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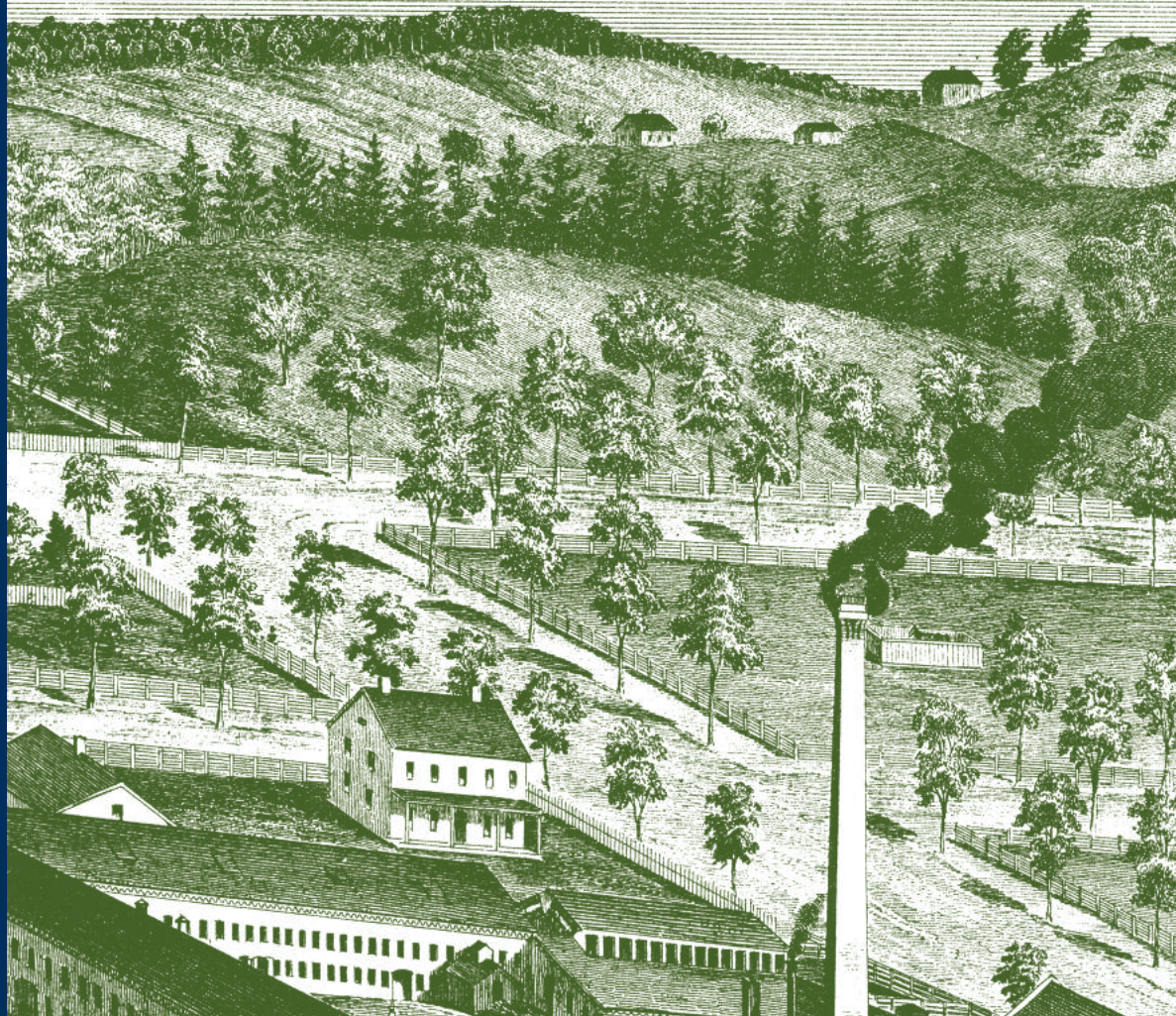
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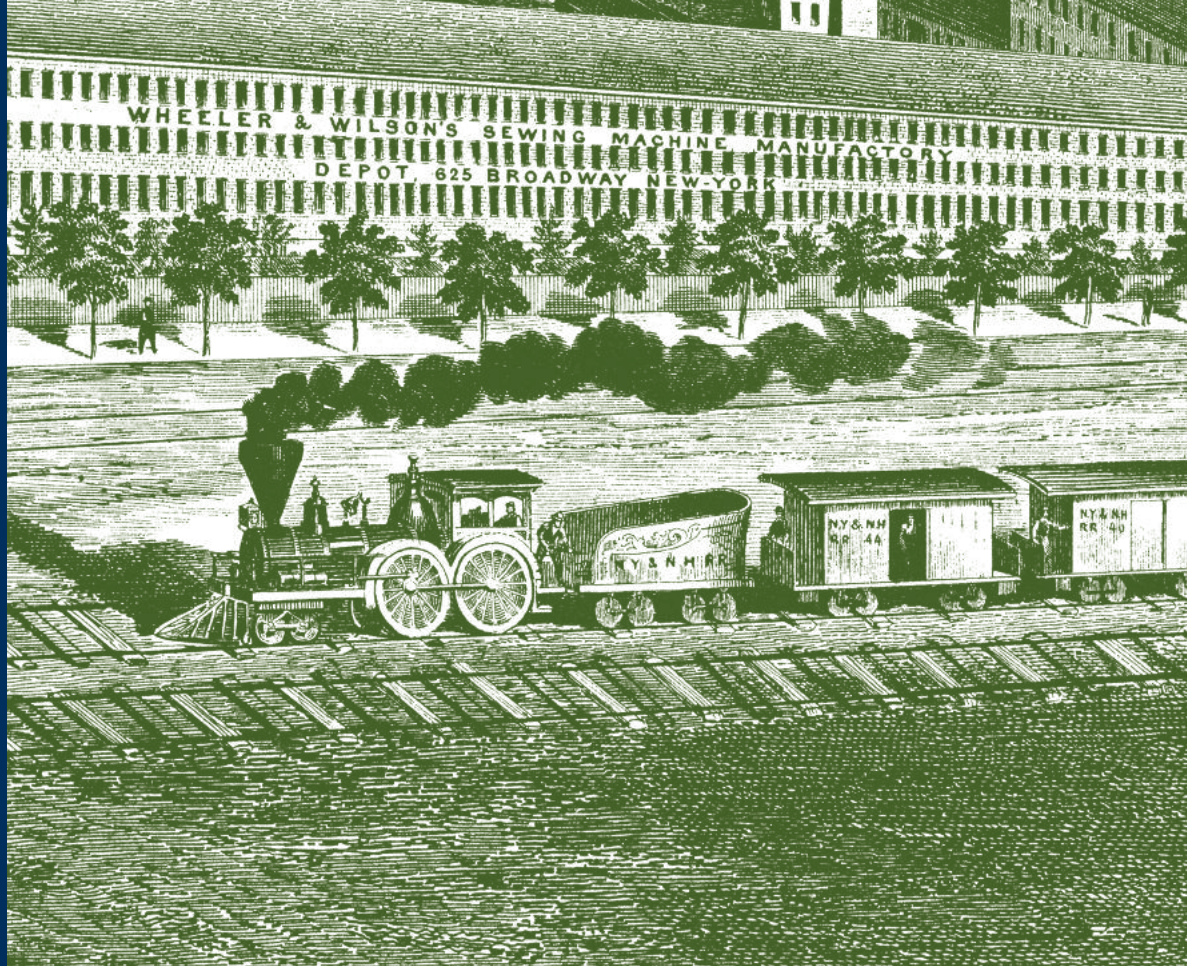
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Transportation Research at the University of California



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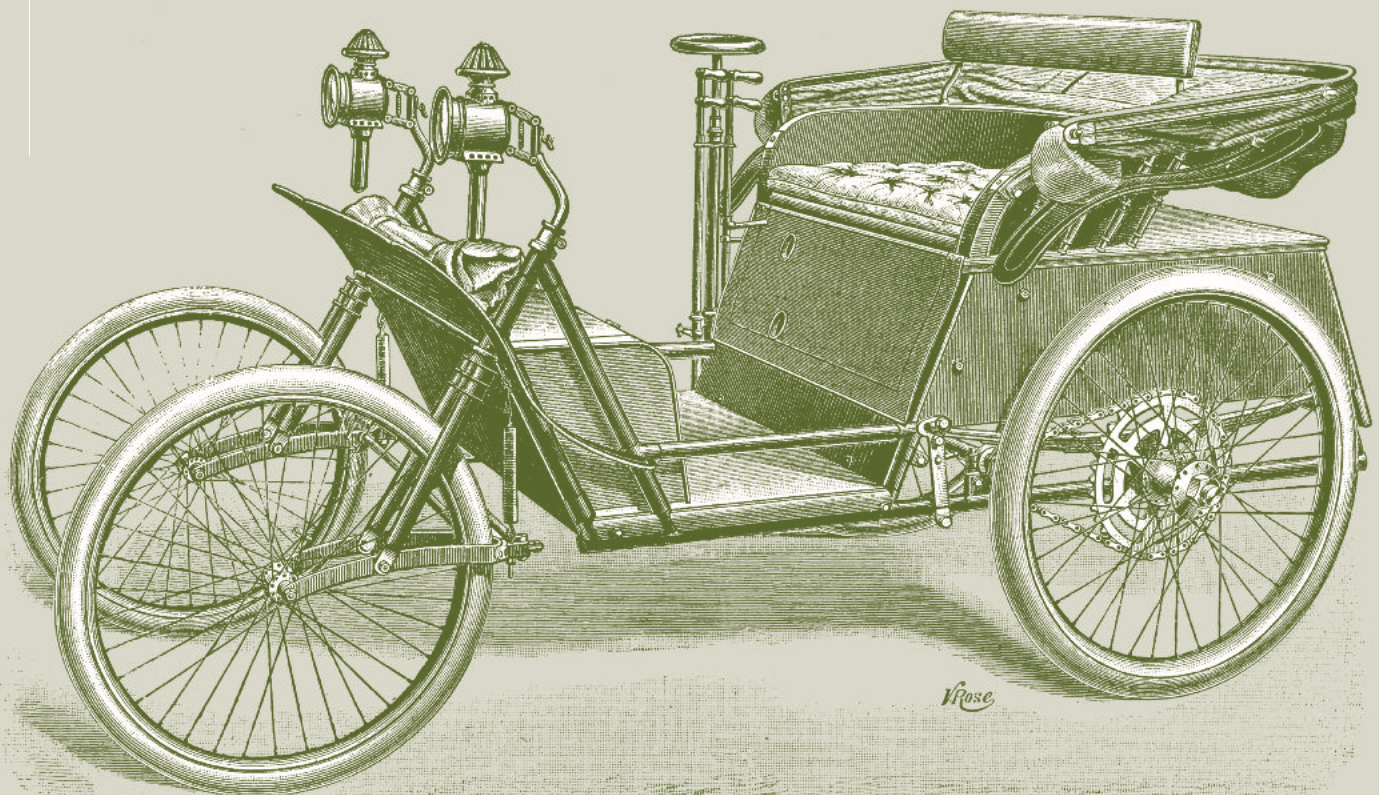
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Urgent Action Required

AT A RECENT CONFERENCE in Berkeley sponsored by the University of California Transportation Center, *On the Road to Sustainability: From Research to Practice*, researcher after researcher discussed the climate implications of a wide range of transportation issues. Participants heard how better coordination of systems for dealing with empty freight containers could reduce the numbers of truck trips; what effects, if any, various finance and land use policies have on the amount of driving people do; what new fuels are in the works and whether they hold potential for greenhouse gas reductions; how much aggregate—rock—is needed to complete California highway projects (a lot) and how much of it must be transported from overseas quarries. Three full days were not anywhere near enough to describe the dilemmas facing transportation due to the threat of climate change. The culminating session brought focus to the urgency needed to solve these dilemmas, with UCTC Director Elizabeth Deakin’s daunting presentation on projections for growth in California (which could be taken as an illustration of worldwide growth), and ITS-Davis Director Daniel Sperling’s discussion of work being done by the Air Resources Board to meet California’s AB32 (the Global Warming Solutions Act).

AB32 mandates a reduction in greenhouse gases produced in California to 1990 levels by 2020—essentially a 25 percent reduction from projected levels. Transportation produces forty to fifty percent of the CO₂ in California. Sperling pointed out three areas where transportation as we know it must change: 1) cars must be more efficient; 2) fuels must be cleaner; and 3) people must drive less. Work is proceeding on the first two,

by government and industry, but the third one poses a different kind of challenge.

Until very recently, legislators and other elected officials rarely dared to openly discuss pricing strategies aimed at reducing driving. Tolls and higher gas taxes, which are designed to shift environmental costs onto those who create them, have been a political dead end. But David King, Michael Manville, and Donald Shoup have a suggestion, elucidated in this issue, for a way to gain political support for pricing roads. Their ideas may make tolls not only palatable—that is, politically feasible—but perhaps even popular. Or at least popular enough to get them implemented, and thus perhaps to cut the amount of driving people do.

Two other essays in this issue shed light on the little-understood area of consumer behavior in reaction to changing regulations and prices. Tom Turrentine, Kenneth Kurani, and Rusty Hefner found that very few people spend time analyzing fuel costs when they set out to buy a car, and in fact those who buy very fuel efficient cars do so for reasons having more to do with feelings than actual costs. Ken Small and Kurt Van Dender take a close look at the “rebound effect” whereby people who do buy more fuel efficient cars actually drive more, thereby reducing the potential fuel savings promised by CAFE standards. They find reason to be hopeful: the authors discovered that not only is this effect small, but that over time it is shrinking; therefore policies that require cars to be more efficient, like CAFE standards, do in the end result in less fuel use.

Monumental changes are necessary if we are going to avoid global climate change. Herein are a few suggested first steps.

—Melanie Curry
Editor

FOR WHOM THE ROAD TOLLS

THE POLITICS OF CONGESTION PRICING

BY DAVID KING, MICHAEL MANVILLE, AND DONALD SHOUP

There is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things. Because the innovator has for enemies all those who have done well under the old order of things, and lukewarm defenders in those who may do well under the new.

NICCOLO MACHIAVELLI

IT IS ALMOST UNIVERSALLY ACKNOWLEDGED AMONG TRANSPORTATION planners that congestion pricing is the best way, and perhaps the only way, to significantly reduce urban traffic congestion. Politically, however, congestion pricing has always been a tough sell. Most drivers don't want to pay for roads that are currently free, and most elected officials—aware that drivers are voters—don't support congestion pricing.

Academics have proposed a host of ways to make pricing politically acceptable. Most of these proposals focus on using toll revenue to buy the public's tolerance, if not its support. Plans have been floated to rebate toll revenue directly to motorists, to spend it on public transportation, and to spend it on roads. Some pricing programs that have been implemented—such as those in London, Singapore, and Stockholm—spend their toll revenue on public transportation, but these programs were implemented in places where drivers were a minority. Other pricing programs, like the SR-91 toll lanes in Orange

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County, required building entirely new roads just to toll them. If pricing is to make a meaningful dent in American congestion, however, it will need to be put in place on existing roads in places where most people drive, and we have scant political guidance for accomplishing that task.

We propose a new way to create political support for congestion pricing on urban freeways: distribute the toll revenue to cities with the tolled freeways. With the revenue as a prize, local elected officials can become the political champions of congestion pricing. For these officials, the political benefits of the toll revenue can be far greater than the political costs of supporting congestion pricing. If congestion tolls were charged on all the freeways in Los Angeles County, for example, and the revenue were returned to the 66 cities traversed by those freeways, we estimate (using a model first developed by Elizabeth Deakin and Greig Harvey) that each city would receive almost \$500 per capita per year.

Cities with freeways have three attributes that make them appropriate recipients for toll revenue: their gains are certain, their residents suffer the environmental consequences of living near freeways, and their local elected officials will have a strong incentive to spend the money in a way that makes their residents better off. >

THE DILEMMA
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THE PROBLEM OF INSUFFICIENT SUPPORT

First, we should address the obvious question: why not rebate the toll revenue to drivers? The answer is that returning the revenue to drivers solves the wrong problem. A rebate is designed to reduce opposition, but opposition is only one part of pricing's political problem, and arguably not the most important part. The dilemma confronting congestion pricing is not just that opposition is too high, but that *support is too low*.

Nothing about congestion pricing matters if no one ever implements it, so all thinking about the politics of congestion pricing must start with the challenge of winning its initial approval. In this circumstance, the absence of advocates is a far greater hindrance than the presence of opponents. Even if there were no opposition to congestion pricing, the political problem would remain because the absence of opposition does not equal the presence of support. We can eliminate every argument *against* congestion pricing, but if we don't create strong political arguments *for* it, we will never properly price our roads.

Congestion pricing lacks a constituency that derives *concentrated* benefits from priced roads, a group whose gains greatly outweigh its losses, and who can be certain before the fact that pricing will be to its advantage. Without this constituency, congestion pricing has few strong advocates—people or groups willing to spend time, money, and political capital to make pricing a reality. Congestion pricing may well be in the public interest, but right now it is no one's *special* interest.

ONLY CONCENTRATED GAINS LEAD TO POLITICAL MOBILIZATION

Even if most people thought they would be better off with congestion pricing, it would still lack strong advocates. Before a group will fight for a policy, the gains need to be big. Specifically, the benefits of the policy must exceed both the costs of the policy *and* the costs of mobilizing and campaigning to adopt the policy.

Drivers are a large and dispersed group, so the costs of organizing them are high while the rewards of successful mobilization are, for each individual driver, relatively low. We could therefore have a situation where congestion pricing would help every driver a little, but where no one would fight for it because it wouldn't help any of them *a lot*. Think of it this way: if you offer a hundred people the prospect of \$1 million each, they will likely organize and spend the time and money necessary to get it. If you offer 100 million people the prospect of \$1 apiece, most will gladly accept it, but few will actively campaign for it.

CITIES AS REVENUE CLAIMANTS

Toll revenue is a major benefit of congestion pricing. British transportation economist Philip Goodwin argues that many of the benefits of congestion pricing are “locked up” in the revenue collected, and are realized only when the revenue is spent. If the potential beneficiaries of the added public spending financed by toll revenue don't know who they are, they will be hard to organize to support the tolls. So what should governments do with the toll revenue to create support for congestion pricing?

Drivers make poor recipients for congestion toll revenue because they are difficult to organize and because their gains from pricing are modest. Cities, in contrast, have lobbyists and elected officials whose explicit purpose is to promote their interests and who can be effective advocates at the state and national level. The city of Los Angeles, for instance, is one of the largest lobbyists in California. And most cities already work together politically, either through informal coalitions or municipal leagues.



For local officials, the potential gains from pricing can be very large. The number of cities will be small compared to the total congestion revenue, so each city's leaders will have a strong incentive to lobby for congestion pricing. Politicians can use a regional pool of money to deliver local services for their own residents. This arrangement will allow local leaders to evade the blame for congestion pricing, because someone else is charging the tolls, but capture credit for new services. The revenue will enhance their constituents' quality of life and their own chances of re-election.

Because local elected leaders are more accountable to residents than are the appointed heads of regional transportation agencies, they would be under more pressure to spend the toll revenue in a way their residents support. Suppose the hypothetical congestion toll revenue from all the freeways in Los Angeles County were returned on a per capita basis (about \$500 per person per year) to the 66 cities traversed by freeways. Each of these cities could then decide on the best way to spend its share of the revenue. Some cities might spend the money on road improvements, others on fixing sidewalks, still others on affordable housing. In this way, revenue return works with, rather than against, the fragmentation of American metropolitan areas. The many local governments in a region can choose to spend the toll revenue in many different ways. We wouldn't >



have to convince an entire region of drivers—many of whom will have relatively little in common—about the wisdom of spending toll money on one or two large programs.

By contrast, consider what might happen if the toll revenue were spent on public transportation. In the United States, transit is used by a small minority, and most transit systems are oriented around center cities where most Americans neither live nor work. Affluent suburban drivers are unlikely to benefit if the toll revenue is spent on transit systems they never use in places they rarely go. They will correctly view such toll payments as transfers to another group, not as payments that come back to benefit them.

So then why not spend the money on roads? In theory this idea is sensible, but in practice it becomes complicated. Congestion tends to be worst in dense areas, and building roads in dense areas is extremely expensive and politically difficult. Congestion is heaviest in central cities and tolls would be highest there. But these cities have little room to build new freeways, and the cost of land is so high that construction would be prohibitively expensive. Building a road also takes time: even modest highway expansions undergo lengthy environmental reviews, and many endure protest and litigation. The final stretch of the 710 freeway in Los Angeles has been held up by lawsuits and protest for 42 years! Tolls paid now would not translate into new roads until years later. Given

the constraints of time, money and space, a road-building authority would likely end up using toll revenue generated in the densest parts of the region to (eventually) build roads in the least dense parts—essentially transferring income from current drivers in high-toll areas to future drivers in low-toll areas. That doesn't seem fair, efficient, or politically feasible.

If we distribute the toll revenue to cities on a per-capita basis, the money can be spent quickly and locally, and revenue distribution is likely to be progressive. In 2000, average per capita income in LA County was \$20,100 a year in the 66 cities with freeways, and \$35,100 a year in the 22 cities without them. Distributing the toll revenue to cities with freeways will thus shift money from richer cities without freeways (like Beverly Hills) to poorer cities with freeways (like Compton). In their study of congestion tolls for Los Angeles, Deakin and Harvey estimated that higher-income motorists will pay most of the tolls—in part because the richest 20 percent of the population own 3.1 times more cars than the poorest 20 percent, and they drive 3.6 times more vehicle miles per day. Higher-income motorists also drive more during peak hours. As a result, high-income drivers will pay to provide added public services for low-income people.

Distributing toll revenue to cities with freeways can also help compensate for vehicle emissions that pollute the air immediately surrounding freeways. Concentrations of ultrafine particulate matter, which penetrates deep into the lungs, can be up to 25 times higher within 300 meters downwind from a freeway than in other areas. Diesel exhaust and road dust also accumulate near freeways, and pose a particular threat to children's developing lungs. Public health researchers have shown that communities near freeways suffer from higher rates of asthma, low birth weights, cardiovascular disease, and some forms of cancer. Local revenue return of congestion toll revenue means that drivers who contribute to these environmental problems would compensate the victims.

CONCLUSION

Congestion pricing is, to borrow a line from the quote that introduces this article, "a new order of things." It is a fundamental change in the way we think about and provide space for driving; what has long been regarded as "free" would now have a price. Those who support pricing should not be surprised that most drivers resist it. Drivers, after all, have "done well under the old order of things," and while they may come to appreciate (or at least tolerate) priced roads, we should not expect them to like the idea beforehand.

But opposition is not the only reason so many roads are unpriced, and reducing opposition is not the same as creating support. Most pricing proposals attempt to placate those who "do well under the old order," and fail to focus on those who might "do well under the new." Congestion pricing will be implemented not when it is tolerable to the prospective losers, but when it is irresistible to the prospective winners.

Unlike many others who have written about congestion pricing, we do not think the toll revenue should go to drivers, transit agencies, or road bureaucracies. Claimants for the revenue should have both the means and the motivation to secure pricing's prior approval. They must be politically powerful, they must be certain beforehand that pricing will deliver a concentrated benefit, and they must be able to use the revenue in way that quickly makes as many people as possible better off. We believe that cities with freeways fit this description, and that their local elected leaders can become the champions of congestion pricing. ♦

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If Cars Were More Efficient, Would We Use Less Fuel?

BY KENNETH A. SMALL AND KURT VAN DENDER

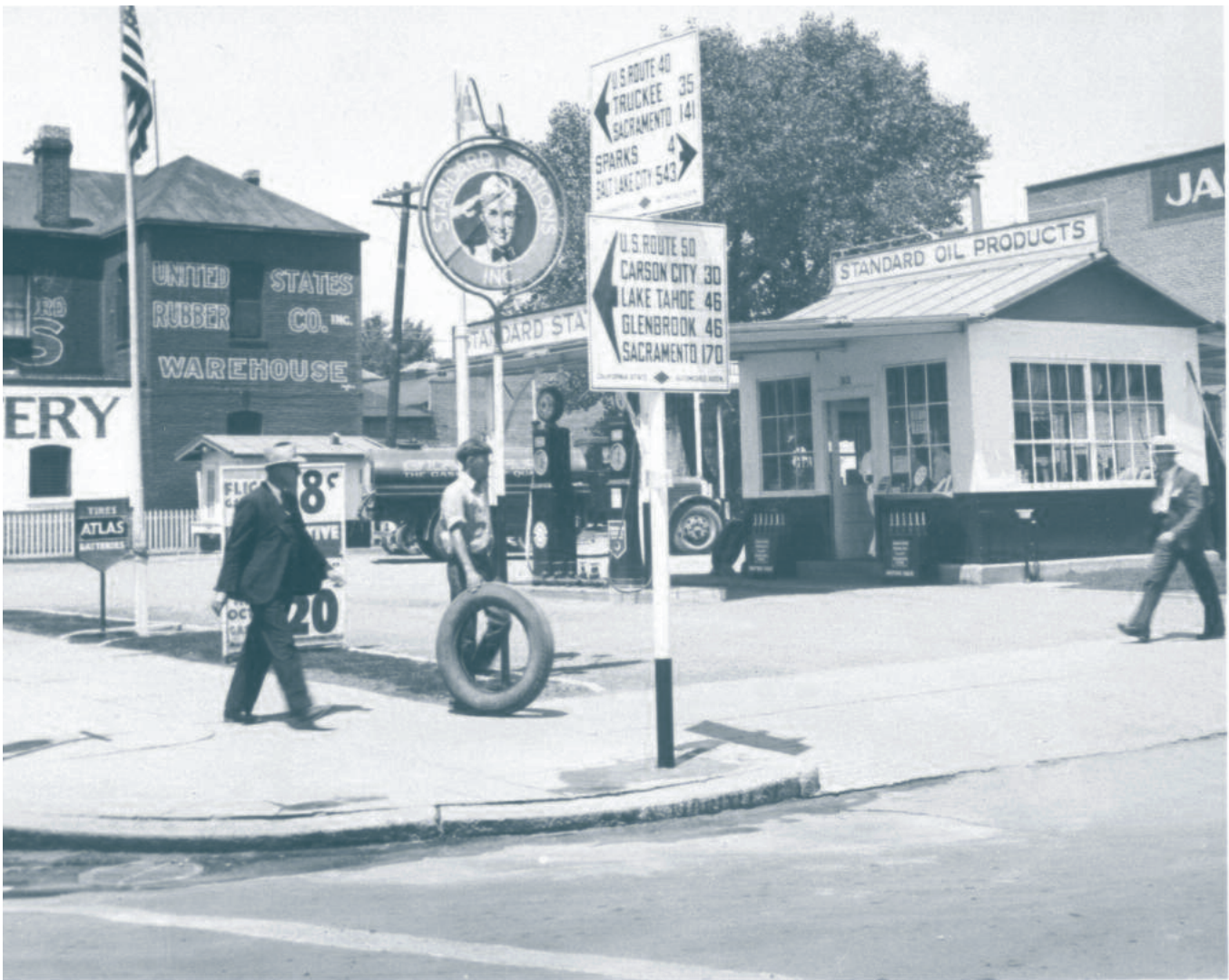
REDUCING US GASOLINE CONSUMPTION MIGHT SEEM A straightforward task: just increase vehicle fuel efficiency, also known as miles per gallon (MPG). That, of course, is the principle behind the existing Corporate Average Fuel Economy (CAFE) standards.

But it's not that simple. If MPG improves, the cost to drive a mile declines, so people drive more. Some critics have even argued that this "rebound" effect is so large that not much gasoline is saved, and other problems such as congestion are exacerbated. Is this right?

Our research measures the size of the rebound effect and discovers that it is not large. Moreover, we find that it has become smaller over time, and is likely to become smaller still. This means that improved fuel efficiency does translate into lower fuel consumption. Our results also have implications for the policy choice between CAFE standards and fuel taxes as ways to reduce energy consumption. This is easiest to understand by relating the rebound effect to a slightly different question: how do drivers respond to changes in fuel prices?

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FUEL COSTS, FUEL EFFICIENCY, AND DRIVER RESPONSE

Drivers respond to an increase in fuel prices in several ways. The most important are: reducing travel, and buying more fuel-efficient vehicles.

First, consider the effect on vehicle miles traveled (VMT). As fuel prices rise, drivers reduce VMT in order to save fuel. We measure the size of this “VMT effect” as an “elasticity”: the percentage change in VMT divided by the percentage increase in fuel prices. For example, if a 100 percent increase in price causes a 20 percent decline in VMT, the elasticity is -0.2.

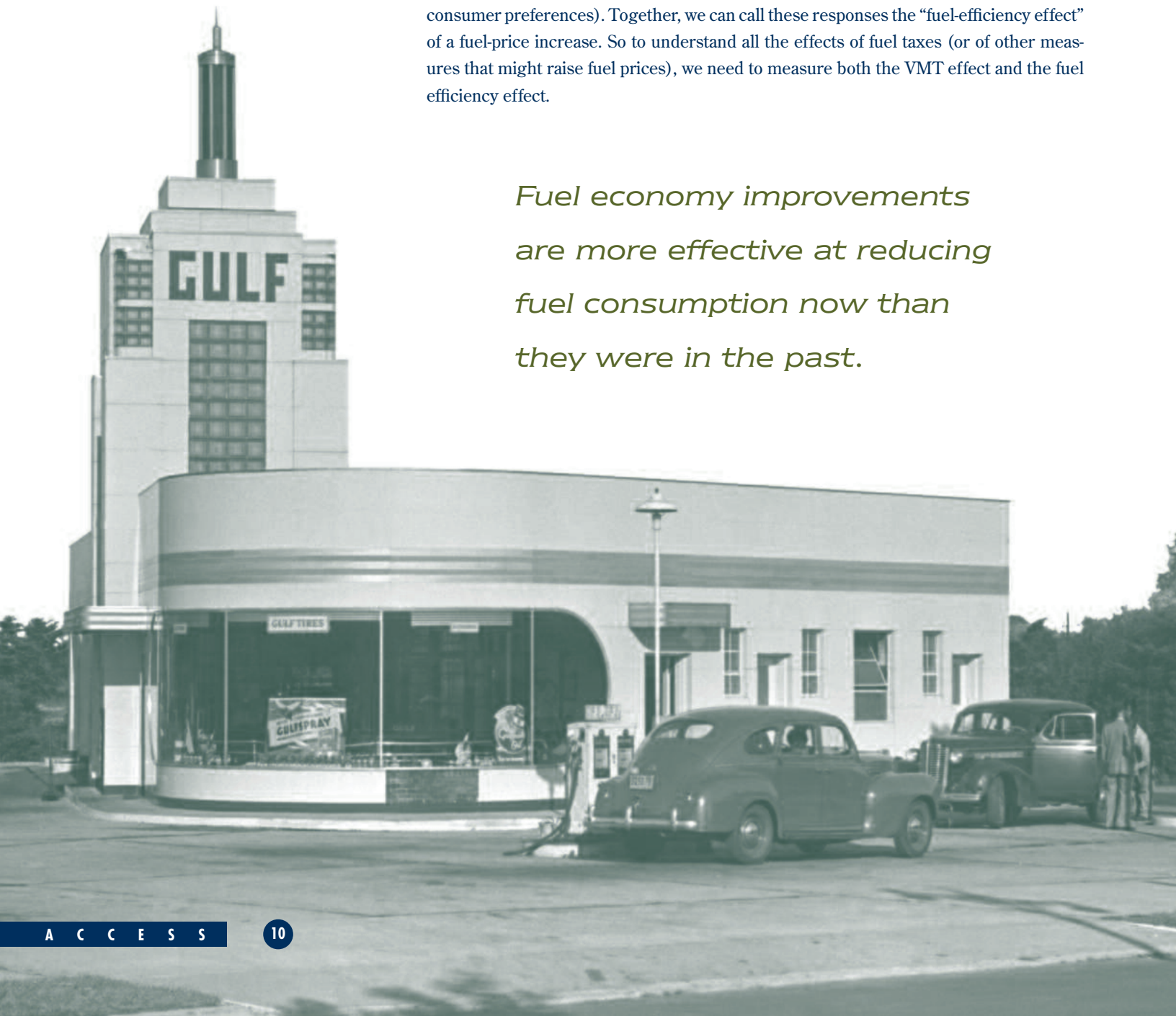
How is this VMT effect related to the rebound effect? Both measure how drivers react to a change in the fuel costs of driving—in one case due to a change in fuel prices, in the other case due to a change in fuel efficiency (MPG). If drivers react the same way to either source of change in fuel costs—as is assumed by nearly all analysts—then >

numerically the elasticities are the same for both. By convention the rebound effect is expressed not as a fraction (like 0.2) but as the corresponding percentage (20 percent). A twenty percent rebound effect would wipe out twenty percent of the fuel savings that would otherwise result from any given improvement in fuel economy.

If the rebound effect is small—say ten to twenty percent—then CAFE standards will mainly work as hoped: eighty to ninety percent of the fuel savings made possible by changes in vehicle characteristics will be achieved. But if the rebound effect is large, say forty to sixty percent, then fuel economy mandates are less cost effective because too much of the hoped-for fuel savings is lost in extra travel. Plus, as already noted, this extra travel may cause other problems.

Second, consider the effect of rising fuel prices on the sales of high-MPG vehicles. This response can occur either through consumer or manufacturer decisions about technology and vehicle mix. As an example, sales of sport utility vehicles (SUVs) fell when gas prices skyrocketed in 2005 (a consumer response). At the same time, the competition to develop hybrid vehicles heated up (a manufacturer response, driven by consumer preferences). Together, we can call these responses the “fuel-efficiency effect” of a fuel-price increase. So to understand all the effects of fuel taxes (or of other measures that might raise fuel prices), we need to measure both the VMT effect and the fuel efficiency effect.

*Fuel economy improvements
are more effective at reducing
fuel consumption now than
they were in the past.*



To recap: an increase in gasoline price produces both a VMT effect (fewer miles driven) and a fuel-efficiency effect (more efficient vehicles used). Together, the two effects determine the price elasticity of gasoline, that is, the reduction in consumption that occurs in response to an increase in price. If this price elasticity of gasoline is large (like -0.8), it means that consumers and manufacturers together respond strongly to higher prices, using less fuel. But if it is small (like -0.3), it means neither consumers nor manufacturers react much to fuel price changes, so a rather large hike in gasoline taxes would be required to achieve a given target for fuel-use reduction. That can present political and administrative problems that would make gas taxes a less attractive option.

MEASURING VMT AND FUEL-EFFICIENCY RESPONSES

So how big is the price elasticity of gasoline? There is reasonable consensus that, when measured over a decade or more to allow consumers time to replace vehicles with more efficient ones, it is around -0.5; that is, if the price of gasoline doubles, its consumption will fall by about half. But as we have just seen, the components of this elasticity also matter because they tell us whether higher prices cause less driving, more fuel-efficiency in vehicles, or both. Furthermore, there have been suggestions that the price elasticity of gasoline has decreased over the last few decades—that is, consumers have grown less responsive to price changes. If that's true, which of its components has decreased?

Many studies have measured the VMT effect or, equivalently, the rebound effect. Most results for the rebound effect are in the range of five to twenty percent over a period of one year ("short run"), and twenty to thirty percent over many years ("long run"). Thus, for example, if CAFE-like standards succeed in doubling fleet-average fuel efficiency, in the long run people might end up driving twenty to thirty percent more. If these results are accurate, they mean that improvements in fuel economy are a fairly effective way of reducing fuel consumption.

We analyzed annual US data by state from 1966 through 2004, and here provide new empirical estimates of the price elasticity of gasoline and its components. (We recently reported similar numbers in an academic publication, but based on data only through 2001.) Because our data set is more comprehensive than that used in most studies, we are able to measure these effects with greater precision and, most importantly, to investigate whether they depend on factors that are changing over time.

In particular, we posit that the rebound effect should depend on both average per capita income and average fuel costs. First, it should *decline* as average income rises, because then time costs rather than fuel costs tend to become more important in determining people's travel decisions. Second, the rebound effect should *rise* as fuel costs rise, for the same reason in reverse: fuel costs then become a larger factor. We also posit that the rebound effect should decline with increasing urbanization because then the time costs of congestion tend to dominate the cost of driving, again relegating fuel costs to lesser importance in people's decisions. >



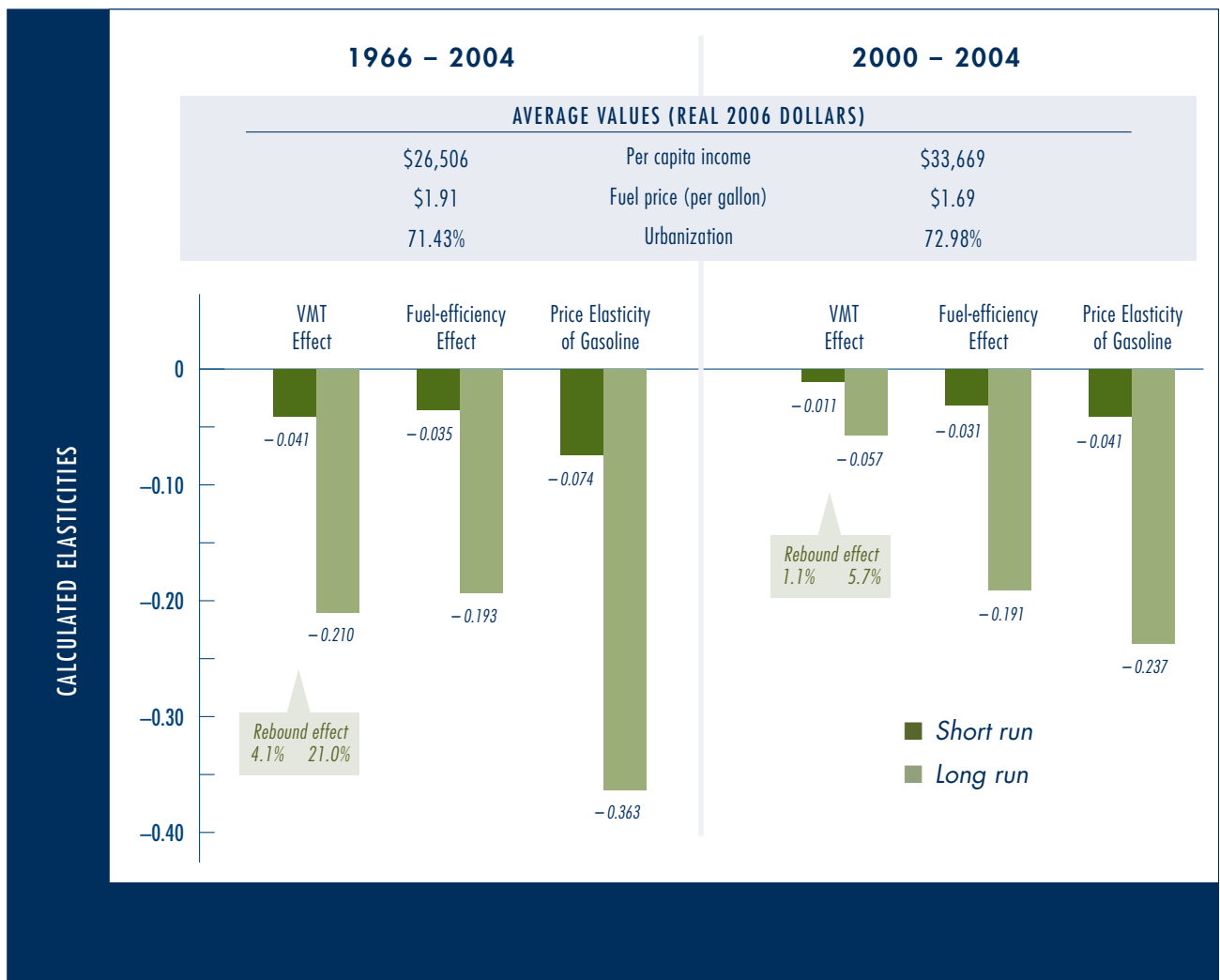
RESULTS

Figure 1 shows our estimates for the VMT and fuel efficiency effects, and the resulting price elasticity of gasoline. (It is not quite a sum of the two, due to an interaction between them.) The left side shows short-run and long-run elasticities calculated at the average values of income, fuel cost, and urbanization in our entire sample—that is, the average prevailing across all states over the 39-year period. (We are able to distinguish between short-run and long-run effects by measuring not only the size of consumers' and manufacturers' responses but also how quickly they make them.)

The chart shows that the rebound effect is 4.1 percent in the short run and 21 percent in the long run, confirming the findings of most studies that the rebound effect is modest: fuel-efficiency mandates over this period might have lost at most 21 percent of their effectiveness through increased driving.

FIGURE 1

Estimated price elasticities



Source: Authors' estimates, using full data set from 1966-2004.

The fuel-efficiency effect is also in line with previous studies, as is the long-run price elasticity of gasoline. The latter means, for example, that a permanent increase of the fuel price from \$2.50 to \$3.50 in constant dollars (a forty percent increase) would reduce fuel consumption by some 14.5 percent in the long run (0.363 times 40), all else equal.

What is most important about our results is what happens when we compare the entire time period to just the last five years. We find that the VMT and rebound effects are affected by per capita income, fuel costs, and urbanization just in the manner we posited. The strongest influence is income, the second strongest is fuel costs. Because incomes rose but fuel costs per mile fell over this period, both sources of variation caused the rebound effect to decline. This decline is substantial: we calculate that over the last five years of the sample, the rebound effect was only about one-fourth as large as its average over the entire period. This means that fuel economy improvements are more effective at reducing fuel consumption now than they were in the past.

While the VMT effect (change in number of miles driven) was declining, the fuel-efficiency effect was changing very little. As a result, the magnitude of the price elasticity of gasoline declined, but only modestly (from -0.363 to -0.237 in the long run). Interestingly, a recent working paper by Jonathan Hughes, Christopher R. Knittel, and Daniel Sperling at UC Davis also finds a decline of the price elasticity over time, although using a quite different approach.

Because we isolate the factors causing this decline, we can also say something about future trends. Projections by the Energy Information Agency show per capita income continuing its steady rise, while gasoline prices are expected to be flat or possibly to rise slowly. (Both income and fuel price are here expressed in constant dollars.) Furthermore, the elasticities we measure are about four times more sensitive to income than to fuel costs; and even if gasoline prices rise further, fuel costs per mile probably won't, because of improvements in fuel efficiency. Therefore, it seems to us extremely likely that the price elasticity of gasoline will continue to fall slowly, and that the rebound effect will decline to a very small value.

POLICY IMPLICATIONS

Our results show that, assuming real incomes will continue their steady rise, the rebound effect will become less and less important as a component of the price elasticity of gasoline. Meanwhile, consumers and manufacturers continue to respond strongly to fuel prices by making changes in fuel efficiency.

These two predictions together—a sharply falling VMT effect but stable fuel-efficiency effect—tell us that government policies focused on either increasing vehicle fuel efficiency or increasing gas taxes can be effective, although in the latter case the increase in gas taxes would need to be quite large. But we should not expect energy policies to bring about much change in collateral problems of motor vehicles, such as congestion or air pollution, because changes in the amount of driving will be small. Those problems will remain whether or not we succeed in reducing the energy impacts of transportation, and solving them will require other measures. ♦

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Fuel Economy: What Drives Consumer Choice?



BY TOM TURRENTINE, KENNETH KURANI, AND RUSTY HEFFNER

WHEN GASOLINE PRICES RISE, IT MAKES THE NEWS. Reporters mob gas stations to ask drivers how they are dealing with the higher prices. Many drivers say, “What can I do? I have to drive.” Some drivers declare they will curtail their driving while others complain of price gouging and oil company conspiracies. We know that few drivers adjust their driving behavior much in response to gasoline price changes on the scale that occurred during our study, but we do see that sales of smaller vehicles have increased, and that hybrids are getting lots of attention. But how do consumers really think about and respond to gasoline prices? Do they know how much they spend on gasoline over the course of a year, or do they think only in terms of price per gallon? When they buy a car, do they think about fuel costs over time, are they just looking for high miles per gallon (MPG)?

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STUDYING CAR BUYERS

In 2003 and 2004 we studied consumers' knowledge, beliefs, and behaviors relative to the price, purchase, and use of fuel, as well as how these elements influenced vehicle purchases. During the interview period, gas prices rose from around \$1.60 to just over \$2 a gallon. We conducted 57 interviews in the homes of Northern Californians who had recently bought a vehicle or were just about to buy a vehicle. We asked mostly open-ended questions and probed for in-depth answers. We gave more attention to the context and validity of the information we received—what some researchers call qualitative research—than to its statistical reliability.

We stratified our respondents into nine “lifestyle sectors” we thought might have different sensibilities about fuel use. For example, we defined several groups we thought would have the awareness and the skills to be particularly sophisticated in their accounting, such as computer engineers, finance professionals, business owners, ranchers and farmers, and even buyers of hybrid vehicles.

The interviews unfolded in four phases. In the first three, we were careful not to blurt out anything like, “So, what do you think about fuel economy?” Rather, we listened closely as households told us their stories about buying and driving cars. The first interview phase covered the history of all vehicles the household had owned. These histories varied from extensive to brief. Some respondents had owned twenty or more vehicles during their lifetime. Others, especially graduating college students, may have been >

buying their first car. The second phase gave us a detailed account of the household's most recent vehicle purchase. In the third phase, we proposed the hypothetical purchase of another new vehicle in which we inserted "fuel economy" as one of several vehicle attributes for the household to consider.

Few households discussed fuel economy during the first three phases of their interviews. The issue of fuel costs most commonly arose in the households of enlisted military personnel (who have very limited income), in households facing an abrupt increase in driving, and in households of graduating college students, who often own cars which were purchased for them by parents. For some students, fuel costs were their entire cost of operating a vehicle.

In the fourth interview phase we inquired about fuel economy and fuel use directly. We asked households to provide details about the fuel economy of their current cars, their day-to-day fuel use and costs, and the importance of fuel economy in past and present vehicle purchases.

INFORMATION GAP

Drivers were able to tell us what it cost to fill their tank and the per-gallon price they paid during their most recent trip to a gas station—if that trip had been made the day of our interview or the day before. If it was any further in the past, then confident answers were replaced by tentative estimates. Many were uncertain because when they paid by credit card they didn't always look at what they spent. Most households confessed to having no idea of their fuel costs over any period of time—weekly, monthly, or annually. They did not budget, manage, or track fuel costs in any systematic way.



Further, many drivers could not tell us with any certainty how many miles per gallon (MPG) their current vehicle got, which was not surprising since many cars do not have fuel economy gauges. Those people who could tell us had either calculated it when they refueled or recalled it from the vehicle's window sticker (only an option if they had purchased the car new). A few who calculated MPG did so to track the condition of their engine, not fuel costs. They had learned from someone—their father or their mechanic, for example—that if they saw a drop in MPG, there was something wrong with the engine.

We also asked about willingness to pay for a vehicle with higher fuel economy and what payback period they expected for the increased cost. We got a range of answers. Even households with high financial skills struggled to guess what improvements in fuel economy were worth to them in dollars and cents. When we asked one couple, both accountants, what they spent each year on gasoline, he offered \$2,000, she offered \$4,000, and after further discussion they laughed and said, "Make it \$3,000." We knew from their low annual vehicle miles traveled that this amount was far too high. More often, this question brought a puzzled look from participants, and was answered with a lift in their voices, suggesting that respondents were guessing. They often seemed to be watching us to see if we thought their answer was a good one.

When we inquired about getting their money back on investments in better fuel economy—a payback period—some searched for an answer and then said, "I guess it would be nice if it were paid off when the loan was paid off," picking the only time frame they associated with the question. When respondents did offer a desired payback period, we asked where they got the number. In almost all cases, interviewees said they were guessing, and that this simply was not the way they had ever thought about buying a car. One banker we interviewed lit up when we asked this question. He said, "I know what you're talking about—that's a payback calculation. I do that every day. But I've never done that with a car. I buy what I need to look successful. Besides, how would I ever calculate a payback when I have no idea what gasoline will cost in the future?" A few said with apparent certainty, "one year" or "two years." However, when we inquired where the number came from, they simply asserted that they spent lots of money on gasoline and would quickly earn their money back through savings. A smaller group proposed longer terms—eight to ten years—noting that they keep their cars for a long time.

Several households explained that their lack of attention to gas costs was due to the fact that they felt they couldn't do anything about it; they had to drive as much as they did to lead the lives they had constructed for themselves.

THE HYBRID CHOICE

Numerous articles in the mainstream media and the automotive press have noted that buyers of hybrids do not make the extra cost of their vehicles back through gas savings. These articles contended that hybrid vehicles cost \$2,000 to \$3,000 more than vehicles of similar size and power. Our small group of hybrid vehicle buyers confessed they had never thought of or calculated a payback when they bought their hybrid. In fact, these people surprised us with how little attention they paid to fuel costs. They did pay a lot of attention to fuel economy. Drivers of hybrids confessed that they watched their fuel economy gauges compulsively. But none kept track of costs. They liked how much better their car's MPG was than other cars, and their gauges made them feel good >

*Decisions
about fuel
economy were
governed more
by emotions
than by analysis;
more by its
meaning than
by its monetary
value.*



about their vehicle choice. It turns out they bought hybrids mainly for ideological reasons, and not to save money.

Surprised by our findings, we designed a follow-up study to look at a larger group of hybrid buyers. We wanted to get a better sense of what motivated purchases of the highest fuel economy vehicles on the market. We built on what we learned from the first study: that consumers look to the media, to experts, and to other consumers to help them decide what to do. Their decisions around cars, fuel economy, and hybrid vehicles drew on social awareness, but not on calculations. They saw the price of gasoline posted at every gasoline station. They listened to reporters talk about gasoline prices on the news. They talked about cars with friends at church or work.

We found in this second study that decisions about fuel economy were governed more by emotions than by analysis, more by what fuel economy means than by its monetary value. In the months leading up to a purchase, these hybrid buyers were thinking and conversing about the high price of gasoline, new technologies, national security, the future, and the environment. When they went to buy a hybrid, they did not comparison-shop fuel-efficient compact cars. The hybrid buyers in this study were likely to have only one vehicle in their choice set: the particular hybrid they bought. They were more likely to be replacing a pick-up truck, SUV, or high-priced luxury car than a small economy sedan. And they often described the decision to buy a hybrid as an exciting moment of commitment to a new set of values.

If a hybrid buyer did talk about fuel economy, it was usually as an aesthetic value rather than a financial one, experienced through their new fuel economy gauges. Some hybrid drivers can watch their vehicle's fuel economy minute-to-minute. One young man

talked about the great pleasure he received from checking his fuel economy gauges at the end of a trip and seeing “what a good job” he did. Most of our hybrid buyers mentioned how much less often they refuel and even how much they are spending per fill-up. But they are no more likely than other drivers in our previous study to calculate costs over time. Some hybrid buyers are concerned about costs, but the costs are more symbolic than calculated, and are rooted in a buyer’s attempt to look financially smart to themselves, friends, family members, and coworkers.

We close with the story of an electrical engineer who said that he had studied the costs of different vehicles carefully. In fact, he was the only household out of 107 in our two studies to have constructed a spreadsheet of costs (including his estimated lifetime fuel costs) for several cars he was considering to replace his BMW sedan. He confessed that in the end he purchased the vehicle that he estimated made the least sense financially—a Ford Escape Hybrid. His reasons were both personal and symbolic: it was the vehicle he liked the most, and he thought buying it was a way to send a signal to an American carmaker about the sort of cars he wanted them to build.

CONCLUSIONS

The lack of knowledge and the inattention to costs by cars buyers may surprise some researchers. In defense of our survey subjects, car manufacturers don’t make it easy for drivers to calculate or track MPG and fuel costs. Even those hybrid vehicles with advanced energy-use instruments show fuel economy only over short periods of time, and don’t track daily, weekly, monthly, annual, or vehicle lifetime costs.

Also, the differences in cost resulting from diverse driving styles, price variations between gas stations, or differences in fuel economy between similar car models are often small. So it’s unsurprising that even hybrid buyers don’t take the time to make calculations or comparison shop for vehicles of similar size or class.

Is there a gasoline price threshold at which car buyers start doing more calculations? Gasoline prices in parts of northern California exceeded \$3.60 per gallon twice since we interviewed our last household. While not ruling out that high prices may have changed behaviors—it may have prompted some consumers to buy vehicles with higher fuel economy—the people in our studies did not indicate that they plan to spend more time making such calculations. If more vehicles had instruments that tracked fuel use and costs, consumers might pay more attention to them. However, in many cases, such instrumentation might only demonstrate that different driving behaviors and even differences between similar car models do not bring large dollar payoffs.

This does not mean that consumers do not care about fuel economy. A quick look at the current car market shows that buyers are shifting away from gas guzzlers. This is happening in a period of heightened attention to many issues related to fuel economy, including climate change and energy security as well as gas prices. But we cannot develop policies or create behavior models that assume drivers calculate costs or even that private cost is the main factor motivating consumers to choose better fuel economy. To be successful, vehicle choice models and policies based on those models must investigate more thoroughly all the aspects of fuel economy that motivate consumers. The payoff is often not so much at the pump or the bank. It comes when we’re sitting at the dinner table with family, when we’re talking with coworkers around the water cooler, or when we check the fuel economy gauge at the end of a trip to see what a good job we’ve done. ♦

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The Intersection of Trees and Safety

BY ELIZABETH MACDONALD

*f*OR AT LEAST 250 YEARS, the finest of streets the world over have been lined with trees. On the best tree-lined streets the trees are planted all the way to the corners. Indeed, in Paris, a city noted for its street trees, if the regular spacing of trees along the street runs short at an intersection, there is likely to be an extra tree placed at the corner. Yet in America, elm- or oak-shaded residential streets and commercial main streets are all too often only memories of good American urban design. In the automobile age, a real concern with safety has resulted in street tree standards that dictate long setbacks from intersections, ostensibly to achieve unobstructed sight lines for drivers. But are street trees the safety problem they are purported to be?

UNOBSTRUCTED VIEWS

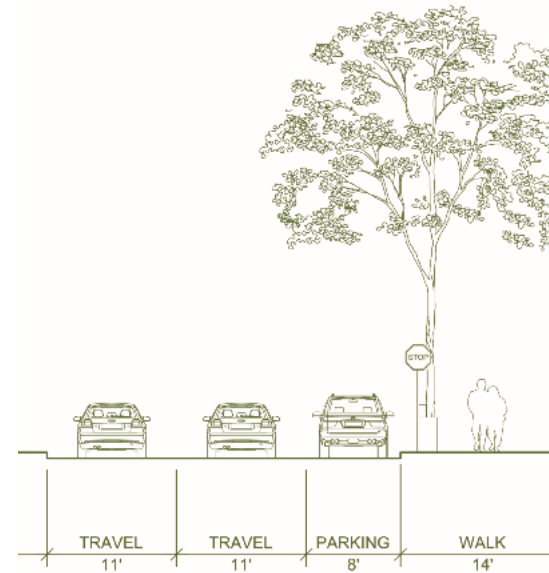
Engineering design policy manuals, such as those of the American Association of State Highway and Transportation Officials (AASHTO), recommend designing street intersections with clear sight-triangles so a driver can see potential conflicts before entering an intersection. These triangles extend hundreds of feet beyond the intersection. Recommended designs eliminate objects above sidewalk level that intrude into the sight-triangle and may interfere with a driver's vision.

Traffic and highway engineering textbooks describing the "clear sight-triangle" concept generally show diagrammatic views of intersections indicating sidewalk trees as objects to be eliminated. In the diagrams, trees are represented as solid circles, implying they are solid cylinders going all the way to the ground. This representation is of course unrealistic because street trees typically are trimmed to branch high. And although the intent of the clear sight-triangle is to eliminate physical obstructions from a driver's cone of vision, which operates in a three-dimensional world, the triangle is conceptualized in two-dimensional terms. In reality, the part of a street tree that would intrude on a driver's central cone of vision is the trunk, a relatively narrow vertical element.

AASHTO policy recommendations and their embedded assumptions that street trees must be eliminated from clear sight-triangles have resulted in many cities adopting street design standards that severely restrict sidewalk trees at intersections. Large set-back restrictions on trees often apply regardless of how a given intersection is controlled, while no similar regulations are written for other things commonly placed on sidewalks near intersections, such as newspaper racks, traffic signal poles, streetlights, and parking meters. Furthermore, urban street design ordinances generally do not require holding back on-street parking spaces a large distance from an intersection, so in practice parking spaces often intrude into the sight-triangles.

In sum, engineering policy recommendations in many cities have resulted in vigorous limitations on street trees near intersections but little regulation of other possibly obstructing elements. This reality is of concern for two reasons. First, restricting street trees may not be solving the intersection visibility problem. Parked cars and blocks of newspaper racks can present more of an obstruction to driver's sight lines than do street trees.

Second, restrictions on street trees at intersections mean that cities are creating streets that do not function as well as they might for pedestrians. Research from social science and environmental design disciplines suggests that sidewalk street trees play a major role in creating well-defined, comfortable, safe-feeling, and inviting pedestrian realms. Closely planted trees at the sidewalk edge can create a transparent fence that protects pedestrians, psychologically and physically, from vehicle traffic on the adjacent roadway. They provide shade on hot, sunny days, and some protection from rain. A recent body of public health research finds associations between environmental form and levels of physical activity, suggesting that people are more likely to walk where they feel comfortable and where the environment is inviting to pedestrians. In addition, street trees provide ecological benefits, such as shading hard surfaces and evapotranspiration, which helps mitigate urban heat island effects. Thus trees should not be restricted without careful consideration. ➤



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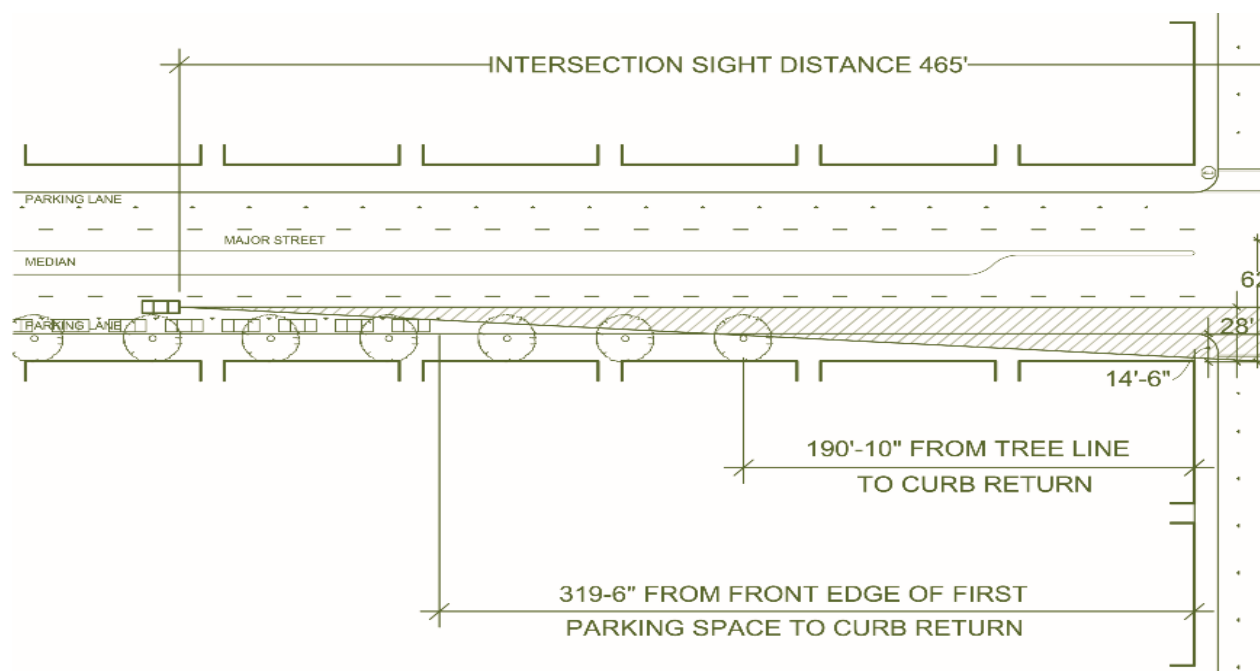
AESTHETICS AND SAFETY

Research from the fields of environmental psychology and public health points to psychological health benefits of nature in cities. Streets make up the bulk of public space in cities, and are distributed more evenly throughout the urban environment than are public parks. Thus they offer the biggest opportunity for the public provision of trees within cities. Research suggests that street trees can play an important role in helping make urban environments legible—in other words easily understandable—for people who live and work in them. Kevin Lynch found that closely planted trees on urban streets contributed to pathway imageability (that is, the ability to form and hold a mental picture of something), which can help people make sense of urban spatial environments, create clear cognitive maps, and navigate from one place to another.

Sidewalks near intersections should be designed for pedestrian comfort as well as safety, since pedestrians tend to gather at intersections. They are route choice points, where people often stop to ponder which direction to go, as well as common meeting locations. Traffic controls at intersections oblige pedestrians to stop and wait there, although the close contact with moving vehicles makes intersections potentially dangerous and uncomfortable places.

Holding street trees back a significant distance from intersections creates large gaps in the tree line. Indeed, with large setback standards, short blocks can have so few trees that any positive effect from them is negligible. On a 200-foot-long block in Portland, Oregon, for example, a typical setback standard, combined with a not-uncommon fifty-foot standard for spaces between trees, would result in no more than three trees per block.

Transportation planners in recent years have begun to adopt a more holistic and complex view of streets than in the past. Emphasis is shifting toward equity concerns, and toward providing streets that work for all transportation modes, especially pedestrians. As a case in point, several years ago the San Francisco Bay Area Metropolitan Transportation Commission adopted a street redesign program directed at achieving pedestrian comfort as well as safety. The first objective often proves difficult to achieve because those qualities that make the best pedestrian environments often conflict with safety standards requiring large setbacks or large spaces between trees.

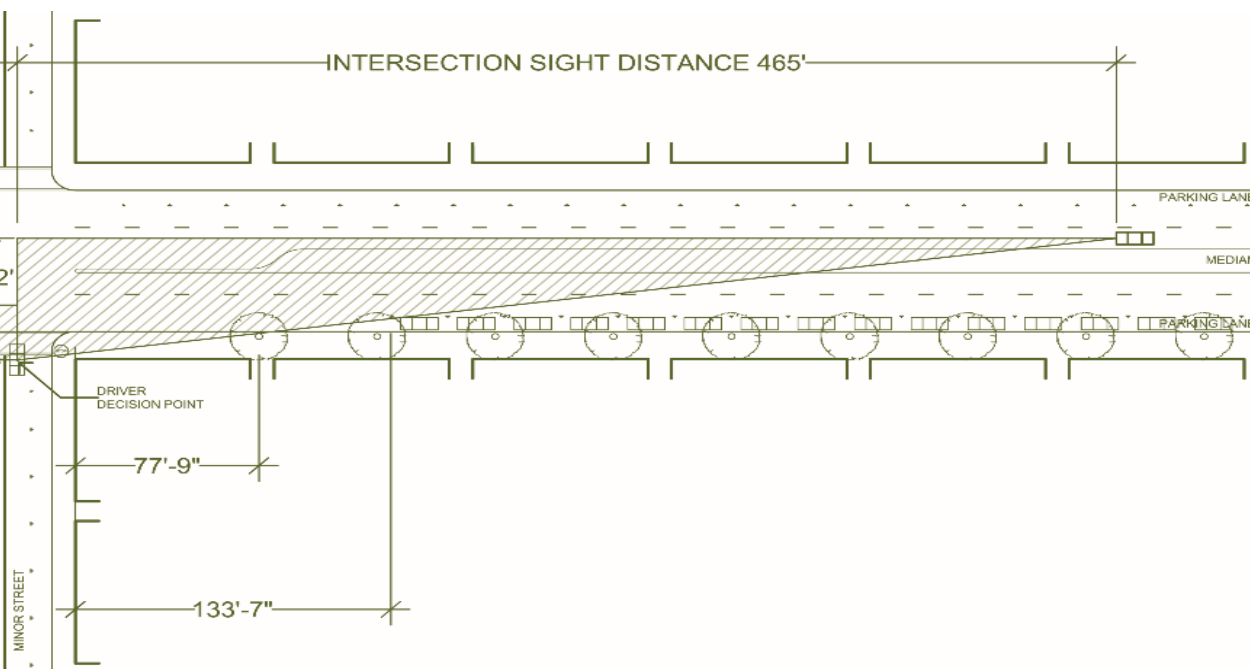


If communities are interested in creating streets that work for pedestrians as well as cars, they should not restrict sidewalk street trees unless it can be shown unequivocally that they create unsafe environments. If all trees cause significant visibility problems, then it makes sense for engineering policy guidance to continue recommending that they be held back substantial distances from intersections without making allowances for the type of tree or how it is trimmed. Perhaps a middle ground is possible, by creating more detailed criteria for sizes and shapes of sidewalk trees within the clear sight-triangle. If street trees don't hinder safety, then there is no need to give them up or avoid planting them near intersections.

LOOKING PAST TREES

Advances in three-dimensional spatial modeling and improved techniques for simulating movement through virtual spaces make it possible for us to explore the impact of intersection street trees on driver's visibility more precisely than was possible in the past. We recently conducted a study at UC Berkeley that had three objectives. First, we wanted to understand how AASHTO guidelines apply to typical urban situations, and to identify any ambiguities and/or conflicts that arise.

AASHTO is concerned with two types of intersection sight-triangles: approach and departure. *Approach* sight-triangles are the views that a driver has from a moving vehicle approaching an intersection; these are applied only at uncontrolled or yield-controlled intersections, where the driver may not have to stop but must be able to see for some distance. *Departure* sight-triangles are the views that a driver has from a vehicle stopped at a stop sign before crossing or making a turn; these are applied where just one of the intersecting roadways has stop signs. AASHTO does not specify clear sight-triangles for intersections with four-way stops. At signalized intersections, AASHTO recommends applying standards for departure sight-triangles only if moves requiring driver judgment are permitted, such as right turns on a red light, or left turns where a separate "left-turn-only" signal phase doesn't exist. (This effectively includes almost every signalized intersection in California, since right turns on red are permitted except where specifically prohibited.) ➤



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We did not study uncontrolled or yield-controlled intersections, which are not commonly found in urban locales, and we likewise ignored signalized intersections, as the sight-triangle specified for a left turn does not affect street tree placement and the sight-triangle specified for the “right-turn-on-red” is the same as for intersections with a two-way stop. Thus we narrowed our research focus to departure sight-triangles at intersections with stop control on just one roadway.

Our second objective was to understand how various planning jurisdictions within California have interpreted AASHTO advice on clear sight-triangles within formal standards that restrict street trees or other objects near intersections. We also wanted to know whether local standards are absolute or if they allow some discretionary leeway. We collected data from thirty cities and compiled it in tables to compare it.

Third, we used computer modeling and drive-through simulations to analyze the amount of visual obstruction caused by street trees and other objects at intersections, as well as to test what drivers see. We first created four digital models of a typical urban intersection. The basic configuration was kept constant but locations of sidewalk trees, parked cars, and newspaper racks varied to reflect AASHTO recommendations, modified AASHTO recommendations, the actual standards in place in Oakland, California, and a researcher-defined pedestrian-friendly option. We animated the models with moving cars and created drive-through simulations from a driver’s viewpoint, showed the resulting video to 96 individuals in a controlled laboratory experiment, and had them complete a questionnaire.

AMBIGUITIES

AASHTO uses a mathematical formula to determine the size of the departure triangles it recommends, with variables related to street width and design speed. These formulas result in very long sections of streets that are supposed to be kept clear of obstructions. (For example, on a main roadway with a 100-foot right-of-way intersecting with a minor street with a sixty-foot right-of-way, the tree line is supposed to be approximately 190 feet back from the corner.) If the recommendations were followed precisely, many urban blocks would have few street trees and little on-street parking, and all of it would be clustered at mid-block.

Our research uncovered a major problem: AASHTO guidelines contain ambiguities that make them difficult to interpret. For example, it’s hard to figure out where to set the location of what’s called the “driver decision point,” which has major implications for how much of the triangle overlaps the parking lane and sidewalk. Using a conservative interpretation of the AASHTO guidelines—setting the point 14.5 feet back from the *curb edge*—makes no sense in cases where buildings come right to the property line. At that point the buildings block most of the driver’s view of the intersecting roadway. On urban streets with sidewalks and parking lanes, setting the driver decision point 14.5 feet back from the edge of the *near travel lane* makes much more sense.

INCONSISTENT APPLICATION

While AASHTO differentiates between intersection types in terms of how they’re controlled, and makes different clear-sight-triangle recommendations for different cases, many of the California cities we studied adopt “one-size-fits-all” street-tree setback standards. Nevertheless, street-tree setback and spacing requirements vary greatly

among the California cities studied; setbacks range from fifteen to fifty feet back from the curb, and minimum spacing between trees from twenty to fifty feet.

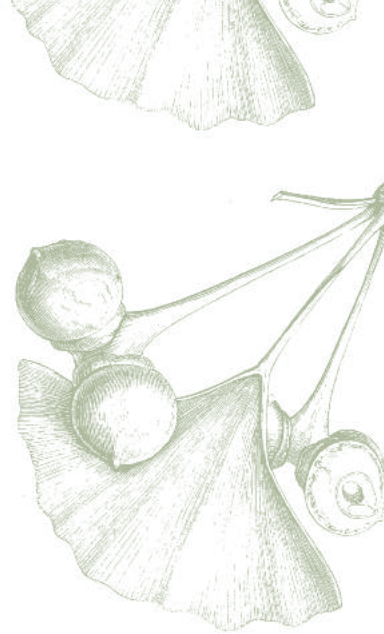
Of the California cities studied, many have no written standards for on-street parking near intersections. Those that do have generally adopted looser restrictions for on-street parking than for street trees, with parking setbacks ranging from 10 to 25 feet back from the crosswalk. Those cities that have adopted standards for newspaper racks invariably permit them to be much closer to intersections than either trees or parked cars, and generally allow them to be both quite long (7.5 to 15 feet) as well as to extend above the eye level of a driver in a typical car.

In addition to setback and spacing requirements, many cities have adopted additional restrictions on street trees, such as required minimum distances from driveways, street lights, signs, fire hydrants, gas meters, water meters, transformers, and parking meters. The cumulative effect of so many restrictions severely limits where sidewalk street trees may be placed along the whole length of a city block as well as near intersections.

In practice, it seems that many cities use a great deal of discretion regarding street tree setbacks and spacing, that is, decisions are apparently often made on a case-by-case basis. The widespread use of discretion means that urban designers are likely not to know the reasoning behind the AASHTO recommendations, nor to be able to successfully challenge them.

MODELING WHAT DRIVERS SEE

Simulation seems to work well as a way of testing visibility at intersections, but it's important to reference actual driver behavior rather than make assumptions about it. The method is particularly useful because it prods analysts to confront three-dimensional realities they might not otherwise consider, such as that tree canopies generally start some distance above the ground. ➤





The primary conclusions that can be drawn from both the experiment results and the survey answers is that, first, the presence of high-branching sidewalk trees near intersections does *not* significantly affect a driver's ability to see approaching cars—or at least its significance is considerably less than that of other equally common curbside objects such as parked cars and newspaper racks.

Second, the presence near intersections of a combination of parked cars and newspaper racks *does* significantly affect a driver's ability to see approaching cars, regardless of whether street trees are kept out of the AASHTO-recommended clear sight-triangle or not.

In the end, the basic conclusion of our research is that street trees—if properly selected, adequately spaced, and pruned to branch high—do not create much of a visibility problem for drivers entering an intersection where there is a stop control on just one roadway. Cars parked on the street—particularly large ones such as the SUVs used in our digital models to simulate worst-case conditions—create a substantially bigger visibility problem, and newspaper racks also get in the way.

Although additional research is necessary, it's clear that the AASHTO guidelines regarding recommended street-tree setbacks at urban intersections need to be re-evaluated. ♦

Alethea Harper, Jeff Williams, and Jason Hayter, all graduate students at UC Berkeley's College of Environmental Design, assisted in this research project. UC Berkeley's XLab, the Social Science Research Laboratory, provided support and facilities for conducting the driving simulations.

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Smarter Parking at Transit Stations

BY SUSAN SHAHEEN AND CHARLENE KEMMERER



TRANSIT STATIONS, SUCH AS MANY OF THE OUTLYING STATIONS along the BART system in the San Francisco Bay Area, provide parking so riders can easily get to and from the station. At first parking spots at BART stations were free to whoever showed up earliest to park. Then in 2002, BART began offering monthly reservations on some parking spots for a fee, so that riders who couldn't rush out of the house to arrive at the station before anyone else also had the opportunity to park.

Commuters without the monthly permits are faced with a dilemma if they want to take BART and can't get to the station early. Do they risk deviating from their driving commute route to try to find a spot at the station? If they don't find one, they will have wasted time and gas, and they'd then have to find their way back to their driving route, now a bit later, and reinsert themselves into the stream of traffic.

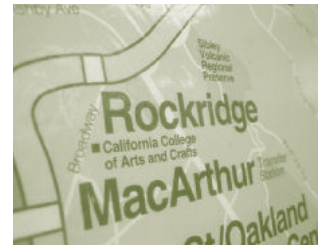
Is there a way for commuters to know whether there are parking spots available? Is there a way for people to guarantee that they can park at the transit station if they exit their driving route? And in the process, is it possible to encourage some drive-alone commuters to park their cars and ride BART?

We think so, using what are called "smart parking" systems—broadly defined as the integration of technologies to streamline the parking process. Parking operators have begun using advanced technologies such as changeable message signs and pay-by-phone schemes in many countries including Norway, Spain, Canada, Ireland, Australia, and the US. We wanted to try it at a BART station in the San Francisco Bay Area.

THE ROCKRIDGE BART SMART PARKING EXPERIMENT

From December 2004 to April 2006, we tested a smart parking system at the Rockridge BART station in Oakland, California, where parking demand is high. There is a substantial waiting list for monthly permits—but even with a ten percent over-subscription rate not all the spots are filled every day because not all the monthly permit holders commute by BART each morning. BART makes these spots available to anyone after 10 a.m. We wanted to see if smart parking technologies could complement the monthly reserved program by providing daily flexibility during the morning commute for those not using transit every day. We also wanted to test the various components of the service, and to see if we could attract new riders off the freeways and on to BART.

The research project was a public-private partnership among California Partners for Advanced Transit and Highways (PATH), the California Department of Transportation (Caltrans), the BART District, ParkingCarma, Inc., a company that builds technology for smart parking applications, and Quixote Corporation, an advanced transportation technology company. Also, Intel donated hardware and Microsoft donated software for the experiment.



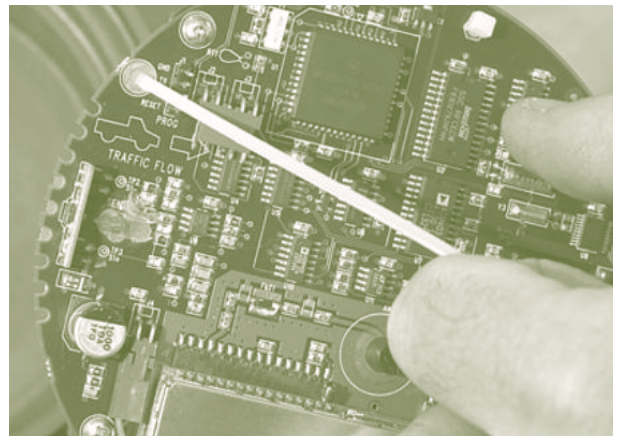
Susan Shaheen holds a joint research appointment at the Transportation Sustainability Research Center (TSRC) of the Institute of Transportation Studies at the University of California at Berkeley and at the Institute of Transportation Studies at the University of California at Davis (sashaheen@tsrc.berkeley.edu). Charlene Kemmerer is a researcher at TSRC (ckemmerer@tsrc.berkeley.edu).



The project coordinated three key technologies that had not previously been combined in any smart parking system. First, six in-ground electromagnetic sensors counted the number of cars entering and exiting the parking lot. Second, a computer reservation system used both an online, real-time user interface and a telephone Interactive Voice Response service. Third, two solar-powered changeable message signs on the freeway near the exit for the Rockridge BART station announced the number of available spaces and which exit to take to access the parking lot.

Researchers conducted two focus groups, two web-based user surveys (at the beginning and at the end of the project), and interviews with ParkingCarma managers and the smart parking project manager, a PATH employee. We also collected and analyzed reservation data from ParkingCarma.

The smart parking experiment used fifty of the 274 spaces in BART's east lot, increasing the number of peak period spaces available by using some spaces set aside for use after 10 a.m. Participants could make either advanced reservations—from two weeks to same day (if available)—or drive-in reservations. They could make the reservations either by phone or online, but could only use advanced reservations three times every two weeks; this restriction was placed on the experiment by the research team to encourage more users. Informational signs on local freeways approaching the station displayed the number of spaces available in real time (but always five less than the actual number >





available, to maintain a buffer). The service operated during the peak hours of 7:30 to 10 a.m., Monday through Friday, and BART security personnel monitored the parking lot, checking license plate numbers to enforce compliance.

During the experiment, there were over 13,000 successful drive-in and advanced reservations made. Final survey results suggest that smart parking increased transit use among respondents: nearly half the respondents said that they would not have used BART to commute if smart parking were not available. Smart parking participants also used BART more frequently, averaging an additional 5.5 trips per month for commuting to work and an extra four trips per

month for off-site trips. Also, the program reduced overall vehicle miles traveled by 9.7 fewer miles per participant per month on average, and their commute time was shortened by an average of 2.6 minutes.

LESSONS LEARNED

We placed changeable message signs on a heavily trafficked roadway that often becomes congested during peak periods. The signs operated during morning commute hours, from 7:30 to 9:40 a.m., Monday through Friday. However, the final user survey revealed that less than half the participants in the surveys and focus groups saw or used the signs to help them decide whether to use the smart parking service. The signs, they said, were not located on their commute route, so it may be that additional signs are needed on roads approaching the station. Their answers highlighted the importance of placement and number of signs. There was also a fair amount of mistrust about the accuracy of the signs. Participants feared the empty parking spots would be filled before they arrived at the station, even though they could call to reserve a spot as soon as they saw a sign. We had not told them about the five-space buffer, of course, and perhaps the mistrust was due to their inexperience with the new technology. We will expand our research on sign messaging and user understanding in our next study of smart parking in San Diego, based on these results.

ParkingCarma's customized interactive voice response telephone system handled approximately 9,000 reservations throughout the experiment. Participants generally liked the spontaneous flexibility that drive-in reservations enabled, but they also offered suggestions to improve the system. Problems arose around its ability to understand verbal commands in a noisy environment, for example, and users wanted instructions to be repeated. They also distrusted the accuracy of the real-time available-space count as given by the phone system. This is another area for further investigation in our next study.

Our respondents noted fewer problems with the web-based reservation system. Participants generally liked the parking history feature, which displayed the dates of all past reservations. Several respondents thought it was difficult to create an online account, but the web site "wizard," intended to help first-time participants, was under-used, according to ParkingCarma staff. Overall, the majority of final survey respondents (75 percent) never encountered a situation where they arrived at the lot with a reservation but there was no spot for them. Further investigation into what happens in such a case will be included in our next study.



Both survey respondents and focus group participants provided general recommendations for smart parking, from requests for more and clearer signs in the parking lot to various levels of project expansion. Not surprisingly, participants wanted to use the advanced reservation service more than the allotted three times every two weeks. Many requested a project expansion, including more parking spaces, increased hours of operation, and more BART stations. When asked in a final survey if they would use BART more frequently if smart parking were expanded to other BART stations, 45 percent answered “yes.”

PARKING FEES

Smart parking fees were implemented in October 2005 (ten months into the experiment at the Rockridge station), to investigate the effects of pricing on user behavior. BART managers set the price of advanced reservations at \$4.50 per day and drive-in reservations at \$1 per day. The majority of respondents did not stop using smart parking when fees were implemented, although reservation data indicate that advanced reservations decreased and drive-in reservations increased (as seen in Figure 1). The percentage of advanced reservations decreased by a monthly average of thirteen percent after the parking fees were implemented. We asked survey respondents what was the maximum price they would pay for smart parking. Figure 2 illustrates that nearly three quarters of them would stop using smart parking if daily parking fees got as high as \$5 per day. Many also expressed concern that the costs of parking and BART fares combined were too much, and the cost of advanced reservations, in particular, was too expensive. ➤



FIGURE 1

Smart parking usage before and after pricing

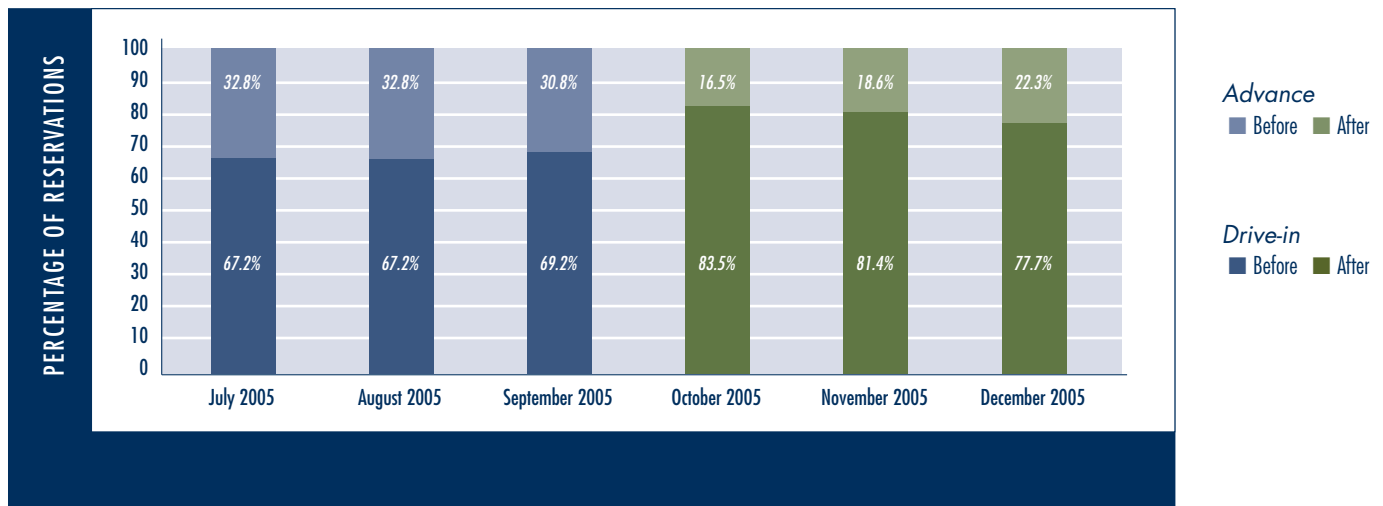
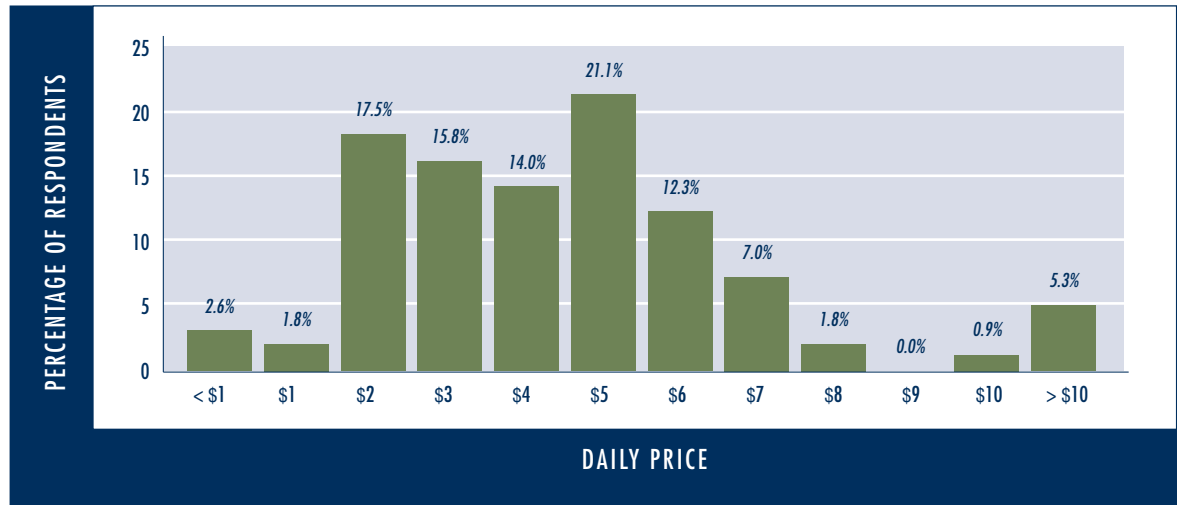


FIGURE 2

Final survey results: At what price would you consider stopping smart parking use?



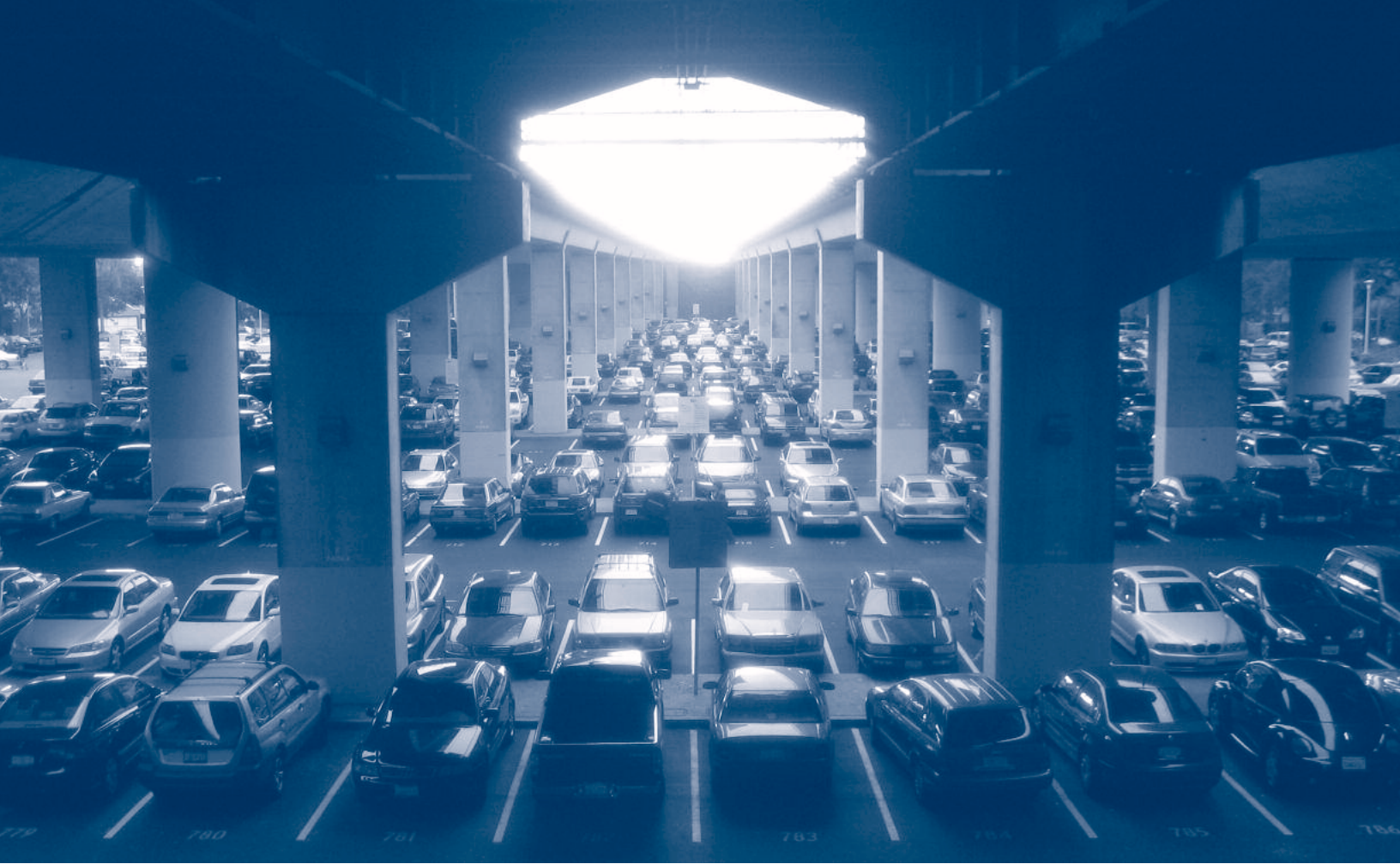
Many of our smart parking users expressed disappointment when the experiment ended and encouraged its continuation and expansion to other stations. When they used advanced reservations they could rely on having a parking space at the station and sometimes they were able to avoid early morning traffic jams by using drive-in reservations. Many focus group participants said their quality of life rose due to the smart parking service; this was related to reduced stress and the ability to sleep a little more.

An important consideration for future smart parking projects is that the majority of users did not discontinue their use of the service after pricing fees were implemented. While advanced reservations did decrease at this time, drive-in reservations increased, and it's likely these changes were due to the price difference rather than to the existence of fees. The main concern about fees was that the cost of parking and BART fares together was too high.

Meanwhile, BART has now implemented fees on all parking spaces at the Rockridge station. Unreserved first-come, first-served spaces cost \$1 a day; BART also put into place a system whereby riders can purchase a one-day reservation online and print out a permit ahead of time. This is similar to the system we introduced in our experiment, but without the advanced technology and the ability to pay by phone on the spur of the moment.

MOVING FORWARD

We will soon apply the lessons we learned from the Rockridge BART smart parking project along the San Diego Coast Express Rail route. This three-year pilot project, funded by Caltrans, PATH, and the Federal Highway Administration, will include a value pricing component, providing the option to pay an additional fee to make advanced reservations for premium parking spots. We will experiment with more detailed messages on changeable message signs, such as traffic conditions and incident reports; using smart cards or transponders to enhance parking payment options; charging different fees depending on factors such as time of day; and expanding the number of parking spaces at and around the transit stations.



CONCLUSION

Through the smart parking experiment, we learned that advanced technologies can be used to streamline the parking process by providing space information and convenient reservation services, and that such a system can complement the monthly reserved program offered at BART stations. Furthermore, as the increase in average BART trips among users (5.5 trips per month for commutes to work and four trips per month for off-site trips) indicates, it is possible to increase transit use among commuters by implementing a smart parking service. Results from the forthcoming project in San Diego will further add to the growing body of work on smart parking technologies and applications. ♦

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ERRATUM

The Almanac in the special Winter 2006–2007 issue of ACCESS (“Love, Lies, and Transportation in LA,” by Charles Lave) contained errors in the last column. Only 1.5 percent of Wyoming workers take transit to work, not 6 percent as stated in the chart. Thus, California’s transit share improves by one line, making its 1991 and 2004 positions the same. Consequently, the average and median for the last column become 2.88 and 1.75 percent, respectively.



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