TAXING FUEL EMISSIONS:

Partial Alternative for Transportation Funding?

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How much does it really cost to drive your car? This article argues that the cost is far greater than what individual drivers are currently paying and propose an "emissions tax" to bring costs in alignment with reality, and simultaneously provide much-needed revenue to the states.

Summary

Though considerably lower than costs associated with congestion and traffic accidents, the costs associated with vehicle emissions are very large. A growing body of research confirms that exposure to several pollutants produced by cars and trucks is associated with negative health effects, including increases in premature mortality. These health effects also carry a cost — doctors' bills and insurance costs. Recent estimates of these costs are as high as $0.016 per mile of automobile travel in dense urban environments, and as high as $0.34 per mile for certain diesel trucks. The costs associated with vehicle emissions, however, are not borne by drivers.

There are no existing mechanisms to charge drivers for the costs of vehicle emissions. The social costs attributable to road travel are greater than its private costs borne by drivers. According to standard economic theory, the price of driving should be equal to the marginal cost of driving, including pollution costs. The failure to charge for the cost of emissions results in excessive vehicular pollution—either through too much travel or because consumers purchase cars that pollute too much.

Because the amount of emissions generated is not fully justified by the private benefits attributable to the transportation that caused it, the result is what economists call a "deadweight loss" for the overall economy. The deadweight loss is the loss to consumers resulting from the misallocation of resources associated with failure to charge for the cost of vehicular pollution. The deadweight loss associated with failing to price vehicle emissions in Pennsylvania could be over $70 million, while the total amount of health costs attributable to emissions is estimated to total over $1.8 billion statewide.

The standard solution in these situations is to align the private cost as close to the true social cost, in so doing encouraging vehicle emissions reductions, whether through reductions of vehicle miles driven or through changes in vehicles to less polluting models. Besides reducing the social costs associated with "unpriced" emissions, an emissions tax could also provide another significant benefit: A new, relatively stable source of funding for public transportation.

Charging users an emissions tax that reflects the health costs imposed on all Pennsylvanians would generate $1.7 billion – close to current State revenues derived from gas taxes. In this way, a potential virtuous cycle could be engendered, whereby emissions tax revenues are used to increase transportation alternatives whose pollution impacts are lower. Further, the transportation alternatives would be provided in primarily urban areas served by transit, precisely the areas where emissions costs are most significant.

1. Current Findings on External Costs of Emissions

There is a growing body of research aiming to discern the costs of vehicle emissions and their component pollutants. The research draws on several disciplines in order to make these estimates, including public health, engineering and economics. There are several challenges in determining the costs of pollution attributable to vehicles: First, one needs to assess the exposure by individuals to the various pollutants, which can vary by location (including topography and wind levels), season and activities undertaken by the individuals.

Beyond defining exposure, the next step is to estimate the link between this exposure and health effects, principally premature mortality. There have been a large number of such studies, where health is in part linked to past exposure to pollutants. Vehicle-generated pollutants for which exposure is found to be associated with health impacts include airborne particulate matter, nitrogen oxides, sulphur oxides and carbon monoxide. Carbon dioxide and other "greenhouse gases" are of increasing concern for their apparent link to global warming, but their health impacts at this point are not firmly established and not included in this discussion.

Given a link to pollutants and health impacts, a final step involves the valuation of these impacts. As monetary values of health benefits or costs are routinely needed for evaluating infrastructure, medical and other investments, economists have developed estimates of these values. Briefly, "willingness-to-pay" (WTP) estimates of health benefits or costs are based on observed behavior of individuals, in particular the amount of money expended to reduce the risk of mortality, illness or other outcomes. This observed behavior is the basis of estimates of costs attributable to a traffic fatality, for example.

Another necessary step involves assessing the emissions characteristics of an existing fleet of cars. This is necessary to determine what proportion of the health effects observed is actually due to vehicle movements. This is a challenging aspect of the analysis, as one must estimate average emissions characteristics for a fleet of differing age and maintenance characteristics.

A recent study by Small and Kazimi reviewed a large body of research literature to obtain estimates of emissions-related health costs in the Los Angeles region. Their careful analysis estimates that health impacts per vehicle-mile driven varied between 4.3 cents for cars to 68 cents for heavy trucks for the fleet of vehicles on the road in 1992. Accounting for more stringent pollution standards for cars as well as improved exhaust controls, they further estimated health costs attributable to the vehicle fleet expected to prevail in the year 2000, which were calculated to be significantly lower.

Table 1: Estimates of Emissions-Related Health Costs in the Los Angeles Region

Vehicle Type	1992 Vehicle Fleet	2000 Vehicle Fleet
Automobile	4.3	2.1
Light Truck	10.1	6.0
Heavy Truck	68.3	45.0

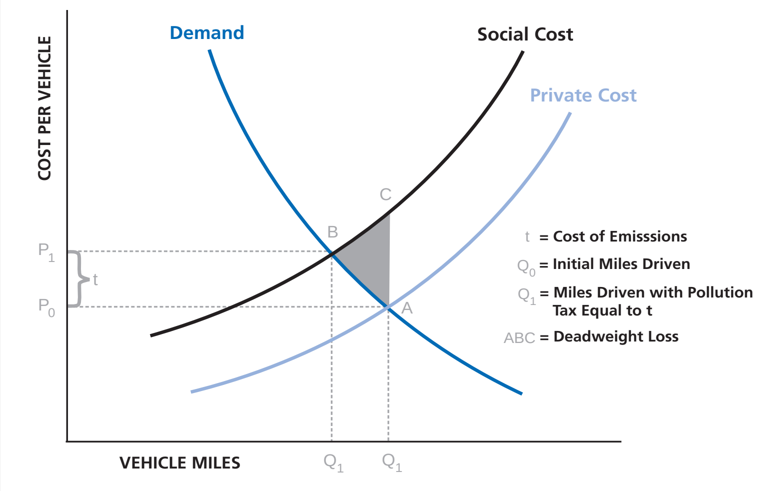
Source: Small and Kazimi (1995)
Note: All costs are in 2003 prices

Underlying these estimates are several layers of analysis, including calculations of exposure levels to pollutants of residents in the Los Angeles area, the link of the pollutants to observed health outcomes, and the probable contribution of vehicles to ambient levels of pollutants. Further, monetary values attached to these health outcomes were also incorporated, principally an estimate of the cost of mortality. In the figures above, the authors surveyed existing WTP studies and concluded that a "value of life" of $6.3 million (in 2003 prices) was appropriate. While a comprehensive review of this literature is not included here, it suffices to say that the values in Table 1 are not dissimilar to those reported in various other comprehensive analyses of emissions-related health costs.

There are several issues to note in terms of assessing emissions costs. First, different locations will have widely different levels of ambient pollution strictly due to the local topography, wind conditions and other factors such as the density of the population. Dense urban environments, with greater concentrations of emissions pollutants, result in higher levels of exposure and health impacts. Second, there are significant variations in estimated health impacts. This imprecision is typically attributed to the difficulties inherent in defining the exposure levels that are associated with ambient pollution. Finally, as noted previously, linking ambient pollution to vehicle emissions is itself based on estimates subject to some variability.

As indicated in Table 1, the trend in emissions-related health impacts has been a positive one. While this is partly due to the exclusion of greenhouse gas impacts in the analysis, and these have increased with the increase in the average size of passenger vehicles, it also reflects improved controls on vehicle emissions. While this is clearly a positive outcome, it also implies that future emissions tax revenues could well decline over time.

Figure 1: Unpriced Emissions and Deadweight Loss in Transportation



2. The Economic Argument for Taxing Emissions

Having established evidence of emissions-related costs, we now discuss why it is a good idea to try and tax these costs. In general, when a good or service's private cost diverges from the social cost of the good or service, the consumption of the good is said to produce an externality. In the case of transportation, for example, the private costs facing a car driver as he or she prepares to commute to work would include their travel time and out-of-pocket expenses, such as gasoline, tolls and vehicle wear and tear. However, the social cost facing society would include other factors, notably the health costs of the emissions attributable to that commute.

If the externality is not priced, then the good or service (in this case driving) is "too cheap," and the amount consumed does not reflect its true social cost. The situation is illustrated in Figure 1, where the private cost of driving for each vehicle increases with total miles driven, reflecting increasing congestion. The private cost lies below the social cost, with the difference in the two cost curves reflecting a constant emissions cost such as the ones described in Table 1. Initially, the equilibrium between the demand for driving and the private costs of driving (on a per-vehicle basis) is at point A, where total miles driven are equal to Q_0. At this point, there is "too much" driving taking place for the level of costs imposed on society. Rather, an optimal level of driving is defined by point B and vehicle miles Q_1, where social costs equal social benefits (as defined by the demand curve).

The dark triangle defined by the points ABC is commonly known as the deadweight loss of having too much driving take place. The goal of social policy would arguably be to align private costs to social costs, thereby reducing driving to Q_1 and eliminating the deadweight loss to society. In instances where the magnitude of the externality can be estimated, economic theory suggests that a tax equal to the externality should be imposed on top of the private costs. As indicated in Figure 1, the imposition of a tax equal to *t* would lead to a reduction in driving to Q_0, thereby eliminating the deadweight loss and internalizing the externality.

What might be the magnitude of this deadweight loss from vehicle emissions? As implied from Figure 1, an estimate of the deadweight loss would require estimates of the actual emissions costs, as well as an estimate of the amount of vehicle miles between Q_0 and Q_1. In order to generate such an estimate, we use the emissions cost on a per-mile basis contained in Table 1, though reduced by 30 percent to reflect lower ambient pollution levels found in urban areas of Pennsylvania relative to Los Angeles (as reflected in the differences in the Environmental Protection Agency's Air Quality Index for Los Angeles and Philadelphia).

Our estimate of the total deadweight loss in Pennsylvania focuses exclusively on emissions generated in urban areas. In the year 2000, total urban vehicle-miles in Pennsylvania were estimated to reach over 66 billion miles, of which 57 billion are attributable to passenger cars, 2.5 billion to heavy trucks and 5 billion to light trucks. A key to estimating the deadweight loss is to assess the reduction in driving that would have occurred if the costs of emissions had been borne by road users. In order to estimate the magnitude of this excess driving, we rely on estimates of price elasticities by vehicle type. The definition of elasticity used for cars refers to ratio of the percentage change in gasoline consumption for car drivers to the percentage change in gasoline prices, while for trucks it refers to the percentage change in freight shipped to the percentage change in shipping costs. In particular, we use an elasticity measure of –0.33 for cars, and for trucks, we use an elasticity of –1.0, measured as shipments to truck running costs. Both measures are reasonable and reflect findings in numerous similar studies.

Using these measures, we estimate that the total excess driving in urban areas on an annual basis is 4.3 billion vehicle miles, with the great majority of this total accounted for by excess miles driven by cars. Using the estimates of emissions costs by vehicle, we calculate a total annual deadweight loss in Pennsylvania of over $71 million a year, as indicated in Table 2. While cars account for the great majority of excess vehicle miles, the far more significant emissions costs engendered by heavy trucks makes them the greater contributor to deadweight loss in our estimates.

Charging a tax to vehicles that reflects the external cost of their emissions would lead to a reduction in driving to a level that reflects the social costs imposed. Based on the values assumed here for the social costs of emissions in urban areas, the equivalent tax imposed on the mile driven on urban roadways would be as indicated in Table 3. Also included is the ensuing percentage reduction in miles driven, by vehicle type. As shown, urban vehicle miles could be reduced by over 6 percent with the introduction of an emissions tax. The large reduction for heavy trucks reflects a higher tax, in line with the emissions costs attributable to that class of vehicle.

3. The Potential Transportation Funding Benefit from Taxing Emissions

There are various options to try and align private costs to social costs of driving, but so far we have assumed an ideal taxation mechanism that reflects not only vehicle miles driven but also vehicle miles driven in urban areas where social costs are significant. Putting aside the issue of the feasibility of such a tax, it is of interest to consider the potential revenues that such a tax would entail. These revenues would be significant, as the tax would be imposed on all vehicle miles driven in urban areas. In Figure 1, this would entail imposing the tax on vehicles that would cause vehicle miles to decline to Q_1. The total tax revenue would then be equal to Q_1 multiplied by the tax (differentiated by vehicle type).

According to our previous estimates, this revenue source could generate upwards of $1.7 billion a year for Pennsylvania, an amount similar in magnitude to current gas tax receipts in the State.

4. The Challenges of Taxing Emissions

While the economic argument for having users shoulder the costs they impose on society is convincing, is the implementation of such a tax for emissions feasible? An ideal tax would internalize the external costs of emissions by having the private cost of transportation reflect its wider social cost. Since this cost is attributable to driving itself, rather than the owning of a vehicle per se, an effective tax would be one levied on vehicle miles driven.

However, as noted emissions costs are particularly significant for miles driven on urban roads, where density of pollutants and population increase the exposure attributable to each vehicle mile driven. But as miles driven on urban roadways account for only 60 percent of total miles driven, levying a tax on all miles driven, regardless of location, may be somewhat ineffective. If the goal of an emissions tax

Table 2: Estimates of Deadweight Loss in Pennsylvania ($ Millions)

Vehicle Type	Total Deadweight Loss
Automobile	26.3
Light Truck	5.6
Heavy Truck	39.4
Total	**71.3**

Source: Greater Philadelphia Transportation Initiative (2003)

Table 3: Emission Tax Levels by Vehicle and Reductions in Vehicle Miles

Vehicle Type	Emission Tax (Cents per mile)	Percent Reductions in Vehicle Miles
Automobile	1.4	6.4%
Light Truck	4.2	5.6%
Heavy Truck	31.2	10.0%
Average	**2.5**	**6.5%**

Source: Greater Philadelphia Transportation Initiative (2003)
Note: The average is weighted to reflect the relative importance of different vehicle type

is to align social costs to private costs of driving, and in so doing reduce socially inefficient underpriced driving, a tax applied regardless of where vehicle miles takes place would be an imprecise tool. This point has similarities to the policy issues raised in pricing congestion on roadways, where pricing (such as existing congestion pricing initiatives in Singapore, Norway, France, California, London and New York City) is at least partly concerned with aligning social and private costs on congested facilities. Further, charging an emissions tax may be particularly challenging to tax correctly. While emissions costs are variable by location, they are also variable by vehicle.

Currently, forms of emissions taxation are used in the EU, as well as Japan. In the EU, for example, most member countries levy a registration tax or annual circulation tax that varies in part with the emission characteristics of the vehicle. For new cars, actual emission rates are used (principally carbon dioxide) as the main basis for determining the tax rate. For existing cars for which emissions data may not readily available, engine size is used instead as a proxy for fuel efficiency and carbon dioxide emission rates.

An immediate advantage of imposing higher registration fees for vehicles is to create an incentive for consumers to switch to less polluting models, as well as to encourage manufacturers themselves to improve emissions standards. Unfortunately, it does nothing to influence the cost of vehicle miles

Table 4: Estimates of Emissions Tax Revenues

Vehicle Type	Total Urban Vehicle Miles (Millions)	Revenues ($ Millions)
Automobile	55,210	770
Light Truck	4,700	190
Heavy Truck	2,340	700
Total	**62,250**	**1,660**

Source: Greater Philadelphia Transportation Initiative (2003)

driven. One way to impose a tax on the private cost of driving is through a fuel tax. Since there is some variability in emissions output by fuel type (with diesel producing less carbon dioxide), a fuel tax could also incorporate the specificity of fuel types. However, an emissions tax imposed uniformly on fuel would not distinguish between either the type of vehicle and its emissions characteristic, nor the type of setting in which the fuel would be consumed. While a system of differentiated fuel taxes by location could be a partial solution to the problem, it would be certain to encourage fuel purchases in low tax rural areas by users of urban roads.

A potential solution could be found in the widespread introduction of electronic toll collection (ETC) technology. At present 95 percent of toll facilities in the United States are equipped with some form of ETC capability. Proponents of congestion pricing have been enthusiastic about the possibility of ETC being the basis for an expanded system of road user charges. However, it is not clear how quickly one could expect ETC to be installed beyond the highways, bridges and tunnels where it is now used to the remainder of the road network. If not, ETC's role would be primarily as a fee collection devise for access to an area, such as with current systems of cordon pricing in place such as London and Oslo. While imposing a charge to access an area could reflect some average emissions cost imposed by vehicles, it would not impose an emissions charge on marginal vehicle miles once inside.

An alternative method for charging could also entail the imposition of an emissions tax as part of an annual vehicle registration process. This would allow the vehicle types and miles driven over the preceding year to be correctly identified, thereby adding some precision to the assessment. However, the system would not resolve the thorny issue of determining the proportion of vehicle miles that had been driven in high impact urban areas versus low impact rural ones.

5. Conclusions

The case for taxing emissions is convincing on economic grounds, as the external costs associated with them are significant. An emission tax could also open up possibilities for generating a relatively steady source of revenues for transportation finance in Pennsylvania. If not subject to the state constitutional prohibitions facing the existing gas tax revenues, this could be a source of funding for non-highway uses, for example transit.

However, there is at present no perfect mechanism to tax users according to the social costs they impose through the emissions they generate. Variability in emissions costs by vehicle type, location of the emissions generation and even fuel type suggests that mechanisms based on registration fees, fuel-based emissions taxes or combinations of the two would be required. Further, the fuel tax component may still require a reimbursement mechanism to compensate those with driving patterns that indicate primarily low impact rural travel.

Added to these challenges is the need to coordinate actions by other states. If such charges were imposed in Pennsylvania only, there would be great incentives to register vehicles and purchase fuel in neighboring states. Further, one could expect a certain resistance to these measures on the part of the auto industry, freight movers as well as a substantial portion of the public. As indicated in the previous sections, a tax that equated private and social costs would not be insignificant, particularly in the case of heavy trucks.

Recent experience with the introduction of congestion pricing in central London offers some insights into how the public might react to emissions taxes. While there has been vocal opposition by some (notably some businesses located in central London), the notion that the congestion pricing scheme would result in greater efficiency and social welfare seems to be increasingly accepted, both by the public and by the media.

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