Implications of Carbon Taxes for Transportation Policies

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Abstract

We consider what an economically efficient federal transportation policy would look like if carbon emissions from motor fuel consumption were priced through a carbon tax. We focus on two broad issues: the role for other policies aimed at fuel conservation, and implications for infrastructure finance. We find that motor fuels in the United States would still be undercharged from the perspective of reflecting externalities (notably congestion, accidents, and local pollution), so that a fuel tax remains justified. Better, however, would be a mileage-based tax because that comes closer to reflecting these externalities; better still would be one that varies with congestion, emissions of local pollutants, or potential for a vehicle to inflict damage on others in a collision. The case for fuel efficiency standards relies primarily on the strength of and reasons for consumer undervaluation of fuel efficiency when making vehicle purchase decisions. The portion of a carbon tax levied on motor vehicle fuels could go a long way toward covering current and growing shortfalls in highway funding, although they would not be eliminated so a case for a fuel tax remains. A mileage tax would provide a more stable fiscal base than a fuel tax, as well as improving the control of externalities.

Key Messages

- Even if a carbon tax were introduced, motor fuels in the United States would still be undercharged from the perspective of reflecting broader adverse side effects, or ‘externalities’ (notably congestion, accidents, and local pollution), in fuel prices.

- Ideally, these other externalities would be more effectively reduced through a variety of per-mile tolls (e.g., that vary across time of day and region to address congestion), with fuel taxes retained only to reflect carbon damages.

- A combination of carbon tax and mileage taxes aimed at externalities would make a part of current policy toward fuel economy standards redundant. The remaining part would depend on beliefs about the importance of reducing dependence on petroleum markets and about the extent of market failures related to apparent consumer under-valuation of fuel economy in making vehicle purchases.

- The case for transit fare subsidies is largely dependent on other factors, as subsidies produce relatively modest carbon benefits. Other existing policies (e.g., regulations governing local emission rates for new vehicles) have a valuable role to play, even if transportation taxes are reformed to better target externalities.

- Appropriately scaled taxes on the carbon content of motor fuels could go a long way toward covering current and growing shortfalls in highway funding, although they would not eliminate them. However, mileage taxes would be more stable as a source of highway funding, as they avoid problems posed by rising fuel economy. In addition, by encouraging more efficient use of roads, they would improve the productivity of highway investments.

- To prepare the longer-term transition to mileage taxes, the federal government could encourage local congestion pricing schemes, pay-as-you-drive insurance, and development of metering technologies.

Introduction

This policy note considers what an economically efficient federal transportation policy would look like if carbon emissions from motor fuel consumption were priced through a carbon tax. Two broad sets of issues arise.

First, what are the implications for other major transportation policies—such as fuel taxes, fuel economy standards, and support for public transit—that are rationalized, at least in part, on climate grounds? We examine the extent to which a role remains for these other policies to address problems other than climate change, such as road congestion and local pollution.

Second, what are the implications of the revenues that would be raised from the carbon taxes applied to motor fuels? Use of even some of this revenue for transportation needs would put the spotlight on debate about how to fund federal infrastructure projects. This issue is coming to a head as rapidly rising fuel economy (see Figure 1) and the failure to adjust nominal fuel tax rates, are steadily eroding real revenues raised per vehicle mile travelled. [1]

This combination of a potentially related policy initiative (carbon tax) and turmoil in infrastructure finance creates an opportune time to thoroughly re-evaluate transportation policies and highway finance. Roads are steadily becoming more clogged, after a brief respite during the recession, even while some other transportation-related concerns—local pollution, traffic accidents, dependence on foreign oil—are becoming less acute (Figure 2). Meanwhile, the backlog of perceived infrastructure needs continues to grow while real fuel tax revenues per vehicle mile fall, the gap being only partially filled by politically volatile appropriations from general revenues (CBO, 2012, Fig. 1).

This chapter considers the two sets of issues in turn, though focusing most attention on the first. We use information from the United States for our empirical estimates and institutional background.

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[1] Federal gasoline and diesel tax rates have been frozen in nominal terms since 1993, despite an increase of over 50 percent in the consumer price level during this time. State rates have roughly remained steady in real terms, but have not been adjusted to compensate for changes in fuel economy: see FHWA (2011), Table MF-205.

Reforming Motor Vehicle Policies in Light of Carbon Pricing

We start by briefly describing the main ‘externalities’ (or adverse side effects) of motor vehicle use that will remain to be addressed if carbon is priced. We then consider how well they could be addressed by fuel taxes alone. Following that we discuss the role of fuel economy standards in the presence of carbon pricing. Then we turn to various types of per-mile tolls that could alleviate some of the (non-climate) externalities more effectively than fuel taxes. Finally, we briefly discuss the implications of tax reform for a potpourri of other existing policies like road building, support for transit, and local emissions standards.

Transportation-Related Externalities (for Light-Duty Vehicles)

For our purposes, a negative externality (or external cost) occurs when individual drivers do not take into account costs they impose on others from their own use of fuels and vehicles. Externalities provide a rationale for government policy interventions, one form of which is to effectively reflect these broader social impacts in the prices or costs individuals face. Even if strong policies are put in place to control the adverse effects of carbon emissions, there are at least three other major remaining externalities from use of light-duty vehicles that need to be addressed: air pollution, congestion, and traffic accidents.

Local (or conventional) air pollution. Long-standing pollution control measures, especially those deriving from the Clean Air Act, recognize several key air pollutants from motor vehicle emissions: especially fine particulates, volatile organic compounds, nitrogen oxides, carbon monoxide, and sulfates (the latter almost entirely from diesel vehicles). Most of the damages are from health effects, which arise largely from particulates and ozone, both of which are formed from atmospheric reactions as well as (in the case of particulates) direct emissions.[2] Emission rates have been declining dramatically (Figure 2) due to ever more stringent regulations for new vehicles, and this trend will continue as the vehicle fleet turns over. An assessment by NRC (2009) valued the remaining environmental impacts by quantifying the effect of emissions on air quality, the extent of population exposure, the extensive evidence on health impacts, and evidence on people’s willingness to pay to reduce health risks. Roughly speaking, they put

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[2] Carbon monoxide is not generally a problem, unless released in enclosed spaces.

environmental damages at 1.3 cents per vehicle-mile for the average (on-road) light-duty vehicle, or about 27 cents per gallon at today's average fleet fuel economy.[3]

Congestion. Generally growth in vehicle miles driven has outstripped growth in road capacity for decades.[4] Although individual motorists bear the costs of road delays, they do not take into account their impact on adding to congestion, thereby increasing delays for other road users. The resulting externality, per extra mile of driving, has been inferred from relationships between speed and traffic flows and from measurements of how people value time lost to congestion (usually taken to be about half the market wage or more). Obviously, congestion is very specific to location and time of day: even at a modest level of aggregation, measured external congestion costs per mile vary from zero for free flowing roads up to around 25-35 cents per vehicle mile for peak travel in large urban centers in the United States (Parry 2009, Table 2). When averaged across different regions and time of day, the congestion externality is perhaps 6.5 cents per vehicle mile.[5]

Traffic Accidents. Although highway fatality rates declined by two-thirds between 1980 and 2010 (BTS, 2012, Tables 2.18), the annual total costs to society from traffic accidents is plausibly on the order of $400 billion a year, or 2.5 percent of GDP (Small and Verhoef 2007, pp. 100-101).

But the nature of the externality here is complex, for several reasons. First, some but not all accident risks are taken into account by individuals in their decisions about when and where to drive and in what type of vehicle. Drivers may well consider the risk of injuring themselves in accidents involving only their own vehicle, but not necessarily the risks to pedestrians and other drivers except insofar as it affects drivers' personal liability and/or insurance rates—a highly uncertain prospect. The risk imposed on other drivers in particular is very complex. On average it may be quite small—although the frequency of collisions (per vehicle mile) rises with more vehicles on the road, their average severity falls as people drive slower and more carefully in heavier traffic— but it is very clear that drivers in heavier vehicles (including pickup trucks and

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[3] Average fuel economy for the light-duty vehicles stock in 2012 is estimated at 20.7 mi/gal in EIA (2012), Table 7. We make some rough adjustments to studies to update estimates to year 2010.

[4] Between 1980 and 2010, for example, urban vehicle miles travelled increased by 132 percent, against an increase in lane-mile capacity of 76 percent (BTS 2006, Tables 1.6 and 1.36).

[5] Authors' calculations using congestion delay data from TTI (2011) and a value of time equal to 60 percent of the market wage.

SUVs) create sizable risks for those in lighter vehicles. Individual drivers also bear some of the costs of property damage (e.g., through the risk of elevated premiums following a crash) but insurance companies pick up other costs. Medical costs from injuries are largely borne by insurance companies and the government, and anyhow these monetary costs are only a fraction of individuals' willingness to pay to avoid injuries and fatalities. Studies that attempt to decompose all these types of costs suggest that motorists impose a cost of around 3.5 cents on other individuals and third parties on average for each extra mile of driving.[6]

The relation between vehicle size and road safety adds a further layer of complexity—injury risks for drivers of small vehicles are increased due to the presence of larger vehicles on the road (whose occupants are in turn are less vulnerable themselves and may be inclined to drive them less carefully). This factor interacts strongly with the design of policies aimed at increasing fuel economy, because those policies may to varying degrees discourage the use of large vehicles.

Other Side Effects from Motor Vehicle Use. Another major externality is additional road maintenance caused by traffic. However, this is almost entirely caused by heavy-duty trucks rather than light-duty vehicles since road wear is a rapidly escalating function of the vehicle's axle weight. Policymakers have also been concerned about energy security; but recently the share of imports in the nation's oil consumption has declined and, as discussed in Box 1, the implications of energy security for fuel conservation policies are opaque.

Summary. The left-hand bar of Figure 3 provides a summary of the relative importance of the different externalities discussed above, by comparing them all on a per gallon basis (i.e., by assuming that an extra gallon of gasoline use leads to 20 additional miles of driving). We include carbon dioxide (CO_2) based on damage of $25 per metric ton—approximately double the mean of peer-reviewed estimates for year 2005.[7] Most noteworthy is that unless CO_2 damage is several times larger than this estimate, congestion and accidents easily dominate it in terms of costs of motor vehicle use. This provides an immediate clue that for motor vehicles, the "side effects" of climate policy may be more important than the direct effects. This is perhaps not surprising: motor vehicles have strong and very immediate effects on matters of great concern in everyday life—time use and risk to health and safety—whereas their effects on people's lives via climate

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[6] Small and Verhoef (2007), pp 100-102, after updating for inflation and declining fatality rates.

[7] IPCC (2007), Section TS.4.7. See also Chapters <> and <> of this book.

change are diluted by dispersion in the global atmosphere, the long gestation of physical impacts, and the potential adaptations future generations will make to those impacts.

Corrective Fuel Taxes

Suppose, for the moment, that gasoline taxes are the only available fiscal instrument to address the above externalities. If a new charge on carbon emissions is introduced, what does this imply for the economically efficient level of gasoline taxes?

There is a standard formula in the literature for assessing the appropriate level of such ‘corrective’ taxes (see Appendix). Based on this formula, the right-hand bar in Figure 3 summarizes the contribution of different externalities to the efficient gasoline tax.

Carbon contributes 23 cents per gallon, identical to its external cost as shown in the left-hand bar in the figure.

Local pollution contributes 14 cents per gallon, only half the value of its external cost. This is because, as discussed in the Appendix, to an first there are no local pollution benefits from improvements in vehicle fuel economy in the presence of binding emission rate standards—pollution only falls if amount of driving is reduced. Because about half of reductions in gasoline usage come from fuel economy improvements rather than reduced driving, the local pollution benefits per (tax-induced) gallon reduction in gasoline are therefore diluted.

The same dilution applies for congestion and accidents—as a first pass, these externalities depend only on amount of driving, not fuel consumption. (Accounting for the relationship between fuel economy and vehicle size, and hence on fatality rates from crashes, would modify this conclusion to some extent.) Thus the congestion and safety benefits per gallon of fuel reduction are less than their average external cost per gallon of fuel use. Nonetheless, these externalities are still large, contributing an estimated 50 and 37 cents per gallon, respectively, to the efficient fuel tax.

Overall, the estimated corrective fuel tax is $1.23 per gallon, more than three times the current tax level, which is $0.40 per gallon ($0.184 at the federal level plus on average $0.218 at the state level).

Estimates of the efficient tax on diesel fuel used by heavy-duty trucks are in the same ballpark as those for efficient gasoline taxes. For the year 2007, Parry (2011) estimated it at \$1.15 per gallon—though the relative contribution of different externalities to the efficient tax is somewhat different than for gasoline. In fact at first glance we might expect the efficient tax to be higher as one extra vehicle mile by a truck adds more to externalities than one extra car mile (e.g., trucks take up more road space and drive slower, thereby adding more to congestion, and they also cause road damage). But this is offset because trucks have much lower fuel economy than light-duty vehicles, which means that a higher per-mile rate can translate into roughly the same per-gallon rate.

In short, the case for taxing fuel goes far beyond climate damage due to carbon emissions. Indeed, even if the climate damages in Figure 3 were incorporated into some broad-based carbon tax and added to the current fuel tax, that tax still would not be nearly high enough to account for the other externalities described here. Moreover, as discussed in Box 1, the corrective fuel tax estimates in Figure 3 might be viewed as conservative in several regards such as, for example, omission of energy security considerations. Thus, if fuel taxes were the only available instrument for dealing with these externalities, we would want to raise them further based on those grounds alone.

Fuel economy Standards

Rather than fuel taxes, the centerpiece of ongoing efforts to reduce motor fuel use is a set of progressively escalating fuel economy standards. Legally, these tighter standards have been developed by integrating new CO_2 standards, introduced by the EPA following their remit to regulate carbon under the Clean Air Act, with into a long-standing program of Corporate Average Fuel Economy (CAFE) standards.[8] We examine the case for continuing such a policy if

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[8] If manufactures were to fully comply with the new CO_2 standards solely through improvements in fuel economy of a given fleet mix, the average fuel economy of new light-duty vehicles would rise from 29 mpg in 2012 to about 35.5 mpg in 2016 and 54.5 mpg in 2025. Actual fuel economy will likely fall significantly below these levels however, due to upsizing, some manufactures opting to pay penalties in lieu of fully meeting the standards, and a systematic difference of about 20 percent between the legally rated fuel economy (as determined by specified laboratory tests) and actual on-the-road performance. Sources: EPA and NHTSA (2010), p. 25328; NHTSA and EPA (2012), pp. 3-4.

Fuel economy standards are also being phased in for heavy-duty trucks that are expected to reduce fuel consumption rates by 7-23 percent by 2017, depending on truck category (Harrington 2011). The same sorts of considerations arise for these regulations as for those discussed above affecting light-duty vehicles. The energy paradox might be less compelling in this context however, given already strong incentives for to economize on fuel use in trucks (which are driven more intensively than cars).

carbon emissions were effectively priced through another means. Whether a fuel economy policy would be redundant appears to depend mainly on two factors: energy security and the so-called “energy paradox.”

First is energy security. To the extent that the national interest is served by reducing our reliance on petroleum—especially imported petroleum—fuel economy standards are one way to address that need. It is difficult for economists to provide guidance on the appropriate stringency of fuel economy standards to address this issue, given the difficulty of measuring energy security benefits (Box 1); and fuel economy standards appear to have considerable political acceptability. What we can say is that, just as for CO_2 emissions, a broad tax on all petroleum products would be more effective than a policy aimed just at new-vehicle fuel economy, because it would exploit some additional opportunities for reducing oil consumption such as reduced automobile use and conservation use of other oil-based products. Furthermore, to the extent that oil imports, rather than oil consumption, is the problem, a better targeted policy would be an oil import fee if it could be made compatible with trade agreements.

Energy security might justify policies to reduce fuel consumption more than would occur just from an optimal carbon tax. But it does not change the fact that a fuel tax would do the same job better. Direct regulation of fuel economy foregoes some important advantages of a fuel tax: it does not discourage amount of motor vehicle usage (in fact, it increases it at least slightly since it makes driving cheaper), and thus it requires more capital expense for vehicle improvements than would a fuel tax designed to achieve the same fuel savings. And of course fuel-economy regulation would not achieve the favorable impacts on congestion, accident, and local pollution as discussed earlier.

The second factor, however, could justify a regulatory policy even if there were no feasibility limit to the fuel tax. This factor is the potential for market failure in energy markets if consumers inadequately consider the lifecycle fuel saving implications when choosing among vehicles with different fuel economies. There is tantalizing but not definitive evidence that this is the case. Engineering assessments suggest a range of fuel-saving technologies that would yield lifecycle fuel savings—discounted at market rates—in excess of the costs from incorporating them into new vehicles. At the same time, many (though far from all) empirical studies have found that consumers implicitly apply high discount rate in their market choices, perhaps failing to account for as much as two-thirds of the true private value of future savings in fuel costs

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when making their purchases.[9] The observation that such seemingly “negative cost” technologies are not always adopted is known as the “energy paradox”.[10]

But as discussed in Box 2, there is much dispute about the reasons for the energy paradox, and whether it warrants government policy intervention. Parry et al. (2010) suggest that, even under generous assumptions about the size of any market failure, the energy paradox by itself may not fully justify the pretty aggressive ramping up of standards envisioned for the next dozen years or so.

Aside from policy stringency, the structure of the CAFE program has recently undergone some other changes, most notably provisions that promote credit trading and that link standards to individual vehicle size, which raise further issues. But since they are tangential to carbon policy, we confine our discussion of them issues to Box 3.

Mileage-Based Taxes

Our earlier discussion makes the case that a higher fuel tax—perhaps much higher—continues to be justified on the basis of other externalities besides CO_2 emissions. However, that was on the assumption that the fuel tax is the only available means to tighten current control of these externalities. But in fact a number of other policies are often proposed for this purpose.

Most externalities are much more closely related to number of miles driven than to fuel consumed. Therefore, it is natural that policies to discourage motor vehicle use are often considered as front-line policies to address motor-vehicle-related externalities. Here we discuss a novel class of these policies, involving per-mile tolls of various kinds.

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[9] While most of the debate has been about consumer rationality, and therefore uses market interest rates as a benchmark with which to compare consumer behavior, there is an additional market failure if market rates diverge from the social discount rate considered appropriate to measure social benefits of future costs. The Office of Management and Budget suggests default values of the social discount rate, in real terms (i.e. adjusted for inflation), of 3% if based on comparing levels of consumption at different times, or 7% if based on comparing current consumption to current capital investment (OMB, 2003). The market rates for car loans and for returns on safe investments lie between these values, making the case for this particular market failure ambiguous. See Goulder and Williams (2012) for an enlightening discussion of the appropriate use of such discount rates for different types of policy evaluation.

[10] The energy paradox may apply not only to vehicles but also to many other sectors such as home appliances and building heating and cooling technologies. See for example Hausman (1979) and recent reviews in Helfand and Wolverton (2011) and Busse et al. (2012).

In principle, a tax on vehicle miles traveled (VMT) is the most effective disincentive to use motor vehicles. Substantial interest in VMT taxes has emerged recently, usually as a replacement for fuel taxes—largely driven by fiscal considerations, as analysts anticipate the continued erosion of the fuel tax base due to increased fuel economy. The state of Oregon has led the way with extensive experiments examining implementation strategies based on tax collection at time of refueling, while the United Kingdom and The Netherlands have seriously considered (though not yet implemented) nationwide VMT taxes based on Global Positioning System (GPS) technology.

While a VMT tax would be a large improvement over fuel taxes for controlling most externalities, it is still a relatively blunt instrument. Each of these externalities can vary widely by time, place, and other circumstances. Therefore, more effective policies would vary per-mile tolls accordingly.

For congestion, this reasoning leads to a per-mile charge for vehicles driving on busy roads, with the charge varied by location and rising and falling during the course of the rush hour. This policy, known as “congestion pricing,” exploits multiple possibilities for drivers to alter behavior in order to alleviate congestion. Examples include moving trips away from the peak of the rush hour, encouraging alternate modes such as carpools, public transit, walking, and bicycling, reducing trip-making (e.g. via telecommuting or combining trips), shifting to less congested routes, changing job or residential locations, and other strategies that analysts may not even have thought of. Some form of congestion pricing has been implemented in Singapore, London, and Stockholm. Partial versions exist in the United States in the form of “value pricing,” usually meaning express lanes that are free to certain users (e.g. carpools) and at a charge to others (Poole 2012).

For accidents, per-mile charges could be scaled according to the extent of external accident risk: higher for higher-risk drivers (based, perhaps, on their rating factor as determined by insurance companies) and higher for vehicle classes that pose greater risks for other drivers and third parties. A start toward such a system has been made privately in the form of insurance rates based on the number of miles driven as well as the usual ratings factors. A government-imposed version has been proposed in the form of “pay as you drive” insurance: conversion of insurance payments into a mileage-related charge, perhaps payable at time of refueling based on odometer readings (Bordoff and Noel 2008).

For local air emissions, an ideal corrective tax would be on the emissions themselves rather than on mileage. Given that this is unlikely, an alternative would be a mileage tax whose rate depends on the emissions characteristics of the vehicle and on the extent of population exposure to those emissions.

Finally, for road damage, this is most efficiently addressed through per-mile tolls on heavy trucks, scaled by their axle weight. Such a tax would encourage truckers and shippers to seek vehicle fleets that carry goods efficiently over more axles with much less road damage. Small, Winston, and Evans (1989) analyze such a system in detail. A limited version exists in the ton-mile tax in Oregon, whose rates for vehicles over 40 tons vary sharply by weight and inversely by number of axles.

In short, the ideal fiscal system for motor vehicle transport would involve charging motorists for each mile driven, where the charge is scaled according to factors affecting the congestion, accident, local pollution and possible road damage costs imposed on other by that mile, with a fuel tax component retained to address carbon emissions.

Other Traditional Policies

In light of where we should be headed, as just described, what are the implications for some other, more traditional transportation policies?

Limiting road capacity. The main rationale for policies restricting road building is that the amount of motor vehicle travel adjusts to the extent of the available road network.[11] This is a direct response to what remains quantitatively as the largest motor vehicle externality: road congestion. But limiting capacity can impose enormous costs, both to individual drivers and to the efficiency of economic systems that depend on people’s ability to interact. This is because such a policy largely works by keeping congestion high, rather than allowing socially desirable capacity expansions with efficient rationing of new road space as would occur with appropriate congestion pricing.

Supporting public transport. Another policy attempting to reduce motor vehicle use is the support of public transportation, especially bus and rail transit in urban areas. This policy helps

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[11] This phenomenon appears especially for high-speed expressways, where some evidence (Duranton and Turner 2011) even suggests that traffic adjusts in proportion, or nearly so, to road capacity. For a representative sampling of the large empirical literature on induced demand, see Goodwin (1996), Cervero (2003), Duranton and Turner (2011), and the literature reviews therein.

to shift people from walking, bicycling, carpools and (to the modest extent that congestion is reduced) automobile trips to transit.

The main drawbacks to this policy involve effectiveness and cost effectiveness. Except for high-density urban areas during peak periods, such policies tend to be very expensive and have a quite limited impact on motor vehicle travel and a very small impact on externalities other than congestion. It has even less effect on energy consumption, because transit vehicles also use energy, particularly petroleum-based energy in the case of diesel buses, and this energy consumption can be quite high per passenger when (as is common) transit vehicles run with low occupancy. On the other hand, public transit provision may provide important travel benefits, and it is even subject to positive externalities that can warrant some level of subsidy. Specifically, by increasing ridership, promoting public transit makes it feasible to offer a denser network of service lines and more frequent service, thereby reducing other users' costs of getting to transit stops and waiting for buses and trains. Both the costs and benefits of public transit are very case specific, however. Given its limited value for energy conservation, we suggest that policies promoting public transit be evaluated based mainly on their benefits to travelers, regardless of whether carbon emissions are taxed or not.

Policies targeting technology and behavior. The discussion above has already included a variety of financial incentives to reduce motor vehicle use and, perhaps more importantly, to change technology and other driving behavior. In the latter regard, congestion pricing would encourage changes in routes or times of day of travel, accident-related mileage charges would encourage safer vehicles, local emissions charges would encourage lower-emitting vehicles and better maintenance of their emissions control systems, and heavy-vehicle charges would encourage distributing loads over more axles.

The same types of changes may be encouraged through regulations rather than financial incentives. Indeed, these are the mainstays of policies in all these areas. Regulations may include restrictions on entering certain areas, incentives to change work hours, mandates on vehicle safety features, emissions maintenance inspections, and axle-specific truck weight limits. One drawback of such regulations is that they do not raise revenues, though the flip side is that, since they do not involve a large transfer from motorists to the government, they may be more politically acceptable. Another drawback is that they are less effective than well-targeted, and appropriately scaled, taxes in promoting all of the opportunities for reducing externalities. This does not mean that they should be scaled back, however: in some cases they serve as reasonably effective policies in the absence of more ideal pricing policies.

A good example is pollution control mandates on motor vehicle manufacturers which, along with more modest inspection and maintenance requirements, have dramatically reduced emissions rates over time (Figure 2) with substantial public health benefits. While some further gains could be achieved by the emissions-related VMT charge discussed above, it would make little sense to put previous gains at risk by rolling back emissions rate standards. Similarly, legal penalties for dangerous driving practices and weight limits on heavy vehicles could retain a useful reinforcing role, even after the introduction of VMT tolls related to accident risk and road damage.

Issues in Transportation Finance

The more dramatic implication of carbon taxes is likely to be on the fiscal, rather than the environmental, side. A carbon tax would raise motor fuel taxes substantially, far more than can be achieved by any amount of pleading on the part of infrastructure advocates or complaints by transportation analysts about the erosion of the user pay principle for transportation finance. For example, a carbon charge of $25 per ton of CO_2, equivalent to 22 cents per gallon of gasoline and 26 cents per gallon of diesel fuel, would have more than doubled the fuel tax rate and raised extra revenue of about $33 billion in 2009. Fuel taxes are the primary component of federal funding for highway infrastructure, and to some extent of transit infrastructure, through the Highway Trust Fund. What implications would such an infusion of funds have for infrastructure financing?

The Infrastructure Funding Gap

The problems of infrastructure finance in the United States have occupied several national commissions and untold policy commentaries (e.g., TRB 2006). Virtually all have bemoaned the failure of tax rates on gasoline and diesel fuel to keep up with perceived infrastructure needs, although they differ in their views as to whether those infrastructure needs are primarily for more highway capacity or for investments in other modes. The possibility of a large infusion of funds from a carbon tax into infrastructure finance has the potential to transform the nature of these discussions.

To gain some perspective, let us consider two of the many ways the shortfall in infrastructure funds has been quantified.

- *Maintaining current real expenditures*. For many years, federal fuel tax revenues, along with other much small revenue sources dedicated to the Highway Trust Fund, have fallen short of authorized highway and transit expenditures; in 2008-2010, the gap averaged $7 billion annually. As a result, the federal government has periodically needed to appropriate general funds to bolster the Fund. Table 1 summarizes the picture. Furthermore, the situation will get much worse as cars become even more fuel efficient: under anticipated trends prior to the latest CAFE tightening, it is likely that revenues will decline in real terms from $35 billion in 2008 to $22 billion in 2035, adding another $13 billion to the current gap of $7 billion.[12] Thus, we can expect a shortfall of about $20 billion per year (in 2008 dollars) just to maintain current expenditure levels. According to CBO (2012), the new fuel economy standards for 2017-2025 model cars will eventually reduce annual revenues by about 21 percent, adding an additional $5 billion shortfall for a total of $25 billion in 2035..

- *Maintaining current levels of service*. The National Surface Transportation Infrastructure Finance Commission (2009, pp. 50-52) assessed estimates of federal highway capital investment needed to maintain current conditions and performance of highways and transit, showing average annual funding gaps of $47 billion for highways and $21 billion for transit, over the years 2008-2035, for a total of $68 billion.[13]

Thus, it appears that carbon tax revenues of a size we are discussing would largely fill the gap between revenues and current expenditure levels, but would not provide enough revenues to maintain current levels of service. And even this latter level of expenditure is projected by US Department of Transportation (2010) to fund only those projects with benefit-cost ratios of 2.0 or greater. Thus, a carbon tax is unlikely to offset the failure of fuel tax rates to keep up with inflation, a growing motor vehicle population, aging infrastructure, and other factors preventing our highway and transit capital stock from performing its desired purposes. Rather, they would shift the focus from how to save the Highway Trust Fund from collapse to whether and how our infrastructure should be significantly upgraded to keep up with growing needs.

Regardless of which is the focus of concern, the problematic state of infrastructure finance naturally raises two questions. First, what is the role of the federal government vis-à-vis the states? In particular, given that most infrastructure projects primarily benefit the state in

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[12] National Surface Transportation Infrastructure Finance Commission (2008, pp. 101-103), especially Exhibit 4-5.

[13] The commission's estimate comes from updating and adjusting figures from the biannual assessment of needs and performance reported in US Department of Transportation (2010).

which they are built, does it make sense for such a large part of the program to be a federal responsibility? This question, relevant mainly to nations with a federal structure, is covered in many commentaries such as Poole (2011) and we will not address it here.

The second question is: what is the appropriate balance between transportation taxes and other taxes in financing infrastructure, accounting for the dual role of transportation taxes in correcting externalities and in raising revenue? A third is: to what extent should revenues collected from transportation be earmarked for that sector? We address these latter two questions in the next two subsections.

Balance between Fuel and Other Taxes

When transportation taxes are considered in the context of an overall fiscal system of raising revenue, one needs to consider a desirable set of relative tax rates on these and other commodities. A common approach to this in public finance is to ask how the inevitable distortions to economic activity can be minimized by choosing such relative rates. When externalities are important, as in the case of the fuel tax, the question comes down to whether the best tax rates on transportation goods, such as fuel, should be set above, at, or below the rates appropriate for addressing externalities. To analyze this issue, we can draw on some well known general principles of tax design for guidance.

First, final goods consumed by households (including passenger vehicles and the fuels they use) will typically be legitimate bases of taxation on purely fiscal grounds, but intermediate inputs such as commercial trucks and their fuels are not. Taxing intermediate inputs at rates higher than those needed to control externalities would distort the way firms do business, causing them to use too little of the taxed input, and too much of other inputs, from a cost-minimizing perspective.

Second, spending on different consumer products should be taxed under a common formula. An important component of such a formula would be how much taxing such a good will affect employment compared to broader taxes on income, payrolls, or consumption. One outcome of such a consideration is that product taxes should be higher, the more inelastic the tax base.

These possibilities have been explored in the specific case of gasoline taxes for the United States, with studies finding that on balance fiscal considerations might warrant some additional taxation of gasoline in excess of levels to correct for externalities— perhaps by 25 to

50 cents per gallon. These estimates are imprecise, but the main point is valid: the case for higher fuel taxes is even stronger when they are set in a broader revenue raising context, even aside from the oft-cited political advantage of creating transparency for how highway infrastructure is financed.

Earmarking

A frequent method of obtaining political acceptance of new sources of revenue is to promise to spend them for specific purposes, usually closely related to those sources. For transportation finance, such hypothecation, also known as “earmarking” or “ring fencing,” would take the form of dedicating revenues transportation, such as from a motor fuels tax, to related infrastructure such as highway construction, maintenance, or rehabilitation. Indeed, in the US this principle is embedded in the Highway Trust Fund, although in recent decades the tie has been loosened by allowing some of the funds to be spent on public transit. For our purposes, the principle could be applied equally well to revenues from a fuel tax, a VMT tax, or the portion of a carbon tax coming from transportation.

To the extent that these taxes are considered in part to be for environmental reasons, hypothecation might take the form of dedicating the revenues to amelioration of environmental damages. For example, revenues from a carbon tax could be dedicated to helping people adapt to the consequences of climate change.

The trouble with hypothecation is that there is no necessary relationship between the efficient level of the tax and the efficient level of spending on a particular program. This is especially true for a tax aimed at mitigating climate change, since the damage resulting from today’s emissions will be mostly felt over a period of centuries. Similarly, needs for transportation infrastructure are long-term and so need not bear a close relationship to current revenues from efficient transportation taxes. Moreover, the chance evolution of the tax rate over time, due to political considerations or unforeseen technological changes (such as improved fuel economy) may unduly influence the level of spending actually adopted. These concerns are not just theoretical: four decades ago the nation was consumed by debates over whether the ready availability of fuel tax revenues was producing unnecessary highway spending, abetted by the “highway lobby”; whereas today the concern is that infrastructure finance has been choked off arbitrarily because fuel taxes are not adjusted for inflation or for growing fuel economy, much less for changing needs for infrastructure spending.

Nevertheless, the tie between highway usage taxes (primarily but not exclusively the fuel tax) and highway spending has served a valuable political purpose in the past, allowing citizens to see a connection between their taxes and a widely appreciated road system. This connection has eroded for many reasons, leading to proposals to forge it anew, for example by eliminating the use of fuel tax revenues for public transit. Hypothecation may turn out to be a reasonable political mechanism to achieve a sound economic goal, but the implications for spending levels need to be carefully assessed against the effectiveness of that spending.

Conclusion

It is an opportune time for a thorough re-assessment of federal transportation policy. The scourge of urban traffic congestion is set to worsen in the near term as the economy recovers, and in the longer term as population and economic growth require accommodation of resulting traffic. Pressure remains on policymakers to enact a comprehensive carbon pricing program, as extreme weather events remind us that atmospheric concentrations of greenhouse gases are rising above levels deemed safe by scientists. And highway budgets are being squeezed as far as the eye can see, as the traditional source of highway funding is eroded through progressively rising fuel economy standards and high oil prices.

These trends point to partially replacing traditional fuel taxes with a system of VMT-based taxes, though retaining some charge on the carbon content of motor fuels. Reforming transportation taxes in this direction appears to have little relevance for the desirability (or not) of other traditional policies, such as support for mass transit and standards governing new vehicle fuel economy and local emission rates.

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Appendix: Assessing Efficient Fuel Taxes to Address Externalities

If fuel taxes are the only available fiscal instrument to address externalities, and there is no other market distortion, then the efficient level of corrective tax for gasoline is given by the following formula (Parry and Small, 2005):

[CO_2 damages per gallon]
+
[(congestion, accident, and local pollution costs imposed on others per extra mile of driving)
×
(miles per gallon)
×
(fraction of the fuel reduction due to reduced driving rather than higher fuel economy)]

Multiplying the congestion, accident, and local pollution costs per mile by miles per gallon expresses these costs in dollars per gallon, though account should be taken of how fuel economy rises with higher taxes (e.g., via manufactures incorporating fuel-saving technologies). Moreover, these mileage-related costs need to be multiplied by the fraction of the tax-induced reduction in fuel use that comes from reduced driving, as opposed to the other fraction that comes from fuel economy improvements. The smaller the first fraction, the smaller the congestion, accident and local pollution benefits per gallon of fuel reduced.

The formula assumes that reductions in vehicle miles driven reduce local pollution, but improvements in fuel economy do not. One channel for fuel economy improvement is people shifting to smaller vehicles, but this does not obviously reduce emissions given that large and small light-duty vehicles alike must now satisfy the same emissions per mile regulations (and, at least to some degree, emissions rates are maintained throughout the vehicle life by state-level emissions inspections and maintenance programs). The other main channel for fuel economy improvement is through manufactures making technological modifications to new vehicles (e.g., improvements in engine efficiency, use of lighter materials, improved aerodynamics). However, evidence for the United States suggests that any local emissions gains are offset, as manufacturers can cut back on emissions abatement equipment and still meet the same binding emissions per mile standards.

The formula above is easy enough to iterate in a spreadsheet, using the values for external costs discussed in the text. We also assume a starting (for year 2010) gasoline price of $2.60 per gallon; fuel economy of 20 miles per gallon; that each 1 percent increase in fuel prices increases fuel economy by 0.2 percent (an increase in the fuel tax of 10 cents per gallon, for example, raises prices by 3.8 percent); and that half of any tax-induced fuel reduction comes from reduced driving. Finally, following Parry and Small (2005), we scale back congestion costs by 30 percent, because driving on congested roads (which is dominated by commuting) is less responsive to fuel prices than driving on non-congested roads (this further reduces congestion benefits per gallon of fuel).

Box 1. Why Corrective Fuel Tax Estimates might be Understated

For several reasons, the corrective fuel tax estimates in Figure 3 might be understated.

They ignore the possibility of an energy security benefit from reducing gasoline consumption, which might arise from reduced macroeconomic vulnerabilities to oil price shocks or from less reliance on oil exporting nations whose international objectives may be contrary to ours. The nature of this benefit is often difficult to state rigorously: at least some of the risks from oil price shocks should already be taken into account in firm and household decisions, and the influence of specific exporting nations is limited by the fact that oil prices are determined in world markets. To the extent any benefits have been measured however, they seem to be fairly modest in magnitude: see for example Brown and Huntington (2010) on the macroeconomic vulnerabilities.

Our corrective fuel tax estimates also ignore the possibility of a safety bonus for other road users to the extent that high fuel taxes encourage some people to shift to smaller and lighter vehicles to economize on fuel. Nor do they consider the dramatic, recently promulgated, ramping up of fuel economy standards through 2025. These standards will mute the tendency of motorists to respond to fuel taxes by buying more fuel efficient cars, since they are already mandated to do so. Thus, a greater portion of a given tax-induced fuel reduction will in future come from people driving less, thereby magnifying the benefits (per gallon of fuel reduced) of reduced local pollution, congestion, and accidents. In other words, this trend will make the fuel tax come to resemble more close a VMT tax.

Finally, assuming that under-funding of infrastructure will not be eliminated quickly, the already large congestion externality is likely to grow larger still, adding to the appropriate level of the corrective fuel tax.

Box 2. The Energy Paradox Controversy

Numerous explanations have been proposed to explain the energy paradox; Helfand and Wolverton (2011) provide a comprehensive review. Most of them do indeed imply a market failure. Consumers may have limited information, or limited ability to calculate future fuel costs from the information they have. There is evidence, for example, of “MPG illusion”: the incorrect belief that increasing efficiency from say 30 to 31 miles per gallon (mpg) provides the same future fuel savings as increasing it from 20 to 21 mpg. Or consumers may have more vehicle traits to consider than they can process, and so omit fuel economy. Or they may be mistrustful of claimed fuel cost savings, doubtful about future fuel prices, or short-sighted in their assessment of the future. Informational inefficiencies in used car markets could perpetuate such short-sightedness by not permitting people to reap the full advantage of more fuel-efficient cars in their sale prices upon trade-in or sale. Moreover, consumers may be subject to borrowing constraints causing their marginal tradeoffs between present and future expenditures to differ from the social rates embodied in discount rates used for cost-benefit analysis.

Other explanations, however, point to limitations of analysts rather than of consumers. Consumers may be aware of undesirable side effects that accompany greater fuel economy, such as reduced acceleration or greater likelihood of needing repairs. Such “hidden costs,” if real and not involving an externality, would then create an additional cost of a policy mandating high fuel economy. If the “hidden cost” consists of aversion to a smaller or lighter car because of fear of injury when colliding with a larger car, then again there is a market failure of the “arms race” variety (White, 2004; Li, 2012).

The appropriate policy response depends therefore not only on the size of the energy paradox (if it indeed exists at all), but on the reason for it. If it is large and is caused by one of the factors involving a market failure, some policy intervention can be justified even aside from any environmental costs associated with energy use. Indeed, the official regulatory impact analysis of currently adopted US standards for model years through 2025 can be read as implying that whether current efficiency standards are worth their cost depends more on the energy paradox than on environmental and energy security concerns. At any rate, there is an urgent need for more information about the extent and exact nature of any energy paradox.

Box 3. Recent Structural Reforms to the CAFE Program

On the plus side, manufacturers now have greater flexibility to trade fuel economy credits among themselves, across different periods of time, and across their car and light truck fleets. This improves the cost effectiveness of the program as, for example, manufacturers can go beyond the standard in years of high gasoline prices when consumers are more willing to buy fuel-efficient vehicles, and use those banked credits in low-fuel-price periods when it would otherwise be costly to meet a rigid fuel economy standard.

On the debit side, standards now vary inversely with a vehicle's size (or footprint), meaning that manufacturers can effectively relax their average CAFE requirements by shifting to larger size vehicles. Removing this perverse incentive would improve the cost effectiveness of the program for a given overall fuel economy improvement, while also alleviating the risk to other road users posed by larger size vehicles.

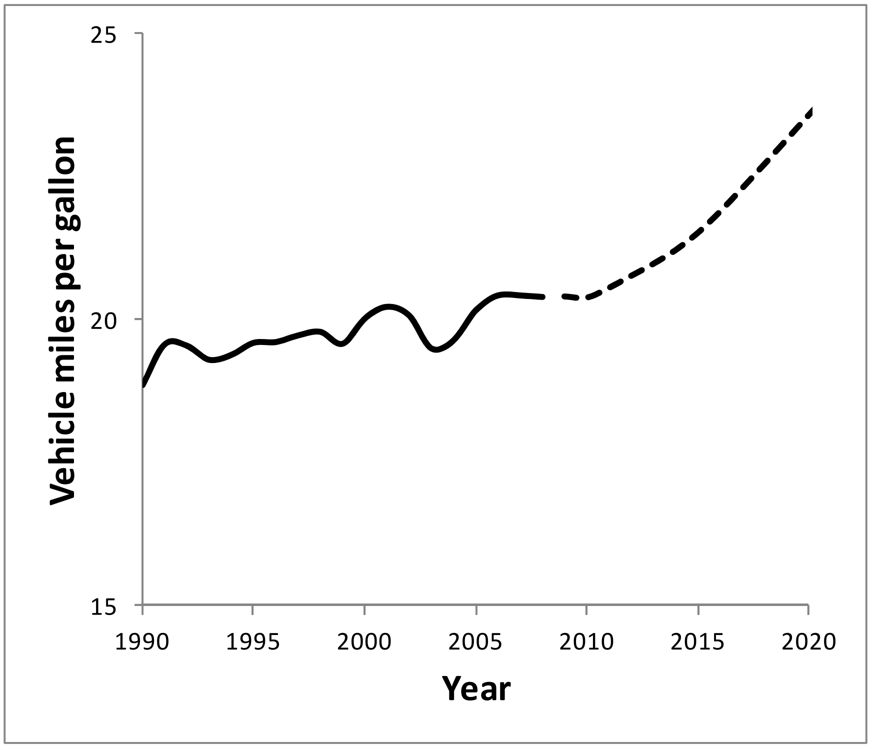
An alternative to fuel economy standards is a type of financial incentive known as a "feebate": a fee charged or rebate given for the purchase of a motor vehicle proportional to the difference between its rated fuel consumption per mile and some arbitrarily chosen standard. See Greene et al. (2005a,b) and Small (2012) for anslyses. In theory, these incentives can be chosen to give results equivalent to those of a fuel economy standard; the similarity is even closer if one recognizes that a manufacturer subject to an efficiency standard has an incentive to adjust its prices to encourage purchase of fuel-efficient vehicles at the expense of fuel-inefficient vehicles. However, because feebates involve potentially significant financial flows, their implementation requirements and political implications may be quite different from those of an efficiency standard.

Table 1. Federal Transportation Spending and Revenues: Annual Average, 2008-2010 ($ billions)

	Motor fuel excise tax revenues	Total excise tax revenues	Expenditures	Revenues less expenditures	Transfers to Highway Trust Fund
Highways	27.6	30.5	35.5	-5.0	
Transit	4.9	4.9	6.9	-2.0	
Total	30.1	35.4	42.4	-7.0	9.6

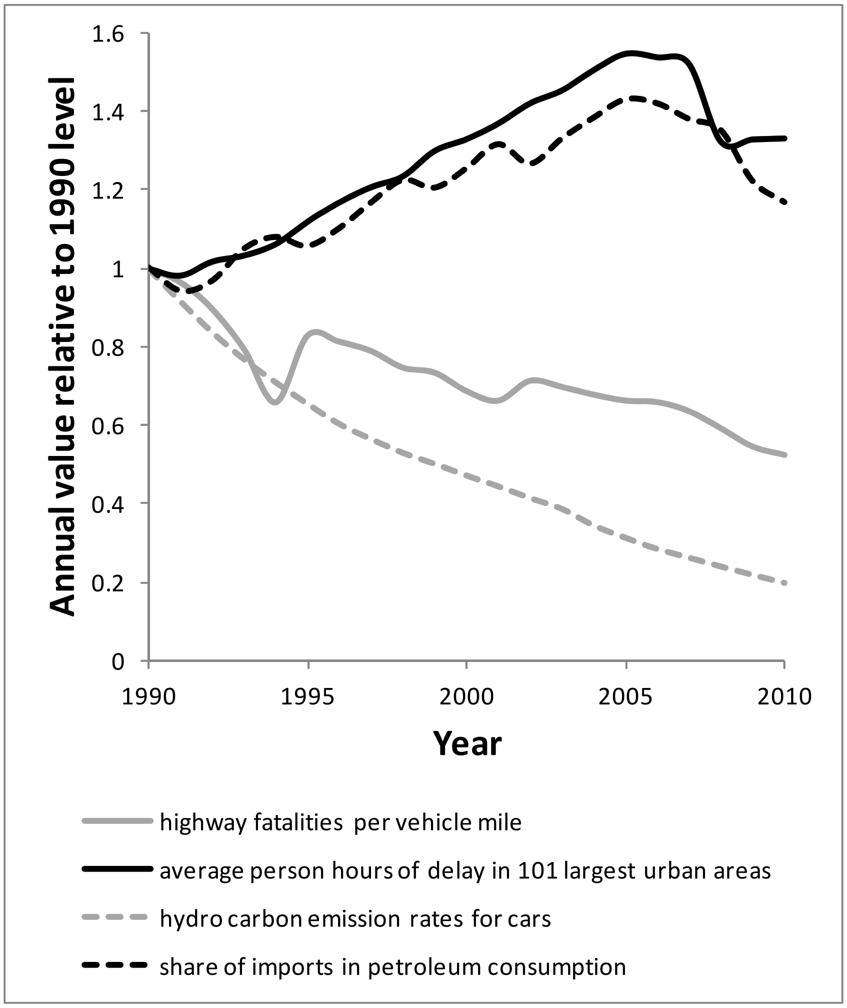
Source: FHWA (2011), Table FE-210

Figure 1. Fuel Economy Trends for (On-Road) Light-Duty Vehicles



Source. BTS (2012), Tables 4.11, 4.12, EIA (2012), Table 41.

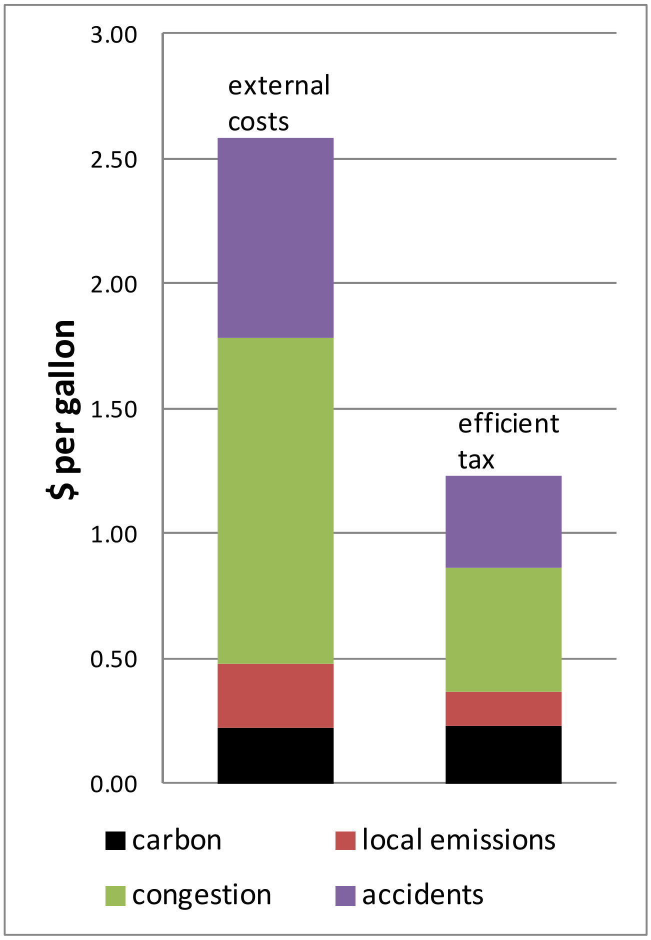
Figure 2. Trends in Travel Delays, Accident Rates, Local Emissions Rates, and Petroleum Imports



Source. BTS (2012), Tables <>. <Ian complete>
Notes.

Figure 3. External Costs and Efficient Fuel Tax for Light-Duty Vehicles

(expressed in year 2010 dollars per gallon of gasoline use)



Source. Costs imposed on others from local emissions, congestion, and accidents, per extra vehicle mile, are discussed in the text. These are converted into per gallon costs assuming a gallon results in 20 extra vehicle miles driven. Carbon costs equal an assumed damage of $25 per metric ton of CO_2 multiplied by emissions of 0.009 metric tons per gallon of gasoline (Davis et al., 2012, Table 11.11). See Appendix for details of efficient tax computation.