

Air-pollution damage costs for motor vehicles: estimates, applications, and perspectives



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Overview

- Estimates of \$/kg damage costs of air pollutants (health, crops, visibility, materials, forests, climate change)
- Applications of damage-cost estimates: total environmental costs, total social costs, EVs vs. gasoline, cars vs. transit)
- Some ruminations on the implications of the analysis



Estimating urban-air pollutant costs

- Use standard multi-step damage model:
 Δ emissions \rightarrow Δ air quality \rightarrow Δ impacts \rightarrow Δ costs.
- Analyses done for all emission sources, all air quality monitoring data, and all population in the U. S., city by city.
- Use actual dose-response functions estimated in the original epidemiological literature.
- Economically correct valuation estimates (WTP for health effects; CS+PS losses for crops, hedonic price analyses for visibility).



External Cost References

- M. A. Delucchi, “Environmental Externalities of Motor-Vehicle Use in the U. S.,” *Journal of Transport Economics and Policy* **34**: 135-168, May (2000).
- J. J. Murphy and M. A. Delucchi, “A Review of the literature on the Social Cost of Motor-Vehicle Use in the United States,” *Journal of Transportation and Statistics* **1** (1): 15-42, January (1998).
- M. A. Delucchi, “The Social Cost of Motor-Vehicle Use,” *The Annals of the American Academy of Political and Social Science* **553**: 130-142 (1997).
- M. A. Delucchi “Should We Try to Get the Prices Right?,” Access, Number 16, University of California Transportation Center, Berkeley, pp. 14-21, Spring (2000).
- Social cost model documentation available at www.its.ucdavis.edu/people/faculty/delucchi/.

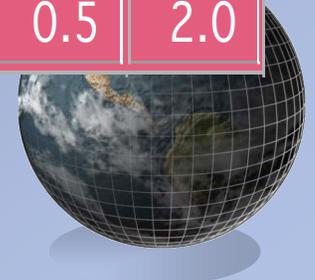


External cost of motor-vehicle emissions in urban areas of the U.S. (10% change in emissions) (1991 \$/kg)

	PM ₁₀		NO _x		SO _x		CO		VOCs, Q	
	<i>Low</i>	<i>High</i>	<i>Low</i>	<i>High</i>	<i>Low</i>	<i>High</i>	<i>Low</i>	<i>High</i>	<i>Low</i>	<i>High</i>
Health	13.7	187.5	1.6	23.3	9.6	90.9	0.0	0.1	0.2	1.6
Visibility	0.4	3.9	0.2	1.1	0.9	4.0	0.0	0.0	0.0	0.1
Crops	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.	0.0	0.0	0.2	0.3
Forests, material	n.e.	n.e.	n.e.	n.e.	n.e.	n.e.	0.0	0.0	0.2	0.3
Climate (US only)	0.00	2.1	0.00	0.01	0.0	-0.06	0.00	0.02	0.00	0.01
Climate (global)	0.05	15.0	0.00	0.04	-0.06	-0.40	0.01	0.12	0.00	0.06
Total MVs	14.6	206.4	1.8	24.5	10.5	94.5	0.0	0.2	0.5	2.3
MVs+U	13.1	176.7	1.7	23.2	4.7	36.2	0.0	0.2	0.5	2.0
MVs+U+RD	2.0	47.5	1.7	23.2	4.7	36.2	0.0	0.2	0.5	2.0

MVs = motor vehicles; U = upstream, RD = road dust.

*CO₂ at \$0.0 to \$1.40/Mg U. S. damages only, \$1.0 to \$10.0/Mg global damages



External cost of oil use in the U. S., 1991 \$/end-use gallon

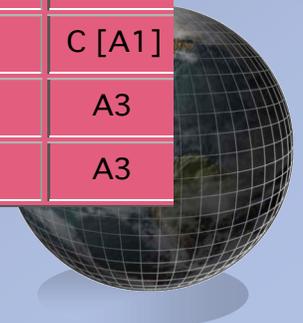
	Gasoline vehicles	Diesel vehicles	All vehicles
Strategic Petroleum Reserve - low	0.0004	0.0006	0.0005
Strategic Petroleum Reserve - high	0.0052	0.0064	0.0054
Defense costs - low	0.0045	0.0056	0.0047
Defense costs - high	0.0505	0.0623	0.0529
Pecuniary externality - low	0.0285	0.0350	0.0298
Pecuniary externality - high	0.0596	0.0730	0.0623
Price-shock cost to GNP - low	0.0189	0.0231	0.0198
Price-shock cost to GNP - high	0.1889	0.2314	0.1976
Water pollution - low	0.0023	0.0026	0.0023
Water pollution - high	0.0076	0.0084	0.0078
<i>All costs - low</i>	<i>0.055</i>	<i>0.067</i>	<i>0.057</i>
<i>All costs - high</i>	<i>0.312</i>	<i>0.382</i>	<i>0.326</i>



Externalities of motor-vehicle use in the U. S. (10^9 1991 \$)

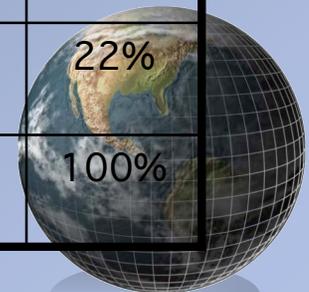
Cost item	Low	High	Q
Accidental pain, suffering, and death	30	120	A3, D
Travel delay, imposed by other drivers that displaces unpaid activities	35	140	A2
Air pollution: human health impacts due to particulate emissions from veh	17	266	A1
Air pollution: human health impacts due to all other pollutants from vehicl	2.3	17	A1
Air pollution: human health impacts due to all pollutants from upstream	2.3	13	A1
Air pollution: human health impacts due to road dust	3.0	154	A1
Air pollution: loss of visibility, due to all pollutants attributable to motor v	5.1	37	A1
Air pollution: damage to agricultural crops due to ozone from motor vehi	2.1	3.9	A1
Air pollution: damages to materials, due to all pollutants from motor vehic	0.4	8.0	B [A1]
Air pollution: damage to forests, due to all pollutants from motor vehicles	0.2	2.0	B [A2]
Climate change due to fuel-cycle emissions of GHGs (U. S. /global damage)	0.0 /2.4	3.5 /25.2	A1, B
Noise from motor vehicles	0.5	15	A1
Water pollution: oils spills, fuel leaks, urban runoff, road de-icing	2.8	7.3	C,D
Expected loss of GNP due to sudden changes in the price of oil	1.6	25	C [A1]
Pecuniary cost increased payments to foreign countries for non-transport	4.0	8.4	A3
Strategic Petroleum Reserve, military expenditures related to oil use	0.7	8.0	A3

Estimates for entire in-use highway fleet in 1990



Environmental costs in perspective: total social cost of motor-vehicle use in the U. S. (1990)

	Low	High	Low	High
(1) Personal nonmonetary costs of motor-vehicle use	\$527	\$968	32%	29%
(2) Motor-vehicle goods and services produced and priced in the private sector (estimated net of producer surplus, taxes, fees)	\$829	\$982	50%	30%
(3) Motor-vehicle goods and services bundled in the private sector	\$76	\$279	5%	8%
(4) Motor-vehicle infrastructure and services provided by the public sector	\$131	\$247	8%	8%
(5) Monetary externalities of motor-vehicle use	\$44	\$98	3%	3%
(6) Non-monetary externalities of motor-vehicle use	\$66	\$717	4%	22%
Grand total social cost of highway transportation	\$1,673	\$3,291	100%	100%



External costs of EVs versus gasoline vehicles (cents/mile)

	Battery EVs			Gasoline ICEVs		
	<i>low</i>	<i>high</i>	<i>best</i>	<i>low</i>	<i>high</i>	<i>best</i>
Noise	0.00	1.20	0.04	0.00	1.60	0.05
Externalities of oil use	0.02	0.12	0.04	0.22	1.25	0.40
Climate change	0.00	0.08	0.03	0.00	0.10	0.04
Air pollution	0.02	0.21	0.07	0.19	2.32	0.75
TOTAL	0.05	1.62	0.18	0.40	5.27	1.24

Uses external cost factors presented previously.
 Gasoline vehicle ca. year 2005 US, at 25 mpg
 CO2 damages US only; global about 10 x higher.



Social cost of EVs vs. gasoline vehicles (cents/mi)

	EV cost minus gasoline cost		
	<i>low</i>	<i>high</i>	<i>best</i>
Private lifecycle costs	0.0	30.00	10.00
Noise	0.00	-0.40	-0.01
Externalities of oil use	-0.20	-1.12	-0.36
Climate change	-0.00	-0.02	-0.01
Air pollution	-0.17	-2.11	-0.69
Total externalities	-0.37	-3.69	-1.09
Social cost	-4	30	9

External costs from previous slide



Difference between efficient prices and actual prices for different passenger transport modes (U. S. ca 1990)

(cents per vehicle mile, except last row is cents per passenger mile)

[Numbers in brackets are my best estimates]

<u>Cost item</u>	<u>Gas auto</u>	<u>Electric au</u>	<u>Transit bu</u>	<u>Light rail</u>	<u>Heavy rail</u>
Air pollution	[2.0] 0.8 to 1	1.5	[20.0] 5.4 to 1	5?	5?
Oil use, water pollution	[0.8] 0.3 to 1	0.4	[4.0] 1.5 to 8	1?	1?
Noise	[0.2] 0.01 to 1	0.15	[2.0] 0.5 to 10	1?	1?
Congestion	[4.0] 0 to 100	[4.0] 0 to 100	[8.0] 0 to 100	n.e.	n.e.
Accidents	2.5	2.5	3.5	2?	2?
Marginal highway and service costs	0.1	0.1	1.5	0	0
Unpriced parking	[1?] 0 to 8	[1?] 0 to 8	0	0	0
Inefficient highway user taxes and fees, meant to cover highway cost	-2.7	0	0 (exempt from fuel taxes)	0	0
Government subsidy: operating costs minus fares, operating+rolling-stock costs minus fares, total operating+capital costs minus fare	0	0	339, 398, 46	685, 1137, 28	372, 797, 11
Extra private costs relative to gas	0	0 to 16 [8]	see subsidy	see subsidy	see subsidy
Total cents per vehicle-mile	[8] 5 to 20	[18] 9 to 16	359 to 620	694 to 2,800	381 to 1,100
Passengers per vehicle	assume 1.0	assume 1.0	11 (average)	26 (average)	22 (average)
Total cents per passenger	[8] 5 to 20	[18] 9 to 16	33 to 57	27 to 108	17 to 53

Total ranges do not reflect congestion cost range



Conclusions (external costs)

- Accident, congestion, air pollution, and oil-use externalities each amount to many tens of billions of dollars per year
- Environmental external costs are dominated by the health costs of particulate air pollution
- In the comparison of the social cost of transportation alternatives, differences in external cost are not trivial, but often are small compared with differences in private costs or in financial subsidies



Three different perspectives

- Conservative economic view: C/B analysis tell us that climate change is unimportant relative to other costs and benefits of transportation, so costly efforts to reduce GHGs probably will not be worthwhile.
- Modeler's view: need more and better models before drawing conclusions.
- Catholic view: we care about climate change and oil-use as citizens and inhabitants of the planet, not as consumers, so monetization and hence cost-benefit comparisons are irrelevant.

