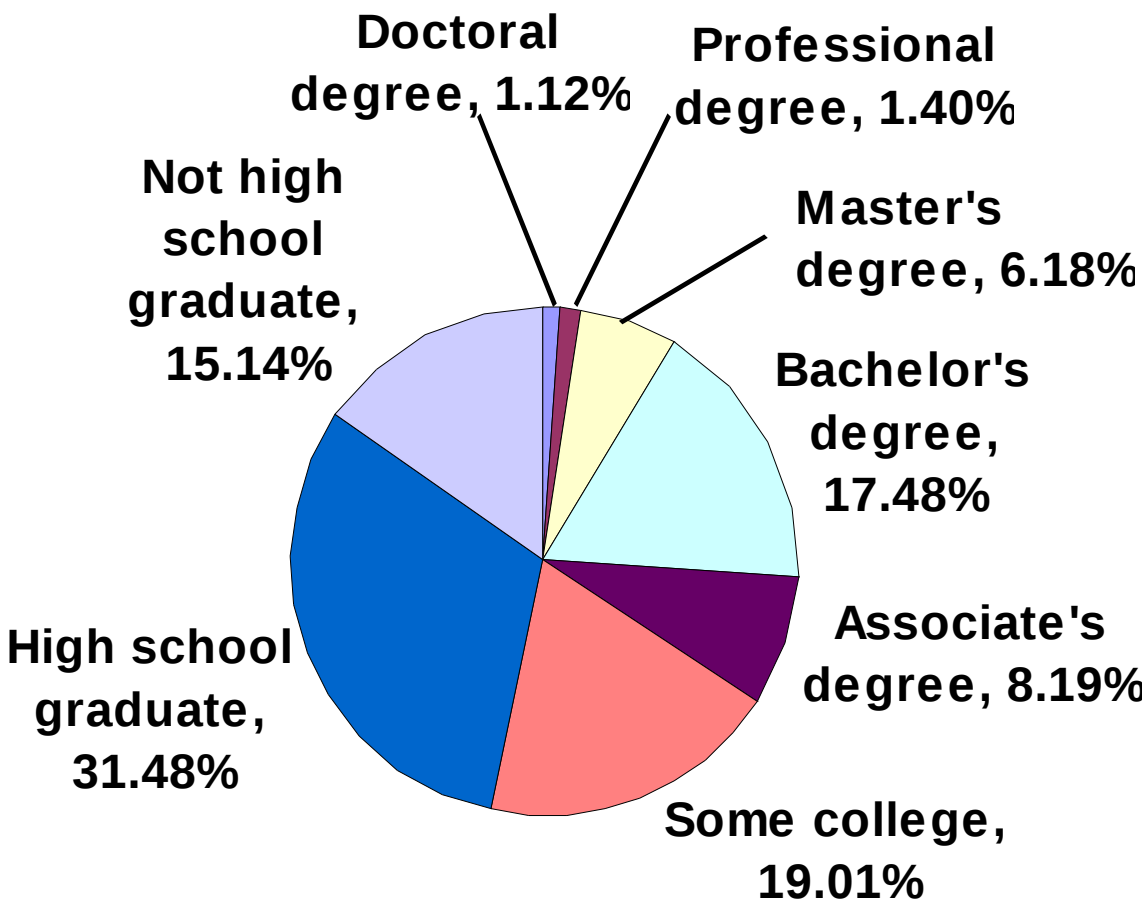
(In millions of 1999 dollars)



Source: U.S. Census Bureau, Current Population Surveys, March 1998, 1999, and 2000.

Census Bureau, *The Big Payoff: Educational Attainment and Synthetic Estimates of Work-Life Earnings*

Present Value of Lifetime Earnings (2)



2007 population by degree status

Present Value of Lifetime Earnings (3)

	1994 SWE ($M)	2007 ($M)	Population fraction	Contribution ($M 2007)
Doctoral degree	3.4	4.2	1.12%	0.05
Professional degree	4.4	5.5	1.40%	0.08
Master's degree	2.5	3.1	6.18%	0.19
Bachelor's degree	2.1	2.6	17.48%	0.45
Associate's degree	1.6	2.0	8.19%	0.16
Some college	1.5	1.9	19.01%	0.36
High school graduate	1.2	1.5	31.48%	0.47
Not high school graduate	1.0	1.2	15.14%	0.18
			Average SWE ($M 2007)	1.94

BLS inflator 1999-2007: 1.2446

SWE = synthetic work-life earnings

Portney's Approach – Household MROD

The probability of at least one member of the household dying is

$$ROD_{household} = 1 - \sum_{i}^{N} (1 - ROD_i) \qquad N = \text{number in household}$$

The marginal probability is

$$MROD_{household} = \sum_{j}^{N} MROD_j \sum_{i \neq j}^{N} \underbrace{(1 - ROD_i)}_{\approx 1}$$

So, for small N

$$MROD_{household} \approx \sum_{j}^{N} MROD_j$$

Portney's Approach – Calculating the VSL

The number of households for which one statistical life is saved with a 1 *μg/m³* reduction of TSP is

$$P_{households} = \frac{1}{MROD_{household}}$$

If these households have an average WTP for a 1 ug/m3 reduction in TSP, then their aggregate marginal willingness to pay (MWTP) is the value of the statistical life saved. That is

$$VSL = MWTP * P_{household}$$

Or

$$VSL = \frac{MWTP}{MROD_{household}}$$