THE PER-MILE COSTS OF OPERATING AUTOMOBILES AND TRUCKS

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ABSTRACT

This report describes a methodology and simple model for calculating the variable, per-mile costs of operating cars and trucks, for use in benefit-cost analysis of highway projects. While the marginal vehicle operating costs generated by changes to trip mileage or operating conditions are typically a small part of total project costs, they can be significant in deciding among alternative designs, construction scenarios, or project timing.

Operating costs for personal vehicles (autos, pickups, SUVs, vans) are developed primarily from consumer guides, with an overall fleet average cost based on vehicle sales. Operating costs for large commercial trucks are based on a review of a number of sources of trucking costs. Factors for adjusting the costs based on stop-start conditions, pavement roughness, and inflation are derived from various sources.

The results are that in a “baseline” case of highway driving on smooth pavement, with a fuel price of $1.50 per gallon, and other costs in 2003 dollars, that personal vehicles average 17.1 cents per mile to operate, and trucks average 43.4 cents per mile, not counting costs associated with the driver or travel time. City driving conditions, involving frequent stops and starts, increase this cost by 3.9 cents per mile for personal vehicles and 9.5 cents for trucks. Extremely rough pavement increases the baseline cost by 2.7 cents for personal vehicles and 5.5 cents for trucks.

INTRODUCTION

When work is done on highways, or when new highways are built, one of the possible impacts is that the people who make trips on those highways might spend more or less money to operate their vehicles. This could happen during construction, either because detours increase the distance that must be traveled to complete a trip, or because slowdowns cause vehicles to be operated at less-than-optimal speeds. Costs could also change after the project is over, again because either the length or the operating conditions, especially speed, might have changed for certain trips. For example, a bypass around a town will generally increase the distance that must be driven, but improve conditions by avoiding stops and starts.

The analysis of whether and how highways projects ought to be done is based on the benefits gained and costs incurred under various scenarios. Two of the biggest benefits of most highway projects are reductions in travel time and in crashes. Standard methodologies for estimating these costs are well established and widely used. A third major impact on highway users, and the focus of this paper, is the cost of operating vehicles for trips through the affected area. While vehicle operating costs are typically a small part of total project costs, they can be significant in the context of deciding among alternative designs, construction scenarios, or project timing. There are four major components of this cost: fuel, maintenance (including tires, oil, and other routine work), unanticipated repairs, and depreciation in the value of the vehicle.

While the potential significance of this issue has been noted for some time, there is no definitive methodology for estimating these costs. Research that addresses vehicle operating costs tends to either provide too little detail, because it is focused on project or transportation costs more generally (*1, 2, 3*); or is incomplete, because it is aimed at a detailed analysis of a specific type of cost (*4, 5, 6*). Existing computerized cost models on the other hand, are often more detailed than is necessary or helpful for the majority of benefit-cost analysis problems. Some typical shortcomings in the research and computer models include:

- Inflexibility: Operating costs depend on conditions; what is needed is not just a number, but instructions on how to adjust the number as conditions change. That is, the reason highway projects are done is to change something about the highway; cost estimates need to account for the impact of these changes.
- Too complex: Some computerized estimation tools are very flexible, but can require more information than is usually available, or more than the typical analyst has time to utilize. For example, personal vehicles are often broken out into many categories based on size and type, but analysts will generally only know the total counts on a highway, not the number in each category.
- Fixed in time: The components of operating costs change in price at different rates, and in general not at the rate of overall inflation. No guidance appears to address explicitly how to update cost estimates in future years.

- Confusion of fixed and variable costs. Many costs of owning vehicles are incurred regardless of how much they are driven. But highway project cost studies should include only the costs that vary with distance driven. This point is not always clear in the literature.
- Life-cycle costs. Some costs, such as repairs, increase as vehicles age. Basing cost estimates on data or studies using new cars will underestimate fleet operating costs.
- Commercial trucks. Costs of operating trucks are generally not closely examined. While these are a small part of the total vehicle fleet, they are driven far more miles than cars on average, so they comprise a somewhat larger percentage of vehicle operating costs.

The philosophy of this paper is that vehicle operating costs are significant enough, and variable enough, to warrant an explicit calculation tool, but they are sufficiently small that the tool should be fairly easy to use and require only limited information. The objective is to develop a baseline cost that can be reasonably customized to local conditions, and a small number of adjustment factors that can be used to account for important project-specific variations, including how to adjust for price changes over time.

An important point here is that this study does not estimate total operating costs and divide by some assumed mileage. This is a standard practice in consumer-based guides, which are rightfully concerned with the *total* cost of operating the vehicle, including costs such as insurance and age-based depreciation that (usually) do not depend directly on how much the car is driven. For our purposes here, however, we are concerned only with the *marginal* resource consumption that can be attributed to mileage or operating condition changes resulting from a highway project.

Some insurance premiums do vary to some extent with mileage. However, at this time insurers do not track the specific number and location of miles driven and charge premiums at that level of detail. This sort of thing would need to be accounted for if it became widespread. However, it would be important in the larger benefit-cost analysis to be careful not to double count insurance costs and crash costs.

Given estimates of the cost of a marginal mile of driving under different conditions, the analyst can then calculate the total cost of the trips being made under the current conditions, and the total costs of the trips during and after the project. This will help with addressing issues of the overall value of the project, as well as questions of construction timing and staging.

The baseline costs described in next two sections apply to a situation of “highway” driving, with very few stops, on smooth pavement, and they are in 2003 dollars.

This paper is a condensed version of a longer report done for the Minnesota Department of Transportation (*7*). This longer report provides additional methodological detail, and describes a spreadsheet model that automates the cost estimation methodology described here.

THE COSTS OF OPERATING PERSONAL VEHICLES

The cost of operating an automobile or light truck is strongly dependent on the characteristics of the specific vehicle model. As analysts will generally not have any information about the personal vehicles that will use a given highway, we develop a weighted average operating cost based on model counts in the existing fleet.

For each model, we break operating costs into five major components: fuel, maintenance, tires, unscheduled repairs, and depreciation. We develop a baseline cost per mile of operating each model based on "highway" conditions. We multiply this by model counts to arrive at a baseline per mile cost for the fleet as a whole. Finally we create adjustment factors to use for accounting for future price changes and other project-specific conditions that might be of interest, in particular pavement roughness and "city" versus "highway" driving conditions.

Personal vehicles are broken into two categories, automobiles and everything else, including pickups, SUVs, and vans. For simplicity, throughout this paper the word "pickup" refers to all vehicles in this second category. We do not consider other types of personal vehicles, such as motorcycles or busses, because these are typically a very small part of the fleet, and we did not have good cost information for these vehicle types.

In this section we describe the methodologies for the baseline estimates for each of the major costs. We treat project-specific adjustment factors in a later section. Total operating costs for cars and pickups are shown in the last section of the paper, so that these costs, truck operating costs, and the impact of adjustment factors can all be shown in one place.

Fuel, Maintenance, Tires

There are two issues in calculating fuel costs: the expected consumption of fuel by a given model, and the price of fuel. Fuel mileage is taken from the standard fuel economy data generated by the Environmental Protection Agency, which offers estimated mileage per gallon for both city and highway driving conditions. For purposes of this paper we use a fuel price of $1.50 per gallon, which is approximately the U.S. average for the last year; since this cost is broken out separately it can easily be adjusted for different gas prices.

An important point regarding the cost of fuel is that the retail price includes federal and state taxes, which are a transfer of resources rather than consumption. Analysts may wish to account for this by using the net cost with taxes removed; which will vary from state to state.

We estimate the costs of maintenance based on the manufacturers' recommended maintenance schedule, as taken from a common consumer guide (*8, 9*). While there are many other consumer guides on the market, this was the only one that broke out operating costs in the necessary level of detail to make it possible to separate fixed from variable costs.

This guide assumes that cars are driven 14,000 miles per year. A major portion of the maintenance costs is the replacement of tires, which are broken out separately as they are estimated differently.

To generate per-mile maintenance cost estimates, we subtract the tire replacement cost from the total five-year maintenance cost. We divide the remainder by 70,000 (the five-year assumed mileage) to get a baseline per-mile cost. We assume that this routine maintenance cost will continue for the life of the vehicle.

Tire costs are taken from the same consumer guide. These costs are based on a 45,000-mile cycle. Thus the per-mile cost for tires is the total, divided by 45,000.

Repairs

The estimated costs of repairs also come from the same consumer guide (*8, 9*) and are based on the cost of a five-year, zero-deductible repair-service contract for each model of car. For most models, the cost of repairs in the fifth year is estimated to be 50% or more of the five-year total. This is the range from about 60,000 to 70,000 miles when parts might be expected to begin failing. We assume for simplicity that for all models, 50% of the five-year repair costs will occur in the first four years, and 50% in the fifth year; and that the costs incurred in the fifth year will then be incurred in all subsequent years.

Thus for repairs, as will also be the case for depreciation, the per-mile cost will depend on the age of the vehicle. However, the important point for estimating marginal repair costs is not the average age of all vehicles, but the average age of the vehicles that are actually on the road at a given time. The U.S. Environmental Protection Agency (EPA) has published estimates of mileage by vehicle age (*10*), and distribution of vehicles by age in the fleet. Taken together, this indicates that for cars, 36.3% of mileage from vehicles less than 5 years old, and for pickups, 42.8%. This latter number is higher partly because of high recent pickup sales, but also because newer pickups are driven relatively more than newer cars. So to get an overall baseline model repair cost for 2003, we multiply the respective repair rates for newer and older cars and pickups by the appropriate fleet percentages, and sum to get fleet averages.

Depreciation

Much vehicle depreciation is due to the simple passage of time, but some fraction is dependent on the number of miles that the vehicle has been driven. Most estimates of depreciation are too high for our purposes here because they are total depreciation (including age-based) divided by some assumed mileage. Here the issue is not total depreciation, but only the reduction in value that can be attributed directly to additional mileage being driven.

We isolated the marginal per-mile depreciation by using standard tables from a used car guide (*11*). One of the characteristics for which specific adjustment factors are offered is the car's mileage. This starts from a standard mileage for a given model year, then adjusts the value up or down based on deviations from this standard mileage. The guide places each model into one of four different classes, with different depreciation rates. The classes correspond roughly to the cost of the vehicle when new; more expensive vehicles depreciate more per mile, in absolute terms (although perhaps less in percentage terms).

In this guide, the marginal bonus or penalty for non-standard mileage is larger for older cars than for newer ones, likely reflecting a belief that additional miles matter more as a car gets closer to the end of its expected useful life. To account for this, we use a different depreciation rate for cars more than four years old, as we did when estimating repair costs. Thus for each vehicle model, the "less than 5 years old" cost for its class is multiplied by the fraction of VMT that is driven by newer vehicles (explained in the section on repair costs), and the "5 years and older" cost by the fraction of VMT driven by older vehicles, to get an average per mile depreciation rate.

The per-mile rates that emerge from this are broadly consistent with other used-car price guides. While all these guides use their own methods for assigning value, and while certain specific situations may imply very high or low per-mile depreciation rates, in general the rates in other guides are in the range of the five to eight cents per mile that this methodology generates.

The Personal Vehicle Fleet

We used a motor industry publication (*12*) to estimate new car registrations by model. We calculated the number of each car model as a fraction of the total car fleet, and for each pickup model as a fraction of that fleet. These were broken out separately because high recent sales of pickups mean that fractions based on recent sales data would assign too much weight to pickups relative to their importance in the entire existing fleet. Thus we use the fractions for cars, multiplied by the per-model costs, to get an average total cost for cars; and the fractions for pickups to get an average total cost for pickups.

This paper gives cost values for the two categories separately, so that analysts using the numbers can adjust the ratio of cars to pickups to match local conditions. Currently (2003) the U.S. fleet as a whole is 55% cars, and 45% pickups. However, this ratio may vary considerably from one area to another, so a state- or area-specific ratio should be used if available. In addition, the EPA (10) indicates that this ratio will decline gradually over time as new pickup sales exceed new car sales; they assert that in 2013 the fleet will be only 40.5% cars. The analyst should consider the change in this ratio over time when estimating costs for projects that are much later than 2003. Pickups are also driven slightly more (12,600 miles) on average than cars (10,600 miles) (*10*). While this doesn't have a large impact on the overall average, the analyst may wish to incorporate an adjustment to account for this.

We also estimated a version of costs using Minnesota-specific model counts. The difference from the U.S. averages was negligible; the only significant local variation is likely to be in the ratio of cars to larger personal vehicles. This insensitivity to specific vehicle counts within the car and pickup categories also indicates that describing the fleet based on new vehicle sales is a reasonable approximation of the entire existing fleet; again with the exception of the split between cars and pickups.

THE COSTS OF OPERATING TRUCKS

The methodology for determining truck operating costs differs substantially from that for passenger vehicles because there are very different types of information available. For cars, there are many third party sources that estimate operating costs and resale values of different models, as a service to potential buyers. No similar service exists for trucks. This is probably because buyers of trucks are more knowledgeable about their purchases, and hence have less use for such services.

Estimates of truck costs are developed from research sources, which are in general aimed at different purposes than the present research. That is, they may include some fixed costs, or some costs that may vary with the number of trips but not with the number of miles driven. Thus the methodology for determining truck operating costs involves analyzing several estimates of these costs along with related information from other sources, and deriving a "consensus" estimate that corresponds to the specific costs of interest here.

While there are obviously many different sizes and types of trucks, we estimate a single composite value to account for all of them. This was done for two reasons. First, analysts will typically not have detailed counts of different types of trucks. Second, and more importantly, we could not establish robust estimates of the costs of operating different types of trucks. The available sources tend to focus either on long-haul tractor-trailer combination trucks, or on "all" commercial trucks; there does not seem to be much information on how types of trucks differ from each other.

The figures discussed here are for standard five axle "van" semi trucks assuming over-the-road interstate driving conditions. We take these trucks as being representative of trucks that would be affected by a typical highway construction project, both because they are the most common type, and because their costs are a midpoint between the other two major truck types that we considered; these were small delivery trucks, and heavy industrial/construction trucks.

Summary of Data Sources

We reviewed a number of sources of semi truck operating costs. These vary considerably in their age, purpose, and scope.

Roth (*13*) used data from annual financial reports submitted by major general freight carriers to the Interstate Commerce Commission. He addresses line-haul costs only. The primary purpose of the report is to help companies that have their own trucking fleets to compare their costs against for-hire trucking operations. The author acknowledges that the cost information as summarized in the report is to a significant degree subject to how given trucking companies chose to report their costs.

A technical report (*14*) done as part of the US Department of Transportation's Truck Size and Weight and User Fee Policy Analysis Study lists and briefly summarizes a number of previous studies that looked at trucking costs-per-mile. Using these sources and others, the authors developed estimates of cost per vehicle-mile as a function of vehicle configuration and operating gross vehicle weight (GVW) ratings.

Berwick (*15*) designed a spreadsheet simulation model which projects trucking costs for different truck configurations, trailer types, and trip movements. Cost assumptions within the model were derived from prior truck costing studies and interviews with various trucking experts.

A minor data source (*16*) was based on annual reports to the Interstate Commerce Commission from 48 long distance haulers of perishable agricultural products and solid refrigerated products.

The purpose of a study by Trimac Logistics (*17*) was to determine 2001 trucking costs for each of the provincial and territorial regions in Canada and to develop US-based trucker comparisons. The information used to set up and utilize this model was derived from a number of sources including quotes from suppliers of equipment, tires, and fuel; consultation with experts in the field; and review of relevant published literature.

Finally, Volvo Trucks (*18*) produces a short guide to help individual owner-operators understand their economic considerations and maximize profits. While it is generated by an equipment supplier, it is reportedly considered within the industry to be a legitimate and useful source of business and cost information pertaining to trucking operations.

These documents had differing data sources, methods, and assumptions behind their cost information. Our goal was to come up with figures that would reasonably and broadly reconcile with the information available in the sources identified above. Table 1 shows the costs taken from the key sources described above, both total and for specific categories of interest. In all cases except Volvo, the “total” costs include some amount related to driver wages and indirect costs. The dates in the “source” column are the years on which the analyses are based, not the year the report was published. The subsequent sections describe how we determined consensus values for purposes of this report.

Fuel

The literature we surveyed had fuel costs ranging from 17.3 to 21.6 cents per mile. Assuming nominal fuel costs at $1.25 (a rough average over the period when these studies were done) this range translates to a range of approximately 7.2 miles per gallon to 5.8 miles per gallon. The Volvo guidance document assumes an average of 6 miles per gallon. Conversations with trucking sources indicate that a big combination truck would get about 6.5 to 7 miles per gallon, and smaller delivery trucks about 9. Based on these facts, we assume 7 miles per gallon as the input for our model. As with gas prices, we use $1.50 per gallon to derive an easily adjustable baseline estimate for this paper.

Repair, Maintenance, Tires

In the literature we surveyed, scheduled maintenance and unscheduled repair are typically included together. Some sources (*15, 19*) indicate that it is likely that the actual rate of inflation for maintenance costs has been significantly less than the CPI over the past ten to fifteen years, and these prices might have even declined over this time. Thus we do not adjust the costs to a common base year. The literature shows a range of 7.1 to 15.5 cents per mile; excluding two outliers, the range is 10 to 12. A relatively dated source (*4*) indicates that large truck maintenance costs are about 3 times that of a mid-sized car. As car maintenance and repair costs in our model turn out to be about 3.5 cents per mile, we use an estimate of 10.5 cents per mile for truck costs. This is also consistent with the central estimates from the published sources.

The literature shows a range of 2.1 to 4.0 cents per mile for tire costs. We use 3.5 cents as a conservative midrange estimate. Again, this is about 3 times the cost per mile for tires for passenger vehicles.

Depreciation

Mileage-based depreciation is not broken out as a separate category in the published literature. The head of a small trucking company gave estimates of the values of trucks of a given age with differing mileage, which implied that the marginal impact of mileage independent of vehicle age is about 5 cents per mile. This is in the same range as the mileage-based depreciation for cars. This is probably reasonable since although trucks cost much more they also last much longer. Another somewhat dated source (*1*) estimates auto depreciation at 3.3 cents per mile, a 2-axle truck at 3.5 cents, and a 5-axle semi at 3.0 cents. While the numbers are dated, the point that all these different vehicles depreciate at about the same per-mile rate supports the trucker's ad hoc estimate.

Based on these sources, we use a depreciation rate that is derived from the rate for the most expensive cars. That is, we use the class 4 depreciation schedule, assuming that 70% of mileage is driven by trucks less than 5 years old, and 30% by trucks 5 years old and more. These assumptions lead to a depreciation rate of 8 cents per mile.

ADJUSTMENT FACTORS

The baseline costs described in the previous sections apply to a situation of "highway" driving, with very few stops, on smooth pavement, and they are in 2003 dollars. These costs should be adjusted in three ways that are specific to a given project: pavement quality, start-stop conditions or congestion, and inflation to future prices.

Although there is some consensus that gradients and curves also affect operating costs, we do not address these here, as they seem unlikely to be significant factors for most highway projects.

Pavement Roughness

While in the past there was some consensus that rough roads were associated with higher fuel consumption, it seems that the studies on which that conclusion was based were done in developing countries with much worse roads than the U.S. The consensus now is that there is no measurable difference in fuel consumption on paved roads of different roughness (*6*). Fuel consumption is higher on gravel roads, but since they are typically lightly traveled, they are unlikely to be the subject of a major benefit-cost analysis.

An early study of the impacts of pavement roughness on other operating costs (*4*) is very detailed; however, the impacts of roughness on operating costs seem unrealistically large, especially for smoother pavement levels. A more recent study (5) indicates that overall costs will only vary by a cent per mile or less within the range of pavement roughness typically observed in the U.S. This document, however, notes an upcoming comprehensive study on pavement quality and operating costs. This subsequent study (*6*) concludes that a unit increase in International Roughness Index (IRI) (in m/km) will lead to a $200 per vehicle per year increase in maintenance and repair costs. The range in IRI between the smoothest and roughest pavement likely to be encountered on a major U.S. highway is about 1.5, implying $300 in extra costs. Assuming 12,000 miles a year, this implies an extra cost of 2.5 cents per mile.

Given all this, we generate a "consensus" impact as follows. We take as a baseline that a Present Serviceability Index (PSI) of 3.5 or better (IRI of about 80 inches/mile or 1.2 m/km) will have no impact on operating costs. We then assign a maximum multiplier of 1.25 for PSI of 2.0 or worse (IRI of 170 inches/mile or 2.7 m/km), with an interpolated multiplier for roughness values between these two end points. The adjustments imply an extra cost of about 1 cent per mile between the smoothest and roughest pavement in maintenance and repair costs. However, because we also assume an impact on depreciation costs through reduced vehicle life, the total cost increase is about 2.5 cents per mile.

We apply these pavement roughness multipliers to maintenance, tire, repair, and depreciation costs. As noted earlier, fuel use is assumed to be unaffected by pavement quality. While there is no consensus in the literature that pavement roughness affects depreciation, we include it here as an extension of repair and maintenance costs. Experience suggests that a car that is driven almost exclusively on smooth highways will last more miles than one that is driven mostly on rough pavement. Since per-mile depreciation reflects the loss in "life expectancy" of the vehicle as it is driven more, factors that reduce the ultimate number of miles that the car can be driven must by implication be increasing the rate at which the car depreciates.

We assume that pavement roughness will affect large truck costs in the same way as car costs, as we could find no compelling evidence to suggest that these costs would differ.

Driving Conditions

"City" as opposed to "highway" driving conditions involve a greater number of starts and stops, and time spent idling. This clearly affects fuel use, as reflected in the dual fuel mileage estimates produced by EPA for vehicle models.

There is some evidence that stop-start conditions affect other costs as well, although here the impact is less clear. Brakes obviously will wear faster in city conditions, but tires and other parts will probably wear less due to the lower speeds. A consumer guide (*8, 9*) notes that vehicle manufacturers consider city driving to be “extreme” conditions, requiring more frequent maintenance.

As a compromise, we assume that tire wear does not depend on start-stop conditions, but that other maintenance and repair costs will be affected. However, the impact should not be as large as the impact on fuel use. Some of the increased fuel use comes from the time that the car spends sitting still; this should not impact wear on other parts. For repair and maintenance, we use a stop-start adjustment that is half as big as the adjustment for fuel use. For example, for cars, fuel use increases about 35% in city conditions, so repair and maintenance costs are assumed to increase about 17%.

We also assume that stop-start conditions will affect depreciation costs in the same way as they affect repair and maintenance. While driving conditions are not an adjustment factor for used car prices (*11*), this is in part because there is no way for the buyer to know the conditions under which the car has been driven. In terms of real loss of “life expectancy” though, it seems intuitive that a car driven in city conditions will not last as long as one that is driven mostly on the highway. And as with pavement roughness, a reduced vehicle life is equivalent to higher per-mile depreciation.

We assume, for lack of better information, that stop-start conditions will impact trucks in the same way that they impact pickups, which amounts to about a 31% increase in fuel, and 15% in maintenance, repair, and depreciation costs (excluding tires). These penalty percentages are slightly lower than those for cars because pickups (and trucks) incur a smaller fuel penalty for city driving, largely because they are not as efficient in highway driving as cars are. Because the penalty for other costs is derived from the fuel penalty, this is lower as well.

Price Changes

Because there is no clear trend or pattern to fuel prices, probably the best number to use is whatever the current price is, unless the analyst has some other forecast of future prices for the period under consideration. This is true of both gasoline (for personal vehicles) and diesel (for commercial trucks) prices.

For maintenance and repair (excluding tires), we recommend a 3% annual price increase, based on consumer price indices (CPI) for the U.S. for the last 20 years. Although truck maintenance and repair costs appear to have inflated very little in the last 10 years (*15, 19*), we assume that in the future they will inflate at the rate assumed for automobile maintenance costs, or 3% per year. The stable prices in the past appear to have been at least in part a result of deregulation and increasing competition in the industry; an impact which will likely not continue in the future.

Tire costs have not had any inflation for the last 20 years according to the CPI. Thus we recommend no inflation factor.

We recommend no inflation factor for depreciation, as auto prices appear from the CPI to have been steady for several years. For both depreciation and tires, a cost inflation factor could certainly be included if the present price stability is significantly disrupted in the future.

SUMMARY

The objective of this research was to reconcile the many available sources of information on vehicle operating costs in order to develop some simple parameters that analysts can use to understand how these costs change as a result of the new conditions created by highway projects or by the construction itself. Thus it is important not just to have a baseline value for these costs, but also to understand how to adjust the costs to account for variations in factors such as start-stop conditions, pavement roughness, and price inflation for future projects.

Table 2 shows baseline per-mile costs in 2003 U.S. cents for automobiles, pickups (including other large personal vehicles), and large commercial trucks. These costs are derived from a baseline scenario of "highway" driving conditions, smooth pavement, and fuel prices of $1.50 per gallon. As the various categories of cost are broken out separately, it should be straightforward for the analyst to adjust for different fuel prices, apply appropriate inflation rates to each category, or make other desired adjustments. To get an average cost for the entire personal vehicle fleet, the car and pickup costs should be weighted according to their proportion of the local fleet, if this information is available; otherwise, according to the ratios outlined in the "Personal Vehicle Fleet" section of this paper.

A point that is worth addressing explicitly is the size of the variable cost estimates for large commercial trucks; 43 cents per mile may seem low relative to total costs of about $1.80 per mile. However, assuming that the driver costs $30/hour in wages and indirect costs, and that the truck travels a mile in one minute, leads to a result of 50 cents per mile in driver costs. The variable cost of 43 cents is 33% of the non-driver total cost of $1.30. This compares quite precisely with automobile variable costs, which at 15 cents per mile are 33% of a typical "total" operating cost of 45 cents per mile, as cited for example in American Automobile Association brochures.

Table 3 shows per-mile costs given "city" rather than "highway" conditions, with other assumptions the same. Projects with a mix of highway and city conditions could be analyzed using costs in between those in Tables 4 and 5. Projects involving extreme congestion levels could use fuel costs that are even higher than those in Table 5; the analyst could judge an appropriate level to use. However, other costs seem unlikely to be greatly influenced by increasing congestion levels, beyond what is already due to "city" driving conditions.

Table 4 shows per-mile costs given extremely rough pavement (PSI = 2), again with other assumptions the same as the baseline. We use PSI of 3.5 as the baseline, so roughness levels between these extremes could be evaluated by interpolation. Pavement smoother than PSI of 3.5 will not further reduce costs; pavement rougher than PSI of 2 (or unpaved roads) could use higher multipliers; the analyst can make this judgment.

To incorporate both rough pavement and “city” driving conditions at the same time, the appropriate marginal increases due to each factor should both be added to the baseline cost estimates.

Our passenger vehicle cost estimates are comparable to those in other published sources (*2, 3*); the intent of this paper was not to develop new estimates, but rather to simplify and clarify the assumptions and methodologies underlying them.

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LIST OF TABLES

TABLE 1 Truck Literature Cost Summary (Cents per Mile)

Source	Total costs*	Fuel	Maint./Repair	Tires
Roth (13), 1992	121	17.3	12.0	2.5
Faucett (14), 1988	109	21.6	10.9	3.5
Berwick (15), 1996	104	19.0	10.0	4.0
USDA (16), 1995	108	19.1	15.5	2.8
Trimac (17), 2001	174	24.4	10.5	3.5
Volvo (18), 2000	64	20.8	7.1	2.1

* Total costs include driver costs except for Volvo, and other non-marginal costs.

TABLE 2 Baseline Costs (Cents per Mile)

Cost Category	Automobile	Pickup/van/SUV	Commercial Truck
Total Marginal Costs	15.3	19.2	43.4
Fuel	5.1	7.8	21.4
Maintenance/Repair	3.1	3.7	10.5
Tires	0.9	1.0	3.5
Depreciation	6.2	6.7	8.0

TABLE 3 Costs with City Driving Conditions (Cents per Mile)

Cost Category	Automobile	Pickup/van/SUV	Commercial Truck
Total	19.1	23.1	52.9
Fuel	7.0	10.1	28.0
Maintenance/Repair	3.7	4.2	12.1
Tires	0.9	1.0	3.5
Depreciation	7.5	7.7	9.2

TABLE 4 Costs with Poor Pavement Quality (Cents per Mile)

Cost Category	Automobile	Pickup/van/SUV	Commercial Truck
Total	17.9	22.0	48.9
Fuel	5.1	7.8	21.4
Maintenance/Repair	3.9	4.6	13.1
Tires	1.1	1.2	4.4
Depreciation	7.8	8.4	10.0