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WHERE THE RUBBER MEETS THE ROAD:

Reforming California's Roadway System

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EXECUTIVE SUMMARY

California's roadway system with an estimated value over $100 billion is in serious trouble both financially and physically. These roadway problems affect a lot of people; California's roadways serve about 26 million vehicles and consume about eight billion hours of traveler's time each year.

As most drivers know from jarring firsthand experience, the physical condition of California's roadways is terrible: only 62 percent of California's interstate system and less than 40 percent of the arterial and collector system is in good condition. Worse still, roadway quality is decreasing even as congestion increases. Of the eight most traffic-congested cities in the United States, four are located in California. Fifty percent of the miles in California's urban freeway system experiences volume-to-capacity ratios greater than 95 percent during peak periods. Nearly 10 percent of the principal urban arterials and almost 7 percent of the minor arterials face similar congestion levels.

Financially, the integrity of the California roadway finance system is also in disrepair. There is not enough money available to fund the perceived "needs" of California's transportation agencies for roadway maintenance and new capacity—reconstruction and resurfacing backlogs alone exceed $16 billion on major California roadways.

An oft-proposed solution to this problem is a general increase in motor fuel taxes. This idea is flawed, however, because it fails to address the underlying problems with the structure of California's transportation funding system. In fact, the reliance on a fuel-tax financing system is a large part of the problem. The very nature of the fuel tax finance system tends toward financial insolvency because of its noneconomic pricing and noneconomic transportation project selection methods. Increasing fuel taxes would only make things worse, leading to the

overpricing of low-cost roads, and wasteful under-utilization of the off-peak capacity of expensive roads.

Detailed examination of the sources and the uses of California roadway revenues reveals that:

×Automobile users are not only paying their way, they are overpaying. Of the nearly $16 billion collected from auto-users through gasoline taxes, license fees, registration fees and user tolls, less than $12 billion is actually used to build, maintain and operate California roadways. Of that $12 billion, almost $4.5 billion is used to subsidize mass transit and for transportation planning in California.

×Failure to differentially price the most expensive capacity (usually the peak, urban capacity) leads to overuse of these facilities and deterioration in their performance due to congestion. More than 56 percent of all vehicle miles traveled in the state occur on just 4.5 percent of the centerline miles and 12.2 percent of the lane miles in the state.

×The lack of pricing signals on these expensive urban roadways leads to continually increasing congestion which, in turn, leads to pressure for new, ever more expensive capacity. This capacity may be built even if the expansion is too expensive to be financed solely by its users. Predictably, this new capacity also displays deteriorating performance over time.

×The subsidization of expensive roadways leads to under-funding of less-expensive roadways. Revenues collected from some locales and roadway users must be used to subsidize others' new capacity, leaving less revenue for the expansion and maintenance of their own local roadways, as illustrated by the statistics on poor roadway conditions cited above.

Overall, the problem with roadway financing in California is not a lack of funds. The problem is that the available funds are not used rationally. The current system of financing leads to a ninefold under-pricing of congested capacity, and a twofold overpricing of uncongested capacity. As things stand, roadway users pay about two cents per vehicle mile traveled on congested roads, instead of the eighteen cents per mile traveled that they should be paying. Users of uncongested roads also pay about two cents per mile traveled while they should only be paying one cent per mile traveled.

Rather than make things worse by increasing fuel taxes or other noncongestion related fees, the solution to California's roadway problems lies in phasing in more rational pricing mechanisms. Short-term financing difficulties can be solved by instituting congestion pricing on the most easily priced parts of the system, namely the urban freeway and arterial system. Off-peak and low-peak charges ranging from one cent to about four cents per vehicle mile traveled and average high peak charges around eighteen cents per vehicle mile traveled on urban freeways and arterials should provide sufficient revenue to cover short-run costs. Long-term solutions will probably depend on the reconstruction of roadways to higher durability standards and the extension of differential pricing to automobiles and trucks to account for the disparate impacts that these forms of transportation have on the California roadways.

I. INTRODUCTION

The current system of roadway pricing and finance in California primarily employs fees applied to retail motor-fuel sales. Consequently, most users of roadways pay a price for road use that is in proportion to fuel consumed, rather than in a manner that corresponds to their individual imposition of costs on the particular roadways actually used. The lack of correspondence between actual roadway costs and prices paid for using roads can be linked to both the poor operating characteristics of California roads and the deterioration in the financial competence of the road-finance system.

This paper discusses a reform of California's roadway finance process that seeks to avoid the degenerative consequences of the current, non-cost-based system. The paper first reviews briefly the key issues raised by the current system of pricing and finance, the broad trends in roadway use and finance, and the current structure of roadway finance. The paper then identifies opportunities for cost-effective reform of the current structure and discusses how a more robust road-pricing scheme might be implemented. The paper concludes with discussion of the public administrative issues in implementing such a reform.

II. ISSUES IN ROADWAY FINANCE IN CALIFORNIA

As will be detailed below, the current system of highway finance in California is dependent largely on taxes applied to motor-fuel sales. In 1993, approximately two-thirds of total revenues used for building, operating and maintaining the roadway system in California were derived from motor-fuel taxes levied by the federal government or the State of California. With the exception of bridge tolls, the other sources of roadway revenue consist of sales taxes, property taxes and other fees which are not usage dependent. Consequently, roadway users in California pay for their roads through a pricing mechanism that depends primarily on total vehicle miles traveled (VMT) and the effective fuel efficiency of the vehicles, and only secondarily on sources that are independent of usage altogether.

In contrast, actual roadway costs depend importantly upon the capacity demands placed on facilities by individual users, the cost of building and operating that capacity, and the user's contribution to wear-and-tear of roadway surfaces and structures. These costs vary sharply with different locales and specific facilities, the type of vehicle being used, and whether or not use occurs during periods that impose significant capacity costs. Clearly, a tax that depends on fuel usage and non-usage-based fees will not well reflect this pattern of costs.

The dissonance between user fees paid via fuel taxes and the actual cost of using a roadway can be great in some circumstances. The average automobile user in California implicitly pays total fuel taxes equal to approximately 2.3 cents per VMT, with some variation, because of the vehicle type and local operating conditions. In contrast, as we will see, the proper road-user charges may exceed eighteen cents per vehicle mile, a ninefold pricing error. Road-user fees associated with heavy truck activity display even greater dissonance between the current, and optimal, charges.

Deviations from cost-based pricing create serious consequences for the utilization and financial integrity of the California roadway system. Indeed, the consequences of reliance on a non-cost-based system of pricing and finance are apparent in several trends in California’s highway economy.

First, existing roadway capacity is inefficiently utilized; without a pricing system that relates to specific roadway costs, users have no incentive to ration their use of facilities that are costly, or during times when use is particularly burdensome. The consequence is congestion, excessive roadway wear-and-tear, and reduced use of vehicles that make more efficient use of roadway capacity, such as buses, carpools, and other high-occupancy vehicles. In a study on roadway congestion completed by the Texas Transportation Institute, four of the top eight cities in the United States with the most serious roadway congestion were located in California.

Second, the financial integrity of the roadway-finance system is weak. The revenue that the current system of finance is generating is not keeping pace with the perceived "needs" for roadway maintenance and new capacity. Currently, reconstruction and resurfacing backlogs alone exceed $16 billion on major California roadways, and only 62 percent of the interstate system and less than 40 percent of the arterial and collector system is in good condition. Competition for the available pool of highway funds is intense, and its allocation to individual projects is increasingly a matter for debate and political exertion.

The problem is not simply a matter of flat motor-fuel taxes not being "high enough." The very nature of the fuel-tax finance system is such that it tends toward financial insolvency because of noneconomic pricing and project-selection methods:

- The failure to differentially price the most expensive capacity (usually the peak, urban capacity) leads to overuse of these facilities and deterioration in their performance (congestion);

- The performance deterioration, in turn, leads to pressure for new (even more expensive) capacity. This capacity may be built, even if the expansion is unable to be financed by its users. And ultimately, without appropriate pricing, this new capacity, too, displays deteriorating performance;

- Revenues collected from other locales and roadway users must be used to subsidize others’ new capacity, potentially resulting in conditions of undercapacity and undermaintenance on those portions of the roadway system, as illustrated by the condition statistics cited above.

The tendency toward insolvency might be addressed by having a fuel tax (or other flat VMT charge) that is high enough to simulate proper pricing on peak use of the expensive facilities. This would eliminate the tendency for some portion of the system to be overused and break the tendency to add noneconomic capacity. But this system would generate revenue far in excess of costs during the off-peak, and on low-cost facilities. This would further the *over*pricing of low-cost roads and lead to inefficient underuse of off-peak capacity of expensive roads.

Thus, the fundamental problem is one of the *structure* of fees, not the average *level*. Indeed, under the current system, it is possible that the average level of fees is too high in some regions at the same time that the public- roadway sector has drifted toward insolvency. This is because of its bias toward making inefficient use of existing capacity and building noneconomic capacity in response to the resultant performance deterioration. Consequently, as we shall see, it is very likely that California could solve its roadway finance problems with *less* total revenue than it collects today.

III. CURRENT SOURCES AND USES OF CALIFORNIA ROADWAY REVENUES

Before embarking on a description of potential reforms, it is helpful to review the current sources and uses of California roadway revenues. One of the consequences of nonfacility specific pricing mechanisms is that the revenue-collection system does not reveal directly the contribution that users in any particular facility or corridor make to the overall revenue stream. Table 1 displays the major sources and uses of roadway revenues in California in 1993. There is a very complex and variable pattern of distribution of the sources and uses of roadway revenues that is only meant to be approximated by this table.

Table 1: Major Sources and Uses of Transportation Revenue in California

Sources			Uses						
	Units	Revenue $Millions	State Hwys, Bridges	County Roads	City Streets	CA Transit, Transp. Planning	Non-CA Highways	Non-CA Transit, Transp. Planning	Other
1. Federal Taxes									
Gasoline Excise Tax	Gallons	$2,346							
Diesel Excise Tax	Gallons	407							
Truck & Trailer Use Tax	Value	155							
Use Tax (est.)	Weight	81							
Tire Tax (est.)	Sales	34							
Total		$3,023	$1,918	$87	$88	$463	($82)	($244)	$794
2. State Taxes									
Vehicle Fuel License Tax (gas)	Gallons	2,295							
Use Fuel Tax (diesel, et al.)	Gallons	301							
Subtotal		$2,596	$1,304	$460	$470	$362			

Retail Sales & Use		$863				863			
Bridge Tolls		171	146			25			
Total		$3,630							
3. Registration & License Fees									
Registration Fees		$1,488	$935						$553
Vehicle License Fees		$2,901		$9	$57				$2,835
Total		$4,389							
4. Local Taxes and Fees									
Sales and Use ×County Trans. ×Spec. Dist. Taxes	Gen. Sales Gen. Sales	690 1,805		72		583 1,761			23 46
Road & Street	Varies	157		23	134				
Transit Fares	Fares	421				421			
General Fund	Varies	655		32	623				
Other Local Sources	Varies	1,009		213	796				
Total		$4,737							
Grand Total		**$15,780**	**$4,303**	**$896**	**$2,168**	**$4,478**	**($82)**	**($244)**	**$4,251**

As the table indicates, in 1993 approximately $16 billion was collected from various federal, state, and local transportation-related levies, with approximately $7 to $8 billion being spent ultimately on roadways in California. The remainder is spent on transit, transportation planning, administration, and contributions to various general funds (including federal deficit reduction). From this perspective, it appears that motor-vehicle transportation in California generates more revenue than it receives. However, sales and use taxes, and vehicle license fees (which are levied in California in lieu of property taxes) are classes of broad-based taxes applied elsewhere in the California economy for general fund purposes, and thus probably cannot be viewed entirely as user-fee mechanisms. Only motor-fuel taxes and registration fees qualify on this basis. Hence, on average, highway user-specific fee devices in California generate revenues very close to the total spent on California roads, although the allocation process is hardly a straightforward one.

A. Current Funding Sources

The primary roadway-related fees in California, in descending order, are motor-fuel taxes, local sales taxes and other local fees, and vehicle registration and license fees, and bridge tolls.

1.Motor-Fuel Taxes

The sale of retail motor-fuel tax in California in 1993 was subject to three major tax increments:

·a federal excise tax of 18.4 cents per gallon for gasoline and 24.4 cents per gallon on diesel fuel;

·a state excise tax (Motor Vehicle Fuel License Tax) of 17.0 cents per gallon of gasoline, and a Use Fuel Tax of 17.0 cents per gallon of diesel or gasohol; and

·a general statewide sales and use tax of 7.25 percent of the retail price, plus county, city and special district increments. (County and city increments may not exceed a total of 1.25 percent. The current highest rate is 8.5 percent.)

The federal excise tax on motor fuel is levied partially for transportation purposes and partially for general fund ("deficit reduction") purposes. Of the 18.4 cents per gallon levied on gasoline, 10 cents goes to the Highway Trust Fund for highways, and 1.5 cents goes to the mass transit account of that fund. Of the 22.4 cents per gallon of diesel fuel, 16 cents goes to highways, and 1.5 cents goes to the mass transit account. Another 0.1 cents is dedicated to a leaking underground storage tank trust fund. The remainder of each tax goes to deficit reduction (currently 6.8 cents for both fuel types).

The state fuel tax is actually composed of two different taxes, one for gasoline, and one for nongasoline fuels. The effective state fuel tax is the same for gasoline, diesel and gasohol fuels, but is less for alternative fuels such as LPG.

2.Bridge and Highway Tolls

A minority of California's roadway facilities currently are priced using facility-specific tolls. At present, only bridges are priced with tolls, the revenues of which are used primarily for bridge and associated roadway purposes. However, the Golden Gate Bridge and Transportation District, in the San Francisco Bay Area, employs some of its toll revenues to finance a bus and ferry transit system. Total revenues from all tolled bridges in California currently are approximately $170 million.

Toll roads are being built in Orange County, California, by two transportation corridor agencies, and in Orange County and elsewhere by private development consortia. At this time, they are not in operation and are not represented in this analysis. However, the use of time-sensitive tolls to finance new roadway capacity is an important change in California highway finance and is consistent with later recommendations in this paper.

3.Vehicle Registration and License Fees

California levies vehicle registration fees annually, applying flat registration fees to automobiles, and flat plus (unladen) weight and axle fees on single- and multi-unit trucks. A total of 26.1 million vehicles were registered in California in 1993, consisting of 17.3 million automobiles, 5.5 million trucks, 2.7 million trailers, and 0.6 million motorcycles. Of the 5.5 million trucks, approximately 200,000 are heavy, multi-unit trucks.

Table 2 summarizes the effective rate ranges for automobiles and trucks as of 1993. The table also provides estimates of the average registration fees and fuel taxes per VMT by vehicle type, estimated by using both California and national statistics.

Table 2: Typical California Vehicle Registration and Fuel-Tax Fees (1993)

	Registration Fee			Fees Per VMT (cents)		
Vehicle Type	Flat Fee	Weight and Axle	Total	Registration Fee/VMT	Est. Fuel Taxes/VMT	Total
Automobile	$28	$0	$28	0.25	2.10	2.36
Motorcycle	28	0	28	1.22	0.91	2.13
Single Unit Truck						
×2-Axle, 3,000 lbs.	28	8	36	0.30	3.16	3.45
×3-Axle, 15,000+ lbs.	28	952	952	7.68	6.10	13.78
Multi-Unit Truck						
×Truck Tractor Only	28	327	355	0.59	7.98	8.57
×3-Axle Tractor-Trailer	56	607	663	1.09	8.79	9.88
×5-Axle Tractor-Trailer	56	1,470	1,526	2.47	8.94	11.41
×Twin Tractor-Trailer	84	1,890	1,974	3.14	9.10	12.24

In addition to vehicle registration fees, California levies a license fee equal to two percent of the vehicle's estimated market value in lieu of a personal-property tax. Market value is determined from purchase cost minus a simple depreciation factor each year. License fees are estimated to total $3.06 billion in 1993–1994 and are administered by the Department of Motor Vehicles. The revenues from this fee (net of administration costs) are dedicated to local governments and are not earmarked for transportation uses, although some local governments do make such use of these revenues.

4.Sales and Use Taxes

Sales, use taxes, and other excise taxes are levied by both federal and state authorities. At the federal level, a truck and trailer use tax of 12 percent is applied to the purchase price of heavy trucks and trailers. In addition, a use tax, based on weight, is levied on trucks, and an excise tax levied on the sale of tires.

In California, sales taxes are levied on purchases of motor fuel at the total effective local rate. Of the state sales tax component (currently 5.5 percent) that is collected on motor fuel sales, 4.25 percentage points are earmarked to nonhighway transportation uses (transportation planning and transit finance). In addition, local sales-tax increments of 0.25 percent (applied to the full retail sales base) are in place in selected California counties to augment local transportation improvement financing (which may include roadways). Finally, special district rates (of up to 0.5 percent) are applied in special transportation districts, generally for financing local transit.

5.Local Taxes and Other Fees

The other main sources of roadway revenues consist of various local revenue devices, including road and street levies, parking fines and traffic citations, general fund sources, and earmarking of other local revenue sources, such as sales tax revenues and fees. These revenue sources are used primarily to finance city and county road development and maintenance, and other expenses associated with the city and county roadway network. In 1993, local revenue sources provided $237 million for county road purposes, and $1.207 billion for city street purposes.

B. Current Funding Uses

As indicated earlier, approximately $7 billion to $8 billion of the various taxes and fees associated with the use of motor vehicles in California are spent annually on the roadway activities of the state and the constituent cities and counties. Approximately 60 percent of the spending is associated with state-administered roadways and 40 percent by counties and cities. (See Table 1.)

As Table 3 indicates, approximately 46 percent of total disbursements for roadways is associated with capital outlays for reconstruction and new-facility development, with 24 percent disbursed for the maintenance of existing facilities. The remaining 30 percent is used in administration, law enforcement, and financing. State-administered roads receive 56 percent of all capital disbursements, but only 25 percent of disbursements for maintenance, reflective of the generally greater capacity and durability characteristics of state, versus local, roadway facilities.

Table 3: Aggregate Shares of Revenues and Disbursements in California

	Shares of Total
Revenues	

Road User Taxes ×Federal ×State ×Local	66.4% 19.1 47.3 0
Bridges and Ferry Tolls	1.4
General Funds	13.1
Property Taxes	2.0
Miscellaneous	15.5
Bond Proceeds	1.7
Total Revenues	**100.0%**
Disbursements	
Capital Outlay ×State Administered Highways ×Locally Administered Roads ×Federal and Unclassified	45.7 25.4 20.2 0.2
Maintenance ×State Administered Highways ×Locally Administered Roads ×Federal and Unclassified	23.7 5.9 17.8 0
Administration and Misc.	11.3
Law Enforcement and Safety	18.2
Interest	0.7
Bond Retirement	0.4
Total Disbursements	**100.0%**

Capital and maintenance outlays by state agencies can be attributed further to individual roads by functional classification. In addition, fuel tax revenues can be crudely allocated to road classes using an estimate of average fuel tax paid per VMT. However, spending on capital and maintenance by local governments is not allocable, as it is not reported on a functional classification basis. Similarly, administrative, law enforcement disbursements, and nonfuel tax revenue cannot be attributed to road class. The attribution of revenues and disbursements by road classification is summarized in Table 4.

Because of the lack of detailed disbursement data, it is not possible to discuss with precision the pattern of cross-subsidization that occurs in order to yield the observed pattern of capital and maintenance outlays on the various classifications of California roadways. However, it is apparent that fuel-tax revenues generated on most minor roads (urban minor arterials, and rural and urban collectors and local roads) are insufficient to support the observed city and county levels of capital and maintenance outlay. (From Table 4, in the aggregate, users of these roads pay approximately $1.5 billion in fuel taxes, but enjoy capital and maintenance outlays of about $3.0 billion.)

In this sense, the current system of roadway finance in California is tantamount to one that relies primarily on fuel tax revenues for freeways and other major facilities, but primarily uses registration, sales-tax revenue, and other mechanisms, such as property taxes, for minor facilities. This is, of course, not the way the actual pricing and investment policy is articulated, but simply an implication of the observed pattern of revenues and disbursements. This aggregate analysis also conceals the important cross-subsidization that occurs within a road classification among users of various particular facilities, capacity to serve traffic at various times of day, and vehicle types. We will return to this issue in the next section of this report.

Table 4: Revenues and Disbursements by California Roadway Class (1992)

Road Classification	Characteristics		Revenues and Disbursements			
	Lane Miles	Annual VMT (Millions of Miles)	Est. Fuel Tax Revenues	Capital Outlay	Maint. Outlay	Total Outlay
1. Urban						
Interstate	7,556	52,566	$1,051	$397	$100	$497
Other Freeway	7,518	42,332	847	417	73	490
Principal Arterial	23,015	52,476	1,050	538	39	577
Minor Arterial	26,802	35,322	706	6	2	8
Collector	20,373	12,937	259	0	0	0
Local	104,382	14,718	294	0	0	0
Urban Subtotal	189,646	210,351	$4,207	$1,358	$214	$1,572

2. Rural						
Interstate	6,362	14,322	$286	$111	$64	$175
Other Fwy/pr. art.	10,124	14,669	293	231	80	312
Minor Arterial	13,924	8,846	177	153	132	285
Major Collector	25,958	9,297	186	18	18	36
Minor Collector	17,103	2,857	57	0	1	1
Local	108,950	2,206	44	0	0	0
Local Subtotal	182,421	52,197	$1,043	$513	$295	$809
3. Unallocable by Road Class						
Local Gov't Capital & Maint.				$1,571	$1,384	$2,955
Law Enforcement						1,420
Administration and Other			3,009			963
Non-Fuel Tax Revenues						
Non-CA Highway Uses						540
Total	**372,067**	**262,548**	**8,260**	**3,443**	**1,894**	**8,260**

The statewide averages, of course, understate the variation at various regional and local levels. Somewhat larger or smaller percentages of VMT and facility mileage are affected by congestion across California's many urban areas. However, this review of the performance characteristics of California roads underscores how unreasonable it is to expect a system of flat fuel taxes and other nonusage specific fees to properly price facilities that have such different characteristics and levels of utilization.

IV. THE PERFORMANCE OF THE CALIFORNIA ROAD SYSTEM

The road system in California is one of the most extensive in the world, with impressive physical and utilization characteristics (see Tables 5a and 5b). There are almost 400,000 lane-miles and 200,000 centerline miles of roadway in California, excluding forest and other nonpublic roads. The largely urban character of California, however, results in a concentration of activity on relatively few urban facilities. Over 80 percent of all VMT occur on urban roadways representing, in the aggregate, only about one-half of total lane- and centerline mileage in the state. Moreover, over 56 percent of all VMT in the state occur on just 4.5 percent of the centerline miles, and 12.2 percent of the lane miles in the state.

The peak-capacity problems are concentrated in these same, intensively utilized facilities. Fifty percent of the miles in the urban freeway system experience volume-to-capacity ratios greater than 0.95 during periods of peak utilization, as well as 9.9 percent of the principal urban arterials and over 6.6 percent of the minor arterials (see Figure 1). Assuming average peaking ratios, this suggests that approximately 23 billion urban VMT in California each year are produced under severe congestion conditions, with 41 billion VMT or so experiencing modest congestion, on facilities with volume-to-capacity ratios greater than 0.70. In rural areas, these figures are approximately 0.7 to 2.5 billion VMT. On a statewide basis, therefore, approximately 10 to 20 percent of all urban VMT (and 1 to 5 percent of rural VMT) is produced under conditions of moderate to severe congestion. On a system mileage basis, the problem affects 3 to 8 percent of the urban centerline mileage, and 0.3 to 1.2 percent of the rural centerline mileage.

Table 5a: Physical Characteristics of the California Roadway System

Road Type	System Physical Characteristics					
	Lane Miles	% of All Lane Miles	Centerline Miles	% of All Centerline Miles	% of Centerline Miles in Good Condition	Average Lanes/Miles
1. Urban						
Interstate	7,556	2.0%	1,028	0.5%	69.0%	7.4
Other Freeway	7,518	2.0	1,381	0.7	70.0	5.4
Principal Arterial	23,015	6.2	6,307	3.3	53.0	3.6
Minor Arterial	26,802	7.2	9,569	5.0	30.0	2.8
Collector	20,373	5.5	9,510	4.9	26.0	2.1
Local	104,382	28.1	57,990	30.2	N/A	1.8
Urban Subtotal	**189,646**	**51.0%**	**85,785**	**44.5%**	**37.3%***	**2.2**
2. Rural						

Interstate	6,362	1.7%	1,374	0.7%	62.0	4.6
Other Freeway/Pr. Art.	10,124	2.7	3,807	2.0	68.0	2.7
Minor Arterial	13,924	3.7	6,763	3.5	43.0	2.1
Major Collector	25,958	7.0	12,834	6.7	29.0	2.0
Minor Collector	17,103	4.6	9,139	4.8	28.0	1.9
Local	108,950	29.3	72,633	37.8	N/A	1.5
Rural Subtotal	**182,421**	**49.0**	**106,550**	**55.5**	**37.2***	**1.7**
Total	**372,067**	**100.0%**	**192,335**	**100.0%**	**37.2%**	**1.9**

* Values are weighted average, computed from data from tables 5a and 5b.

Table 5b: Utilization Characteristics of the California Road System (1993)

Road Type	Traffic Characteristics					
	Annual VMT (millions of miles)	% of Total VMT	Daily VMT per Lane Mile	% of Centerline Mileage at V/C>0.70	% of Centerline Mileage at V/C>0.80	% of Centerline Mileage at V/C>0.90
Urban						
Interstate	52,566	20.0%	19,060	83.6%	76.4%	57.9%
Other Freeway	42,332	16.1	15,427	66.0	59.5	45.5
Principal Arterial	52,476	20.0	6,247	41.9	26.5	9.9
Minor Arterial	35,322	13.5	3,611	22.5	26.4	6.6
Collector	12,937	4.9	1,740	9.5	6.2	2.1
Local	14,718	5.6	386	0.0	0.0	0.0
Urban Subtotal	**210,351**	**80.1%**	**3,039***	**8.7%***	**6.3%***	**3.1%***
Rural						
Interstate	14,322	5.5%	6,168	27.3%	19.7%	5.6%
Other Frwy/Pr. Art.	14,669	5.6	3,970	12.2	8.3	5.7

Minor Arterial	8,846	3.4	1,741	7.2	3.5	0.9
Major Collector	9,297	3.5	981	2.8	2.3	1.6
Minor Collector	2,857	1.1	458	0.5	0.4	0.2
Local	2,206	0.8	55	0.0	0.0	0.0
Rural Subtotal	**52,197**	**19.9%**	**784***	**1.6%***	**1.1%***	**0.5%***
Total	**262,548**	**100.0%**	**1,933***	**4.8%***	**3.4%***	**1.7%***

* Values are weighted average, computed from data from tables 5a and 5b.

V. PRICING AND INVESTMENT: THEORY VS. CURRENT POLICY

The purpose of economically efficient pricing and investment policy is to minimize the cost of providing goods and services in the economy. Conversely, if a system of pricing and investment is not implemented properly, economic resources are wasted, and the level of well-being in a society is less than it otherwise would be.

While economic efficiency is important to any sector of the economy, it is clearly important to a sector of the size and central role of highway transportation. The principles by which the California road system operates affect the utilization of 26 million vehicles, 8 billion hours of travelers' time, and roadway infrastructure and rights-of-way that likely have a current value in excess of $100 billion. The central role of highway transportation in determining land-use patterns and the cost of other goods and services means that distortions arising in the highway transportation sector will manifest in distortions in a wide variety of other marketplaces.

In this section, we develop a model of what optimal pricing and investment policy would look like were it applied to the California road system and contrast it to the system currently in place.

A. Efficient Pricing and Investment: The Theory

Efficient use of economic resources requires attention to both pricing and investment policy and the coordination of these policies. The efficiency role of road user charges is to communicate to road users the actual cost increments they impose on society. By asking users to pay these so-called *marginal costs*, they are induced to economize on their use of valuable resources, rather than dissipating those resources on frivolous or low-value activities. Road-user charges thus can be seen as devices for economizing on the use of resources associated with existing roads.

The efficiency role of investment policy is to optimize the addition of new capacity to the road system; new capacity should only be added when its costs are exceeded by the new benefits or savings in other resources that attend the use of the new capacity. Investment policy thus is linked to pricing policy because the amount and characteristics of roadway capacity affect the costs of use and, hence, the marginal cost-based road-user charges that the users should bear.

1.Setting Roadway Prices

Setting roadway prices correctly (close to the costs occasioned by each user) is important if the policy is to be fair and is to produce economic benefits. It follows from the theory of congestion pricing that roadway prices should reflect the cost of using roadways. Most roadways and bridges are already in place, and in some cases they already have been "paid for" in the sense that bond debt or other borrowing used to finance their construction has been retired, perhaps long ago. But usage does impose incremental costs in several important ways. First, the use of an existing road imposes maintenance cost burdens, which vary both by the type of vehicle and the durability of the facility. Hence, at least one element of marginal road-user costs would be differentiated by vehicle type and roadway characteristics. As we will see, this issue is particularly important in differentiating between the user charges faced by automobiles versus those faced by heavy trucks.

Second, there is another important recurring cost of travel: the time that users spend on the roadway and the delays they cause one another. Although individual road users bear their own time costs, they do not bear the time costs they impose on other users. When drivers add their vehicles to the traffic stream on a busy road, they slow down traffic and delay other travelers, essentially imposing costs against the will of other users. Marginal road-user charges should reflect these social time-cost burdens so that users' behavior is conditioned to the time costs they impose upon others. This component of road-user charges is the *congestion-pricing* element of road-user charges.

Congestion prices vary with two main conditions: the ambient volume of traffic already on a road relative to its capacity and the performance of the vehicle that is adding itself to the traffic stream. For roadways with very light levels of traffic, congestion prices would be very small. But speeds drop quickly as roads become congested, implying that an additional vehicle adds significant overall time penalties to the traffic stream. For a typical freeway that is operating near its practical capacity, aggregate delay penalties of 10 minutes or more may be experienced by other traffic for each new vehicle-mile traveled by the additional vehicle. Depending upon the implicit value that the other traffic places on that time, the appropriate congestion price thus may be very high. And the appropriate price will vary with the vehicle's characteristics as well; a heavy and slow vehicle, such as a truck or bus, imposes delays that are equivalent to four or five automobiles.

2.Road User Charges and Investment Policy

Thus far in this discussion, road-user charges seem to bear no obvious relationship to the cost of building roads. They seem to be calculated only from assignment of incremental maintenance costs (which depend upon the type of vehicle and the durability of the roadway) and the congestion-time burdens (which depend upon current road conditions and the type of vehicle). In fact, however, if the process of building new roads is properly integrated with congestion pricing, congestion charges ultimately do bear a relationship to construction costs. The reasoning is simple but frequently overlooked in discussions of road pricing.

The logic is as follows. Road-user charges reflect the incremental cost of providing service to an additional vehicle on an existing road. An alternative way of accommodating an additional vehicle is to add capacity (or otherwise improve the road), i.e., to make an investment in the road system. In some circumstances, it may be less costly for society to invest in enhancing the size or durability of the roadway than to force additional vehicles to use the existing, busy, high-maintenance roads at high prices. Therefore, roadways should be improved as long as the incremental improvement cost is less than the cost involved in serving them on the existing roads (as indicated by the road-user charges). Thus, investment should continue until the road-user charge is just equal to the incremental cost of a capacity enhancement. Consequently, road-user charges and the costs of construction (amortized on a VMT basis) *are* ultimately one and the same.

Optimal pricing and investment policies thus are intimately related. The current level of road-user charges, together with information on incremental investment costs, is used to make, simultaneously, efficient use of existing roads, and add efficient amounts of capacity. Indeed, the levying of proper road-user charges provides highway officials with very important investment decision-making information: if road-user charges are very high relative to incremental improvement costs, then it is likely that the roadway is *under*built and society would benefit from having an improved roadway; in contrast, if road-user charges are low relative to incremental improvement costs, it is likely that the roadway is *over*built, and society would be better off if resources were used elsewhere.

This theoretical review makes it clear that the failure to price existing roads properly imposes two types of penalties. First, existing roads will not be used efficiently. As a consequence, valuable maintenance and/or time resources will be misallocated because of the failure to levy marginal cost-based road-user charges. Under typical conditions, congestion will be inefficiently high on busy roads, and wear-and-tear will be excessive on low-durability roads, exaggerating maintenance costs and accelerating the deterioration of the roadway.

Second, inefficient investment decisions will be made. The performance of the road system will be poor, with conditions of high congestion and deterioration. The public will understandably seek relief from this poor performance and demand roadway improvements. Consequently, improper pricing stimulates investments in road capacity and durability that would not be justified under appropriate pricing conditions.

In summary, theory implies that an improperly priced highway system likely will experience: 1) excessive congestion on busy roads; and 2) accelerated deterioration of low-durability roadways; at the same time, it will demonstrate a tendency to invest in roadways that do not pay for themselves.

These conditions are precisely the ones that prevail in California today. As the review of roadway performance above indicated, California's road system is plagued, simultaneously, by congestion on its busy urban and rural segments and deterioration of pavement condition that is the most severe on low-durability roadways, particularly in the arterial and collector parts of the system. (See Table 5-a.) Meanwhile, the rising backlog of roadway projects in California cited above is consistent with the notion that the system is facing mounting difficulty meeting the maintenance and expansion requirements stimulated by the state's road pricing practices.

California does not have a pricing and investment policy that provides the incentives and signals required for either efficient utilization of existing roads or efficient investment in new capacity. As we have seen, California employs a tax-based roadway finance system which has at best haphazard (and largely unintentional) price effects.

Its investment policy is dominated by legislatively determined revenue-allocation formulae, based on county or city shares of population, registered vehicles, fuel tax revenues, assessed valuation of tangible property, and county road miles which, by their very nature, are unlikely to yield efficient allocations of investment activity (see Figure 2). For example, the State Highway Account, which is used to finance major freeway facilities in California, must allocate construction spending between the northern and southern portions of the state via a statutory, 40/60 percent split.

3.Procedures for Estimating Optimal Road-User Charges

What would be the optimal road user charges if California employed an efficient pricing and investment policy This question has two answers. The first is the level of road-user charges that would optimally price existing facilities taking the current durability and size of roadways as given. The second is the level of road-user charges that would prevail after making optimal adjustments to roadway durability and size. The former will be referred to here as the *short-run* level of road-user charges, and the latter as the *long-run* level of road-user charges, in keeping with the formal terminology of economists.

In either the short- or long-run case, road-user charges will vary with traffic levels (hence, by time of day), with the costs of the specific facility, and with the type of vehicle (because that influences congestion-delay effects and maintenance burdens in the short-run, and capacity and durability characteristics in the long-run).Calculation of optimal short-run user charges requires several pieces of information about a roadway. First, the marginal maintenance costs imposed by each vehicle type for each mile it travels must be estimated in order to attribute those costs to specific vehicle types. Second, to properly attribute congestion-delay costs, the relationship between traffic flows and speed must be understood in order to measure the incremental time burden (congestion delay) a vehicle imposes at various traffic levels for each mile it travels. Third, information is needed on the value of travelers' time in order to impute a dollar value to this congestion delay. Finally, because travel demand will respond to changes in road-user charges (trips may be eliminated, shifted to other roadways or times of day, etc.), some knowledge of the responsiveness (*elasticity*) of demand is necessary to determine equilibrium road-user charges.

Calculation of optimal long-run road-user charges requires determination of the roadway configuration that provides the lowest total congestion, maintenance, and capital costs necessary to serve a given volume of traffic with its associated load characteristics (i.e., truck mix). By spending more on road capacity, congestion costs are decreased, but maintenance and capital costs are increased; by spending more on road durability, maintenance costs are reduced, but capital costs are increased. When the marginal road-user charges are calculated for the optimal, cost-minimizing configuration in the manner described earlier, we then have the long-run optimal road-user charges.

Actually making these calculations for a roadway system as large, diverse and complex as California's is a task for an entire transportation research department, of course, and we will not be able to provide detailed analysis here. However, the seminal work of Kenneth Small and Clifford Winston, which analyzed road-user charges in an aggregate way can be adopted, with adjustments, to the California circumstance. In what follows, we borrow heavily from Small and Winston.

VI. AN ESTIMATE OF EFFICIENT ROAD-USER CHARGES FOR CALIFORNIA

In keeping with the approach taken by Small and Winston, we first examine the issue of optimal roadway durability and the road-user charges that would be paid by vehicles of various axle and weight classes were they to be charged marginal maintenance costs. We turn later to the task of pricing congestion, i.e., optimal pricing and investment in roadway capacity.

A. Optimal Maintenance Charges

Although the volume of heavy-vehicle traffic is small, wear-and-tear on pavement surfaces and structures increases exponentially with the load per axle. Optimal short-run pricing would impose a road-user charge that incorporated the actual incremental maintenance burdens imposed by vehicles of various weight and axle configurations, given the current level of durability of the roadway. Optimal *long-run* pricing would impose a charge that represented the marginal maintenance costs on the optimally durable roadway.

Estimates of these costs are presented in Table 6, derived from Small and Winston's model, with modifications. The model predicts (with construction costs and other adjustments by the author), the pavement costs for the average lane-mile of roadway, by type of road. The predictions square reasonably well with the available data; current spending for pavement construction on the state highway system averaged $205,000 per lane mile in 1992, for example.

Table 6: Optimal Pavement Durability and Marginal Maintenance Costs for California Roadways (1993)

Road Type	Pavement Construction Costs		Marginal Maintenance Costs (cents per VMT)									
			Automobile		Single Unit, 2-Axle Truck		3-Axle Tractor Trailer		5-Axle Tractor Trailer		6-Axle Twin Trailer	
	Short Run	Long Run	Short Run	Long Run	Short Run	Long Run	Short Run	Long Run	Short Run	Long Run	Short Run	Long Run
Urban												
Interstate	$213,033	$285,169	0.00	0.00	3.2	0.4	4.6	0.6	2.9	0.4	3.9	0.05
Other Freeway	194,261	249,101	0.00	0.00	5.8	0.8	8.2	1.1	5.2	0.7	7.0	1.0
Principal Arterial	167,052	210,924	0.01	0.00	14.6	14.6	20.9	1.7	13.1	1.0	17.8	1.4
Minor Arterial	143,006	158,193	0.03	0.00	45.4	45.4	64.9	6.1	40.9	3.9	55.4	5.2
Collector	126,554	168,106	0.13	0.01	168.0	168.0	240.4	26.2	151.4	16.5	205.3	22.4
Local	126,554	126,554	0.04	0.04	54.9	54.8	78.6	78.4	49.4	49.3	67.1	66.9

Rural												
Interstate	200,800	239,399	0.00	0.00	1.6	0.7	2.3	1.0	1.4	0.6	1.9	0.8
Other Frwy/Pr. Art.	164,310	182,871	0.00	0.00	5.9	1.5	8.4	2.1	5.3	1.3	7.2	1.8
Minor Arterial	137,522	138,999	0.01	0.00	13.4	3.5	19.2	5.0	12.1	3.1	16.4	4.3
Major Collector	126,544	78,886	0.02	0.01	22.1	13.4	31.6	19.2	19.9	12.1	27.0	16.4
Minor Collector	126,544	71,081	0.03	0.02	41.5	21.6	59.4	30.8	37.4	19.4	50.7	26.3
Local	126,544	126,544	0.10	0.10	135.2	135.6	193.5	194.1	121.8	122.2	165.2	165.7

For most road types, life-cycle costs would be reduced if pavements were more durable (thicker) than the current practice. The calculations in Table 6 imply, for example, that in the long-run, urban interstate pavements should be about 30 percent more durable than current practice. This has the effect of increasing the cost of the pavement, but reducing maintenance over time and, hence, the associated marginal maintenance charges in the long-run.

Some specific numbers are helpful in illustrating this point. The marginal maintenance costs of the existing roadway network (hence, the *short-run* maintenance costs) are trivial for a 4000-pound passenger automobile except on minor roadways, but are significant for trucks. Indeed, the estimated optimal short-run fees for heavy vehicles are sharply higher than the total fuel-tax fees currently paid by these vehicles on California roads. A single unit, two-axle truck weighing 33,000 pounds, for example, should be paying approximately 3.2 cents per VMT when on (relatively durable) interstate roads, but as much as $1.68 per mile when on thinly paved collector roads. Similarly, a six-axle twin trailer weighing 100,000 pounds should be paying about 3.9 cents per VMT on urban interstate roads, but as much as $2.05 per VMT on urban collectors (see Figure 3). This contrasts sharply with the essentially flat 3.1 cents and 9.0 cents per VMT currently paid by these vehicles (see Table 2). From the standpoint of optimal maintenance charges alone, trucks are marginally paying their way on interstate facilities and are severely underpaying on most other road types.

In the long-run, however, higher levels of durability would reduce sharply the marginal maintenance costs that need to be incorporated into road-user charges. Indeed, with the exception of travel on collectors and local roads, marginal maintenance charges would be *less than* the marginal fuel taxes paid by most classes of trucks today. Thus, current highway pricing and investment policy results in the construction of roads of less-than-optimal durability, while at the same time undercharging for the actual wear-and-tear incurred and thereby accelerating deterioration of the system infrastructure.

As the table reveals, the range of optimal congestion charges is quite wide, ranging from about one-half cent per VMT in the off-peak on freeways to almost nineteen cents per VMT on congested arterials. This pattern of charges is in sharp contrast to the (essentially) flat 2.1 cents per VMT implicitly levied by the current structure of fuel taxes in California. Total revenues would be approximately $8 billion per year. Thus, total revenue generated by congestion prices would be approximately 30 to 40 percent higher than that generated by current user taxes (assuming, for the moment, there is no change in traffic volumes in response to the higher user charges in congested areas, and lower charges on lower-cost facilities and in off-peak periods). More likely, however, carpooling and bus transit usage would increase significantly in congested urban settings in response to congestion pricing. It is thus possible that in the long-run, total revenue generated using congestion charges would be less than is generated today by flat charges. Since more efficient use would be made of existing capacity, however, the need for future capacity also would be reduced.

Table 7 does not explicitly address the appropriate congestion prices for trucks and buses. However, on most types of roadways, trucks and buses have a congestion effect equivalent to three to five automobiles. Using this rough rule of thumb, trucks and buses would be charged congestion fees ranging from 1.5 cents to over 90 cents per VMT depending upon the time and place of travel.

B. Optimal Congestion Charges

The second aspect of efficient pricing (and one that is quantitatively more important in some settings), is proper pricing of roadway capacity, i.e., congestion pricing. The logic of congestion pricing was discussed above. Short-run congestion prices are relatively easy to calculate with knowledge of the value of time, the relationship between congestion delay and traffic volumes, and the patterns of traffic over the course of the day. In this case, we have only limited information about peak traffic volumes by road classification and thus must apply a fairly aggregate analysis.

Using the congestion function described by Small and Winston (after adjustment to 1993 dollars for time values), it is possible to estimate the marginal burden in delay costs that is imposed by additional vehicles under various ambient traffic conditions. Using the distribution of volume-capacity conditions reported on California roadways of various classifications, the range and average congestion charges can then be calculated, as can total revenue from the congestion charge. The results of this exercise are summarized in Table 7.

Table 7: Estimated Short-Run Auto Congestion Charges and Revenues (1993)

Road Type	Congestion Charge (cents/VMT)				Total Congestion Charge Revenue ($Millions)
	Off-Peak	Avg. Low Peak Charge	Avg. High Peak Charge	Average	
1. Urban					
Interstate	0.49	1.33	17.31	5.18	2,451
Other Freeway	0.49	1.33	17.31	4.25	1,619
Principal Arterial	1.05	3.76	18.69	3.59	1,694

Minor Arterial	1.05	3.76	18.69	2.98	946
Collector	1.05	3.76	18.69	2.46	286
Local	1.05	3.76	18.69	2.13	282
Urban Subtotal					**$7,278**
2. Rural					
Interstate	0.49	1.33	17.31	1.71	221
Other Fwy/Pr. Art.	0.49	1.33	17.31	1.33	175
Minor Arterial	1.05	3.76	18.69	2.34	187
Major Collector	1.05	3.76	18.69	2.26	189
Minor Collector	1.05	3.76	18.69	2.15	55
Local	1.05	3.76	18.69	2.13	42
Rural Subtotal					**$869**
Total					**$8,147**

As rough as these short-run congestion charge estimates are, they are much less rough than any guess we might make of long-run congestion charges. As we discussed earlier, long-run user charges depend on the costs associated with developing additional capacity (lane miles). Unlike the pavement construction costs we used in the analysis of optimal long-run maintenance charges, the costs of developing additional lane-mile capacity depend critically on the particular locus of the facility. Land values, structure costs, and development-disruption costs vary widely by location and make any attempt at aggregate estimation heroic.

Nevertheless, we can surmise the approximate relationship of long-run congestion costs to short-run costs. It is very likely that a significant proportion of the California road system is overbuilt (in terms of lane capacity), even if congested. We can surmise this from the fact that the historic absence of congestion pricing has the effect of overstating needs for new capacity. To the extent that road-building authorities, in turn, responded by supplying such capacity, it follows that more total capacity has been built than would have been the case under efficient pricing.

If the roadway system is overbuilt, then it follows that continued use of existing roads, priced at the level of the short-run charges displayed in Table 7, is less costly than expansion of capacity. Consequently, the congestion charges in Table 7 likely constitute a lower bound on optimal road-user charges. This is particularly likely to be the case in densely developed urban areas in which right-of-way costs, esthetic and noise requirements, construction disruption, and other costs of new capacity are likely to be very high. The levels of optimal congestion charges calculated by Small and Winston for hypothetical urban expressways and arterials (approximately 14 to 15 cents per passenger car vehicle mile in 1982 dollars) are consistent with this observation.

A final observation on the calculations presented in Table 7 concerns the question of how much of the network needs to have its pricing reformed. Specifically, is it possible to retain a motor fuel tax, VMT tax, or some other flat-pricing device to price all but selected facilities, vehicles, and/or time of day This is essentially an issue of the "second-best" pricing strategy; clearly, if administration of a highly differentiated and ubiquitous road- pricing scheme were costless, it would be preferable to price all facilities and vehicles in a manner consistent with their true economic costs.

In reality, it is costly to administer a comprehensive road-pricing scheme, and in low-cost, low-traffic-density settings, the cost of administering efficient charges is likely very high, per VMT. In addition, as discussed earlier, a very high proportion of total VMT are associated with the congested urban freeway and arterial system. And, as Table 7 reveals, the average auto congestion charges on the less-used segments are, in any case, at less variance to current levels of motor fuel taxes than is the case for the heavily used urban freeways and arterials. All of these considerations suggest that it is likely to be desirable to levy appropriate road-user charges for automobiles on the congested portions of the urban freeway and arterial system. The other parts of the system may not suffer serious efficiency losses if a flat road-user charge (either a motor-fuel tax or a VMT charge) is used in place of a differentiated user fee. (The VMT charge has the advantage of being immune to the effects of fuel economy on the effective road-user fee, but introduces administrative cost and surveillance issues.)

C. Long-Run Pricing of Heavy Vehicles

The conclusions above apply to the efficient pricing of automobiles. The pricing of trucks and other heavy vehicles raises somewhat more complex issues. Trucks impose both heavy maintenance burdens and heavy congestion burdens. While the latter are subject to the same considerations as above for automobiles, **to a large extent,** the former problem is worse on the lightly used (and low durability) portions of the roadway network. As discussed earlier, it is highly likely that the high rate of deterioration in the urban and rural nonfreeway system, and the high rate of city and county expenditure on roads, is due to the effects of heavy trucks on the suboptimally thin pavement of these roads.

These considerations, coupled with the fact that the maintenance burden varies widely by truck type, augur for relatively comprehensive pricing of truck movements. Yet, because of the relatively low volume of truck traffic in the aggregate on these facilities, it is likely that extending pricing to these facilities will not be cost-effective until vehicle-locating systems (such as global positioning satellite-type systems) that do not rely on wayside detectors are developed. The bottom line simply may be that the system of truck and auto road-user charges may have to start with the large, congested, urban facilities, migrating to other portions of the system as pricing technology improves the cost-effectiveness of implementation.

It should be pointed out that comprehensive pricing of trucks and other heavy vehicles does not necessarily imply that trucking enterprises will be worse off as a result of implementing road-pricing properly. It is true that the prices that would be charged trucks on existing roads would be higher than trucks currently pay today. However, proper congestion pricing also would improve traffic-flow conditions significantly which, in turn, benefits trucking companies. Higher peak-travel speeds save on expensive operator labor and save shippers the inventory financing costs associated with having their products move more slowly to the marketplace.

In Table 8 the truck-operating savings associated with improved speeds are calculated for a range of hypothetical driver wages, shipment values, and operating speed improvements. As the table indicates, if proper pricing improves operating speeds by 20 miles per hour, the trucking company saves 8.4 to 26.2 cents per mile in operating costs (depending on the driver's wage and the value of the shipment). For many, and perhaps most, trucks currently operating in congested conditions, the higher user charges may be more than offset by the operating savings resulting from improved operating speeds.

Table 8: Truck Operating Savings Associated with Improved Speeds (cents/mile)

Speed Improve-ment (MPH)	$10,000 Shipment*		$100,000 Shipment*		$1,000,000 Shipment*	
	Wage at $10/hr.**	Wage at $20/hr.**	Wage at $10/hr.**	Wage at $20/hr.**	Wage at $10/hr.**	Wage at $20/hr.**
5	1.5	3.0	1.7	3.2	3.2	4.8
10	3.4	6.7	3.7	7.0	7.1	10.5
15	5.6	11.2	6.2	11.7	11.9	17.5
20	8.4	16.8	9.3	17.6	17.8	26.2
25	12.0	23.9	13.3	25.2	25.5	37.4
30	16.9	33.5	18.6	35.2	35.7	52.4
35	23.6	46.9	26.0	49.3	50.0	73.3
40	33.7	67.0	37.1	70.5	71.4	104.7

Notes: * Hypothetical Shipment Value ** Hypothetical Driver Wage/hr.

Source: Author. Assumes 10 percent inventory finance cost.

In the long-run, the effect on trucks of optimal pricing of maintenance and congestion will be even less onerous than the short-run effects. As was pointed out earlier, California roadways (other than newer freeways and major arterials) likely have been built to suboptimal durability standards. Consequently, trucks must be charged relatively high prices to compensate for the high level of damage they impose on the existing road system. However, with improved roadway durability, the optimal charges are much less. One should be careful, therefore, about concluding that road pricing is necessarily to the disadvantage of trucking or any other user group.

VII. CONCLUSIONS AND FURTHER DISCUSSION

The current structure of marginal road-user charges in California is very simple, but apparently at great variance with the actual pattern of marginal maintenance and congestion costs imposed by road users. As calculated earlier, the average road-user charge paid by automobiles (via state and federal taxes applied to fuel) is approximately 2.1 cents per VMT. Although automobiles differ in their fuel efficiency, for all practical purposes, current marginal road-user charges are flat, and largely independent of the particular facility being used or the ambient traffic conditions.

In contrast, the marginal congestion costs associated with additional VMT on existing, already-congested facilities, likely averages over 18 cents per vehicle mile in the peak period and may be higher in selected instances. Conversely, actual cost on uncongested and low-cost facilities is only one cent or so, approximately half of the current charge per VMT. This ninefold underpricing of congested capacity, and twofold overpricing of uncongested capacity, is clearly justification for road-pricing reform, and is likely at the heart of the mounting congestion and finance problems of the California urban freeway system. On the other hand, for automobiles, the marginal maintenance cost component of optimal road-user charges is small. Optimization of this component for automobiles does not *per se* justify reform of the current system of road-user charges.

The picture is quite different, however, for trucks. Currently, by virtue of slightly higher federal fuel taxes, and fuel economy that deteriorates rapidly with the weight of the truck rig, trucks pay between three and nine cents per VMT, with the highest fee being paid by the very heaviest trucks. In essence, the marginal road-user charges for trucks increase somewhat with the weight of the vehicle, but also are largely independent of the particular facility being used or the ambient traffic conditions, and are also poorly associated with actual axle loadings, which are the main determinant of pavement wear and stress.

Optimal marginal maintenance costs for trucks, on the other hand, vary significantly with the type of vehicle, and the type of roadway over which they are operated. If optimal short-run maintenance charges were charged on today's road network, the appropriate charges would be several times the existing charges, except on durably built freeway systems. Given the disproportionate role trucks play in contributing to congestion, the economics of road-use fees suggest that the fuel taxes paid by trucks today are significantly below optimal, short-run charges.

In the long-run, both marginal maintenance costs and marginal congestion costs are susceptible to reduction through investment in durability or capacity, respectively. However, whereas the distortions may be severe enough (and the remedy cheap enough) in the case of maintenance costs to justify additional investment in durability, it is less obvious that adding lane capacity to reduce congestion costs is an economically efficient act at this time. Resolution of this question, and accurate computation of long-run user costs, awaits detailed studies of individual facilities.

A. Impacts of Pricing Reform on Highway Finance in California

These conclusions about pricing reform have several important implications for the effect of reform on the fiscal balance of the highway finance system:

- In the short-run, optimization of both congestion charges and maintenance charges augurs for higher average revenues, per VMT, than the current system of motor fuel taxes, registration fees, and other sources. This suggests that reform would immediately improve the fiscal health of the highway network, at the same time the selectively higher prices moderate system utilization and the need for capacity enhancement and maintenance.

·As roadways are reconstructed to optimally higher pavement-durability standards, and lane capacity is added where efficient, the question of the *long-run* solvency of the system arises. That is, do the efficient road-user costs fully recover the costs of constructing and maintaining the optimally configured system The answer to this question depends on the technical issue of whether there are economies or diseconomies of scale encountered with durability and capacity enhancement. Although the literature does not offer a definitive answer to this question, it is probably prudent to conclude that an optimally priced and scaled roadway system may fall short, by at least a small amount, from collecting sufficient revenues through efficient road-user charges.

·There are, in turn, two implications of this conclusion. First, contrary to the expectations of some policy makers, in the long-run, efficiently administered road pricing and investment is unlikely to generate a lot of excess revenue to support transit and other public projects. Second, it may be necessary to maintain a modest tax source in addition to road-user charges to provide the missing revenue to the road system. To preserve the efficiency effects of the road-user charges, however, this source would have to be in the form of a registration fee or some other nonuse based device.

·The performance of California roadways would improve significantly with congestion pricing and proper pricing of maintenance burdens. Properly priced and constructed roads would enjoy much higher peak-travel speeds (with peak-period speed on the order of 50 miles per hour, according to Theodore Keeler and Kenneth Small). In addition, properly maintained roads would reduce private individuals' costs of operating and maintaining their vehicles.

B. Implementation Hurdles

Reform of road-user charges, while justifiable economically, has been held hostage by three forces, only one of which is removing itself as an obstacle. First, administration of a road-user charge differentially by vehicle, by time of day, and by specific facility has, until recently, been an administrative near-impossibility. However, electronic toll-collection (ETC) technology is rapidly eliminating these administrative barriers. Presently, even advanced systems of ETC-based pricing impose administrative costs of a penny per VMT or less, making them cost-effective for the most serious instances of mispricing. As the technology progresses, implementation costs may decline further, permitting even broader penetration of this approach to pricing, and promising larger, and more consistent efficiency benefits.

The second force resisting change is lack of support from policy makers and the general public, for whom the benefits of utilizing the road system more efficiently seem vaporous because of the difficulty of communicating the complex, underlying economics. To this end, economists and transportation analysts must begin focusing their educational efforts outward, in the direction of the lay public and key policy makers.

A third, related issue that has distracted the debate on congestion pricing is the equity implications of reform of road pricing. Congestion pricing is seen as a reform that can be afforded by the rich, but which will unfairly burden the poor. This argument is frequently used against road-pricing reform, even though this argument is false for several reasons:

·As we have seen, congestion pricing does not generate more revenue than the current system (and may generate less) and thus is not, overall, a greater financial burden; rather, it mainly changes the structure of user fees, increasing them on some types of travel and vehicles, and reducing them on others.

·It is actually the current system, rather than a system of congestion prices, that is regressive in its structure. As we have shown, the current system underprices peak-hour, peak-direction travel on expensive facilities, making up for the shortfall by *overpricing* non-peak travel on the rest of the network. In relative terms, it is the rich, not the poor who are peak-hour, peak-direction commuters; hence, the current system requires the poor to subsidize the travel capacity needs of the rich.

·The failure to price peak-roadway usage correctly reduces the incentive to utilize high-occupany vehicles (bus transit and carpools) as a means of keeping the per-traveler cost down. This reduced demand, in turn, has the effect of financially handicapping transit operations, which always have been of particular importance to poor commuters. In addition, the high congestion levels of urban California roads at the peak handicaps the performance of bus-based transit by limiting the number of round trips that are able to be made by a given number of transit vehicles and operators.

·In any case, congestion pricing generates revenue that can be used to address any inequities that might arise, in sharp contrast to other solutions to California's transportation troubles which themselves raise equity issues and may require total greater public spending on transportation. Massive, public-transit investment, for example, will require additional taxes to develop, which may themselves have regressive effects.

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ENDNOTES

1. See Table 3 below for details of this calculation.

2. On the basis of average miles traveled per vehicle (11,600 p.a.) and total gasoline and diesel gallonage, the average fuel consumption of a California vehicle is 19.4 miles per gallon. Gasoline and sales taxes in California currently average 45.1 cents per gallon, resulting in an average user fee of approximately 2.3 cents per VMT.

3. Transportation Research Board, *Curbing Gridlock: Peak-Period Fees to Relieve Traffic Congestion* (Washington D.C.: National Academy Press, 1994), pp. 55–56.

4. State of California, Business, Transportation and Housing Agency, Department of Transportation, Division of Highways, Office of Federal Reporting and Analysis, *Assembly of Statistical Reports-1992, California Public Road Data Including Highway Performance Monitoring System Data*, Sacramento, Calif., 1994, pp. 96, 98.

5. Abstracting, for the moment, from the fact that users will try to avoid such a policy by buying more fuel-efficient vehicles.

6. Calculated by the author from various sources including United States Department of Transportation, Federal Highway Administration, *Highway Taxes and Fees, How They are Collected and Distributed*, Washington, D.C., 1993., State of California, Office of the Controller, *Annual Report Financial Transactions Concerning Streets and Roads of Cities and Counties of California, Fiscal Year 1992-93,* Sacramento, Calif., 1994., State of California, Office of the Controller, *Annual Report of Financial Transactions of Transportation Planning Agencies of California Under the Transportation Development Act and the Local Transportation Special Taxing Authorities' Acts, Fiscal Year 1992-93*, Sacramento, Calif., 1994, State of California, Department of Finance, *California Statistical Abstract 1993*, Sacramento, Calif., 1994, and State of California, Department of Motor Vehicles, "DMV History, Operations, Organization," March 1993.

7. The figure provided in the table is uncertain because of the uncertain utilization of the county transportation fund components of the sales tax.

8. United States Department of Transportation, Federal Highway Administration, *Highway Taxes and Fees, How They are Collected and Distributed*, Washington, D.C., 1993, various tables.

9. This fee rose to 18.0 cents per gallon in 1994. However, to maintain comparability with other data in this study, the 1993 figure is employed.

10. The latter two are charged via the Use Fuel Tax.

11. California Revenue and Tax Code Sections 7351 and 8651. See United States Department of Transportation, Federal Highway Administration, *Highway Taxes and Fees, How They are Collected and Distributed*, Washington, D.C., 1993, Table MF-106.

12. In addition to these increments, there are other taxes and fees applied at the distributor level. The most important of these is the so-called Motor Oil Fee of 1.4 cents per gallon charged for weights and standards administration and enforcement. In addition, fees are charged for distributors and producers and brokers licenses, and other minor programs. These fees, because they do not finance transportation, per se, are not presented in Table 1.

13. The Foothill/Eastern TCA and the San Joaquin Hills TCA.

14. Franchise agreements have been signed between Caltrans and consortia developing Orange County state routes 91 and 57, San Diego County state route 125, and the so-called Mid-State project.

15. State of California, Department of Finance, *California Statistical Abstract 1993*, Sacramento, Calif., 1994, Tables J-4, p. 5.

16. United States Department of Transportation, Federal Highway Administration, *Highway Taxes and Fees, How They are Collected and Distributed*, Washington, D.C., 1993, Tables MV-103, United States Department of Transportation, Federal Highway Administration, *Highway Statistics 1992*, Washington, D.C., 1993, Table VM-1. The registration fee per VMT is calculated assuming a California registration fee that would apply to typical characteristics of the vehicle type as tabulated. The VMT by vehicle type is derived from the cited sources, which provide national average VMT by vehicle type. The actual average registration fee per VMT in California, therefore, may be slightly different.

17. Vehicles are depreciated over 11 years. Trailer coaches are depreciated over an 18-year period.

18. The base fee of $2.326 billion plus $0.732 billion as a result of "realignment" of the values of resold vehicles. See "Budget Estimate," Governor of California.

19. California Revenue and Tax Code Section 7102. See United States Department of Transportation, Federal Highway Administration, *Highway Taxes and Fees, How They are Collected and Distributed*, Washington, D.C., 1993.

20. State of California, Board of Equalization, *Annual Report 1992–93,* Sacramento, Calif., 1994, pp. 26–27, A-30.

21. United States Department of Transportation, Federal Highway Administration, *Highway Statistics 1992*, Washington, D.C., 1993, Tables HF-1 and HF-2.

22. The figure 2.1 cents per VMT is used in the calculations presented here. This includes average sales taxes and all components of the federal taxes.

23. The author's calculations from United States Department of Transportation, Federal Highway Administration, *Highway Statistics 1992*, Washington, D.C., 1993, Tables FA-4D, FE-21, HF-1, HF-2, HM-60, MF-1, MF-2, SF-12, STP-1, and VM-2.

24. Calculations by the author from United States Department of Transportation, Federal Highway Administration, *Highway Statistics 1992*, Washington, D.C., 1993, Tables HM-20, HM-50, HM-60, HM-61, HM-63, and VM-2.

25. Small and Winston, *Road Work*, June 1988, pp. 560–569; Kenneth A. Small and Clifford M. Winston, "Optimal Highway Durability," *American Economic Review*, 1988.

26. Small and Winston estimate that, for rigid road surfaces, the maintenance burden increases by approximately the cube of the load per axle. See Small, et al., *Road Work*, Table 2-1.

27. Data supplied verbally by Caltrans Highway Division, January 1, 1995.

28. That is, the optimal spending for pavement construction should be approximately 30 percent higher than it is today.

    Specifically, we only know the incidence of volume-to-capacity ratios by road type.

29. Small, et al., *Road Work*, Table 6-1.

30. The available data on roadway volume-capacity conditions report the centerline miles of California roads experiencing various peak volume to capacity ratios. The congestion prices are calculated on that basis and then applied to VMT in proportion to the affected centerline miles. This necessary simplification likely results in attribution of high congestion charges to a smaller proportion of VMT than is properly the case.

31. Small, et al., *Road Work*, Tables 6-2, 6-3.

32. See, for example, Theodore E. Keeler and Kenneth A. Small, "Optimal Peak-Load Pricing, Investment, and Service Levels on Urban Expressways," *Journal of Political Economy,* 1977; Marvin C. Kraus, "Indivisibilities, Economies of Scale, and Optimal Subsidy Policy for Freeways," *Land Economics,* 1981a, and Marvin C. Kraus, "Scale Economies Analysis for Urban Highway Networks," *Journal of Urban Economics*, 1981b.

33. Randall J. Pozdena, "An Introduction to Congestion Pricing for Policy Makers," Oregon Department of Transportation, Forthcoming, 1995.

- See Randall J. Pozdena, "Market Based Solutions to the Transportation Crisis: The Concept," Bay Area Economic Forum, May 1990, for an illustration of this fact for the San Francisco Bay Area.