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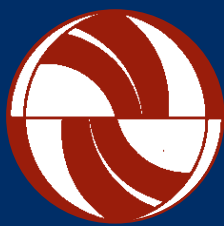
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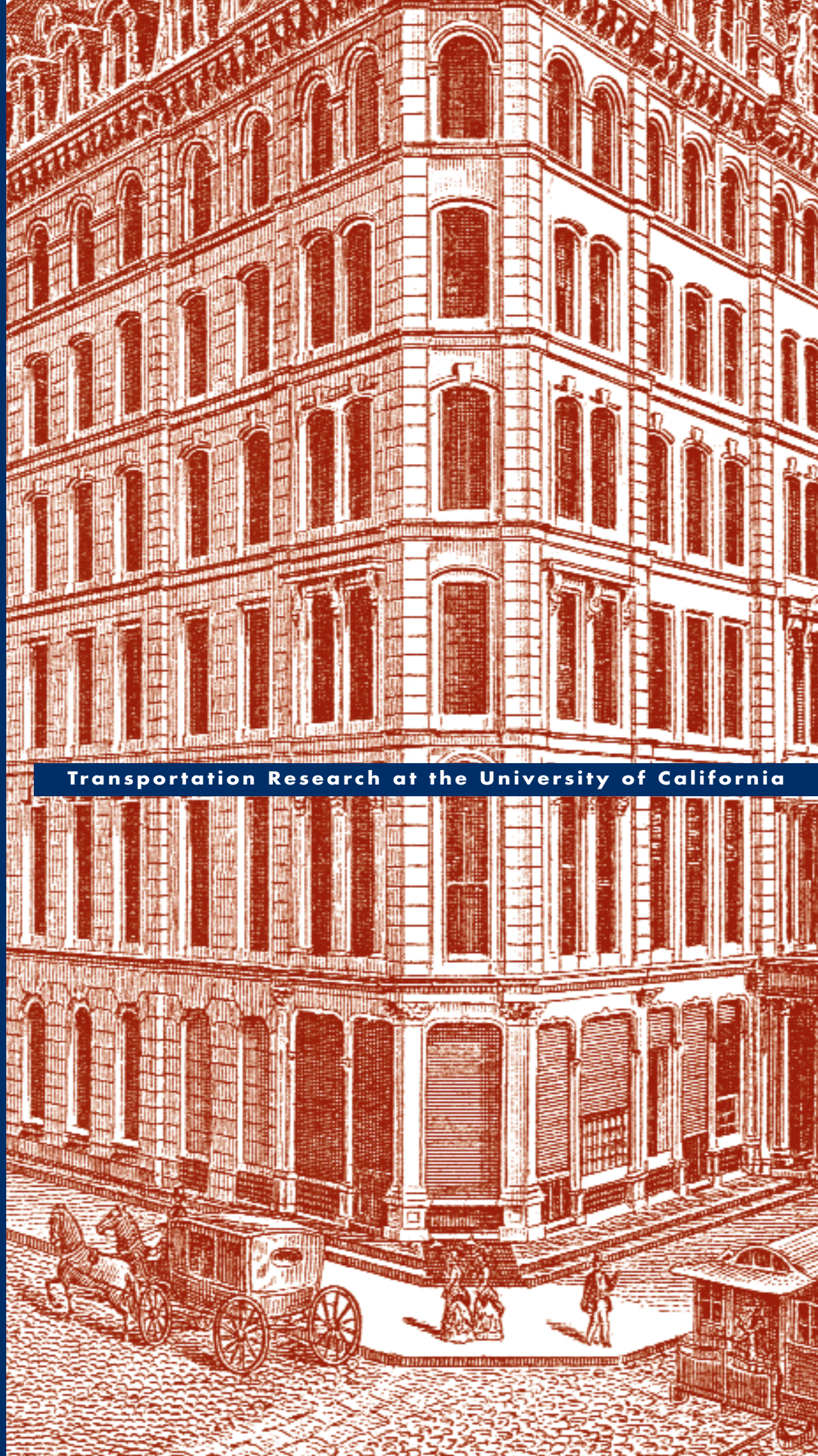
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Peer reviewed

# TRANSPORTATION



SPRING 2005  
NUMBER 26



Transportation Research at the University of California



## *Earmarking Threatens University Research*

“**E**ARMARKING” OCCURS when Congress allocates funds to specific recipients for specific purposes. Legislators have long designated funds for highway and transit projects in their home districts, fulfilling commitments made to their constituents. But funds spent for strictly political reasons can divert financial support from potentially productive projects, bypassing formal evaluation processes, economic, social, and environmental appraisal of alternatives, and citizen involvement and debate.

Historically, research funding has not been earmarked, but recently that has been changing. Recipients of research funds traditionally have been selected by open competition and peer-review processes. Widely circulated announcements encouraged researchers to design studies for work on particular problems. Experts anonymously reviewed proposals and recommended the most promising for funding. Congress, however, has increasingly decided that specific universities, named in legislation, should carry out certain research projects and host certain research centers.

In fiscal year 1995 earmarks accounted for about 1 percent of USDOT expenditures on “research and technology,” but by 2003 they accounted for 14 percent. A striking example of this trend occurred in the Federal Highway Administration’s Research and Technology (R&T) program. In FY 1997, the last year of the Intermodal Surface Transportation Equity Act, approximately 12 percent of R&T was earmarked. The 1998 Transportation Equity Act for the 21st Century (TEA-21) increased earmarking to about 19 percent of TEA-21’s research authorizations for the next six years. Earmarks from the annual Congressional appropriations process increased the average level of earmarking during the TEA-21 years to 33 percent of the R&T program. Earmarking is even more extreme in some parts of the federal research program. The Technology Deployment Program, for example, saw earmarks in the range of 26 to 54 percent during the life of TEA-21. The Pavement Research Program was “over-earmarked” in some years—total amounts earmarked exceeded the funding set aside for those programs.

This shift to earmarked research funds raises questions about the quality and productivity of our national transporta-

tion research program. Open competition and peer review encourage scholars to prepare novel, comprehensive research proposals. Competitions judged by qualified reviewers require proposal writers to be thorough, innovative, and persuasive. Earmarking, in contrast, directs energy toward lobbying—toward persuading legislators who are powerful but often poorly informed about the substance of research. Presentations to elected officials may focus on the merits of geographic distribution of funds or on how many jobs might be created by an award rather than on the rigor of the intellectual work. At worst, persuasion of legislators may consist of little more than campaign contributions and appeals to the loyalty of alumni who hold seats in Congress.

Writing research proposals, reviewing them, evaluating alternatives, and reading researchers’ publications all broaden knowledge and thus further advance the field. Energies devoted to lobbying produce much smaller returns.

Earmarking can also have a deleterious effect on the USDOT, whose objectives include renewing the interstate highway system and improving safety. As earmarking grows, some research aimed at supporting these missions may be neglected or delayed. Public agencies often follow multi-year research and development plans involving numerous contracts which must be coordinated to achieve larger objectives transcending individual research projects. Earmarks designated without regard to overall research plans can sidetrack programs and weaken an agency’s ability to fulfill its functions.

The trend toward increased earmarking of transportation research funds must concern all who realize that America has led the world in applying science and technology to transportation. University research has been remarkably innovative and valuable precisely when it has been unrestrained, competitive, and apolitical. Earmarking can be part of a complex research and development strategy, but it should not dominate. There must be room left for agencies to plan their research programs and room for scholars to participate through competitive, independently conceived, and peer-reviewed transportation research.

—*Martin Wachs and Ann Brach*

## PAYING FOR ROADS

# New Technology for an Old Dilemma

BY PAUL SORENSEN AND BRIAN TAYLOR

**WHO SHOULD PAY FOR ROADS?** How should they pay? These frequently debated questions echoed through the first two decades of the last century as motor vehicle use accelerated. It seemed only fair to ask users to pay for roads, but collecting road-side tolls was costly, slowed traffic, and was feasible on only the most heavily traveled highways. Paying for roads with general tax revenues was far simpler, but was seen as unfair to the many people without cars or trucks who would be forced to pay for roads that they would seldom use. The eventual solution—the motor-fuel tax—was a brilliant one: the tax was cheap and easy to collect, and it charged travelers in rough proportion to their use of roads.

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While the motor-fuel tax has been the backbone of surface transportation finance for over eight decades, its buying power has waned considerably in recent years. In response, public officials have gradually turned away from a “user pays” principle of highway and transit finance and toward other instruments of taxation, such as voter-approved local sales taxes and general revenue bonds. A wrinkle in this trend, however, has recently emerged in the form of electronic tolling. Many such “toll-booth-free” systems have gone into service around the world in recent years, and many more are on the drawing boards. The most ambitious of the proposals currently in development would replace the venerable fuel tax entirely with a distance-based user fee. There are many possibilities presented by distance-based tolling systems, as well as many uncertainties and risks.



### **IS THE MOTOR-FUEL TAX RUNNING OUT OF GAS?**

Because it is levied per gallon, inflation and improved fuel efficiency combine to erode the buying power of the motor-fuel tax. To keep pace with rising costs and increasing travel, the per-gallon fuel tax levy needs to be hiked regularly. But while fuel taxes have risen a few times since the early 1980s, they have fallen far short of the combined effects of inflation, vehicle fuel efficiency, and new program responsibilities. In a political climate that remains wary of any kind of tax increase, public officials have tended to put periodic stopgap revenue measures before voters for approval, often in the form of local sales taxes or bond measures targeted for specific transportation projects.

Even with such ad hoc measures, however, the gap between revenues and construction and maintenance needs has been widening since the 1970s across the US. In California, for example, the state Transportation Commission currently reports an unfunded backlog of highway maintenance and construction projects in excess of \$100 billion. Moreover, the recent rise in popularity of extremely fuel-efficient hybrids and the continuing development of alternative-fuel vehicles threatens to weaken the relationship between road use and gasoline tax revenues even further. All evidence, then, suggests that the fuel tax’s days may be numbered, though what that number might be remains the subject of considerable debate.

### **THE RISE OF ELECTRONIC TOLLING**

As transportation experts ponder the life expectancy of the gas tax during these first decades of the 21st Century, they are again asking: Who should pay for roads? Then, how should they pay? While the questions have not changed from nearly a century ago, the possible answers have. This is because a new breed of information technologies—including on-board computers, global positioning systems (GPS), digital maps, and wireless communications—now make it relatively easy and cheap to measure and record vehicle travel by road segment and time of day, even across different states and jurisdictions. Such technology effectively opens the door to numerous pricing options long proposed by transportation economists but never before deemed feasible or practical.

In a report we recently prepared for the Transportation Research Board, we identified 88 examples from around the world of innovative electronic tolling applications already in place or in the advanced stages of development. The cases we examined incorporate a variety of pricing schemes, ranging from facility congestion tolls to area congestion tolls to weight- and distance-based user fees and insurance charges. Of these, by far the most technically advanced plans with the greatest revenue implications are ➤

proposals to replace the fuel tax with a general-purpose, network-wide, distance-based user fee for automobiles and trucks.

Although exact implementation details for distance-based user fee proposals vary, the technical strategy, in its simplest form, works as follows. To determine and record travel information, each car must be equipped with an on-board unit that integrates these components: a GPS receiver, a set of digital maps identifying jurisdictional boundaries, an odometer feed, a rate table for computing distance charges, and some form of wireless communication technology for reporting billing data. During each trip, the computer repeatedly checks the GPS receiver to determine geographic location, then compares this information with digital maps to establish the current jurisdiction. Each mile traveled (based on the odometer feed) is then sorted and stored by jurisdiction, and the computer uses this information, along with the rate table, to keep a running total of fees owed to different authorities (for example, different states).

Periodically, this information is transmitted to a billing agency so that charges can be levied and fees paid. This can occur, for example, via dedicated short-range communications when the driver refuels, in which case the fees could be simply added to the fuel bill. Alternatively, data could be uploaded to the billing agency on a monthly basis, and the vehicle owner can be billed electronically. To prevent toll evasion, on-board equipment must be tamper-resistant; some units are programmed to perform regular checks against the odometers to ensure that the units have not been turned off during any period of operation. Jurisdictions may also choose to mount roadside devices that can communicate with passing cars to verify that on-board units are installed and operational.

While such distance-based fee proposals are ambitious, several states in the US have already launched efforts to evaluate the feasibility of per-mile electronic tolling. In 2001,



for example, the Oregon legislature commissioned the state's Department of Transportation to develop a long-term vision for road finance, which resulted in a detailed proposal for a mileage-based road fee, now being tested in and around Eugene. The Minnesota Department of Transportation pooled resources with fourteen other states (California, Connecticut, Iowa, Kansas, Michigan, Missouri, North Carolina, Ohio, Oregon, South Carolina, Texas, Utah, Washington, and Wisconsin) and the Federal Highway Administration to fund a proposal, developed by researchers at the University of Iowa, for a multi-jurisdictional (state-to-state) mileage fee.

While these US proposals are just now being tested, distance-based electronic tolling has already gained considerable traction in other parts of the world, most notably Europe. Austria, Switzerland, and Germany have all recently launched automated weight-distance truck tolls across their national highway networks, and the United Kingdom is planning to develop a similar system in the next few years. The Netherlands had developed plans to implement a distance-based fee applying to both trucks and passenger cars, but the idea was shelved in 2002 with the election of a more conservative government. More recently, the cities of Copenhagen, Gothenburg, and Helsinki have experimented with distance-based user fees, while the European Space Agency, eager to find applications for its upcoming Galileo satellite global positioning system, has begun to lay out specifications for a pan-European distance-based road tolling system. While many of these European experiments have cited fiscal shortfalls as a central motivation, they have also explicitly focused on other important objectives such as accommodating increased travel among European Union member countries, managing congestion, encouraging shifts away from single-occupant autos, tracking burgeoning truck travel, and providing incentives for the purchase of cleaner-emission vehicles.

#### **DISTANCE-BASED USER FEES: PREMATURE OR OVERDUE?**

So why the recent surge in electronic tolling? Have the user-fee purists and technophiles succeeded in convincing the motoring public and its elected officials that electronic tolling is the way to go? Hardly. We think that the driving force behind the upsurge in electronic tolling, particularly here in the US, is a pragmatic one: public officials, many of whom have long been wary of tolls, are desperate to find new sources of transportation funding.

However, the move towards electronic tolling is well short of a juggernaut. The idea continues to meet considerable skepticism, and in some cases outright hostility, among many transportation interest groups, voters, and elected officials. In 2004, for example, California's new head of the Department of Motor Vehicles publicly suggested that the state must eventually shift to some form of a mileage-based user fee. Her statements were widely and sensationally covered in the press, and were generally greeted with a chorus of boos from liberals and conservatives alike.

The most common objections related to privacy and environmental issues. For those concerned with privacy, the prospect of on-board equipment that could allow the government to track and monitor drivers without their consent or knowledge is chilling indeed. Meanwhile, environmental advocates worry that distance-based pricing schemes would take the form of flat mileage fees, accounting for neither fuel economy nor emissions. Replacing the existing fuel tax with such a flat fee would effectively eliminate one of the few tax-related policy incentives for purchasing more efficient vehicles. ➤

*Have the  
user-fee purists  
and technophiles  
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convincing  
the motoring  
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officials  
that electronic  
tolling is the  
way to go?  
Hardly.*



*Replacing the existing fuel tax with a flat fee would effectively eliminate one of the few tax-related policy incentives for purchasing more efficient vehicles.*

In her response to the new DMV chief's comments, California Assemblywoman Fran Pavley (D-Agoura Hills) neatly summed both of these objections:

"People who drive fuel-efficient, less polluting cars would have exactly the same tax burden as people driving huge gas guzzlers...Allowing the government to track Californians' movements everywhere they drive is a totally unacceptable Big Brother-type intrusion....Invading our privacy and providing a disincentive for people to drive clean-air vehicles would be a terrible U-turn in public policy. This one belongs in the scrap heap."

Such concerns are understandable, and public suspicions are certainly not allayed by sometimes histrionic press coverage. A recent *Los Angeles Times* article discussing the Oregon pilot test, for example, reported that "tracking devices send a signal to a GPS satellite following the car," which paints an alarming image for anyone concerned about privacy. But GPS satellites don't follow cars; rather a GPS receiver in the car uses signals from the satellite to determine its own location. Such misrepresentations aside, it becomes evident, when one digs a little deeper into the details of distance-pricing proposals, that both privacy and environmental concerns can be addressed through appropriate technological and programmatic design.

Each of the distance-based pricing proposals we studied aims to protect users' privacy through several ingenious strategies. In the University of Iowa proposal, for example, drivers would periodically download billing data from the onboard unit onto a smart card, then upload the data to the billing agency via a card reader at a filling station or on a home computer. The transfer process would be divided into two transactions. The



first would upload user identification and total amount owed. Then a second, anonymous connection would report the division of the bill to different jurisdictions. Jurisdictions would thus receive the appropriate revenues, but the government would never know *where* or *when* any individual had traveled, only the total amount owed.

To address environmental concerns, mileage-based tolls could easily be set to vary by vehicle-emissions class. This approach has already been employed in the German weight-distance truck-toll system, where the distance charge is fifty percent higher for the most polluting vehicles than for the least polluting ones within any given weight class. Such adjustments could certainly be applied to passenger vehicles as well as trucks.

It is, in a certain sense, ironic that many environmentalists resist the idea of developing the technical apparatus necessary to levy mileage fees. Many transportation analysts are intrigued by electronic tolling *because* it permits variable charges to reflect the numerous costs—congestion delays, damage to road beds, vehicle emissions, etc.—that users impose on society. Such pricing strategies are already being explored. The Puget Sound Regional Council, for example, is currently performing a trial of network-wide congestion tolls using on-board computers equipped with GPS receivers and digital road network maps.

### THE EVOLVING DEBATE

While most of the debate surrounding distance-based user fees has focused primarily on privacy and environment, there are several additional—and in our view more pressing—questions that have received much less attention in public, political, and media debates. Switching to a distance-based user fee system would require a massive investment in new technology, as well as developing new administrative capabilities within government to manage the programs. Are the current political liabilities of the fuel tax really so great as to warrant development of such an enormous new system? Might interest in electronic tolling evaporate with a few substantial hikes in the per-gallon motor-fuel tax?

Regardless of the new technologies chosen to levy distance-based user fees, a host of policy questions remains. Should the transition to electronic tolling be revenue neutral, or should fees be set to fund the backlog of existing maintenance and construction needs? Should fees vary by vehicle weight and/or emissions class? Should heavy trucks be charged more to travel on secondary roads—where they do the most damage—than on more heavily-engineered highways? Should urban areas be allowed to layer congestion tolls on top of base fees? Which of these ideas is the public prepared to accept? In London and Southern California, less sophisticated congestion pricing programs have successfully increased vehicle flows and reduced delays with little or no public outcry. But whether network-wide schemes would be received as calmly is far from clear.

Finally, depending on how these policy questions are answered, tolls could be structured to increase transportation system efficiency, effectiveness, and equity—or they could be set to disproportionately benefit powerful entrenched interests. Indeed, while some are enamored of the potential to improve efficiency, effectiveness, and equity, others oppose electronic tolling precisely because it opens the door to variable fees that address these issues. Trucking interests, for example, could be expected to push for flat, per-mile tolling to avoid paying higher variable tolls for operating heavier or more-polluting vehicles. At the same time, manufacturers of large sport utility vehicles, >



already stinging from lagging sales due to recent increases in fuel prices, might be expected to lobby against the inclusion of per-mile emissions or fuel-efficiency fees.

In short, while distance-based pricing offers the *potential* to price for a variety of externalities, whether or not such strategies would survive the political bargaining process remains very much in doubt. Reopening the long-settled questions of who should pay for roads and how they should pay entails considerable risk and uncertainty for nearly everyone. If raising the motor-fuel and other established transportation taxes had not become so difficult politically, it's likely that the development of electronic tolling systems would be moving along much more slowly.

### WHAT NOW?

We have painted a conflicted picture. On the one hand, electronic tolling schemes are burgeoning worldwide. On the other, many elected officials, transportation interest groups, and members of the motoring public remain hostile to the idea. And while the fuel tax appears to be running out of gas, two or three substantial increases to the per-gallon levy could fix it, at least for the next several years. So where are we headed? We see three possibilities.

First, we could allow the gasoline tax to wither, while accelerating the trend toward local sales taxes, transportation bond measures, and other ad hoc efforts to cobble together a funding program for transportation. In doing so, transportation finance will become part and parcel of broader political debates over public spending priorities and will be increasingly disconnected from transportation system use.

Second, we could try to convince elected officials, the media, and voters of the wisdom and simplicity of the nearly century-old system of user-fee finance centered around the motor-fuel tax—at least for the next couple decades. A revived focus on transportation user fees, however, would require that the current trend toward general taxes to finance transportation be reversed.

Or third, we could turn to electronic tolling as the inevitable successor of the motor-fuel tax, sooner rather than later. While the transition costs will be substantial, the continued growth of alternative-fuel vehicles suggests that, for better or worse, the venerable fuels tax will eventually have to be replaced. The opportunity to use such a scheme to price the many external costs of driving is intriguing to many. But critics believe we are more likely to move away from variable pricing and toward a flat-mileage-fee system that would eliminate the fuel efficiency incentive in the current per-gallon gasoline tax.

So who should pay for roads? How should they pay in the years to come? The recent upsurge suggests that electronic tolling of road use may be coming faster than many thought possible. The possibilities are many, the risks substantial, and the future uncertain. ♦



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## UNNOTICED LESSONS FROM LONDON

# ROAD PRICING AND PUBLIC TRANSIT

BY KENNETH A. SMALL

**O**BSERVERS OF CITY LIFE have long looked to mass transit to create urban vitality. Transit is supposed to promote a healthy high-density street life within economically vital business and retail districts, and to concentrate new developments into attractive patterns. Above all, it's supposed to limit road congestion without resorting to ugly high-volume roads everywhere.

These goals have been frustrated by the limited ability of mass transit to attract travelers out of automobiles and by the enormous expense of building and operating mass transit. While many recently built transit systems have achieved some desirable effects, none have seriously lessened traffic congestion. Furthermore, few cities have been able to afford a system extensive enough to make more than a small change in urban form; and the share of trips by mass transit continues to fall virtually everywhere.

Meanwhile, other policies to control congestion have been disappointing. The only one that seems able to create dramatic improvement—road pricing—is highly unpopular. Even so, congestion has proven so intractable that pricing has begun to gain a foothold—in Singapore since 1975, in three Norwegian cities since the 1980s, on selected express lanes and bridges in California, Texas, and Florida, and on a new east-west expressway in suburban Toronto. Most dramatically, in 2003 London's Mayor Ken Livingstone introduced road pricing to the streets of central London, in the form of a daily charge of £5 (about US\$8) during business hours on weekdays.

Why has transit failed as a means to alleviate congestion, while road pricing, despite severe political liabilities, is experiencing an upswing? Ironically enough, we may have been looking at the problem backwards. Rather than mass transit being the solution to congestion, perhaps congestion pricing—a measure often viewed as an alternative to transit—could be transit's savior. >

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"IT'S  
THE  
TOPS"

line Elms Lane Battersea  
Lapham Junc Wandsworth  
West Hill Putney Heath

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ROEHAMPTON DANEBURY  
AVENUE

PAY DRIVER



By clearing cars off the most congested streets, pricing sets off a “virtuous circle” for mass transit, especially bus transit. Here’s how it works:

- More expensive rush-hour road travel encourages use of alternatives, including mass transit. This builds the transit patronage needed for financial viability.
- Reduced automobile congestion speeds up transit vehicles sharing the streets with cars. This in turn creates two further favorable effects:
  - Patronage is further encouraged because public transit is now faster.
  - Higher speeds reduce costs to transit providers.
- Higher patronage and lower costs encourage transit providers to add service in the form of new routes, greater frequency, or both. Lower costs also encourage lower fares.
- Better and cheaper transit service further encourages patronage. More new riders are diverted from automobiles, thereby further reducing congestion.
- This new patronage reinforces agency finances and service offerings; and so the circle continues.

These effects can all occur quickly. Over a longer time, there may be other effects as well. By reducing parking demand, new downtown land becomes available for development, thereby increasing the economic efficiency and vitality of downtown. By making travel from a distance more expensive, nearby residential land increases in value, which encourages higher density there, making it easier to serve with high-quality transit and walking-distance retail centers. If road-pricing revenues are used to enhance downtown—arguably part of political feasibility anyhow—then even land used for downtown businesses may rise in value, especially if the “virtuous circle” significantly enhances its accessibility through better transit service. This rise in land prices creates some of the hoped-for positive effects on downtown development density.

Each of the elements in this favorable chain of events has been known in the research literature, but no one seems to have pulled them together to remark on the prospect that road pricing could give a significant shot in the arm to transit. To keep it simple, I look next at just the short-run effects—those described in the bulleted list above. Any long-run benefits are then icing on the cake.

#### QUANTIFYING THE EFFECTS

Mayor Livingstone’s audacious policy innovation surprised everyone with its smooth implementation and quick success, cutting car traffic entering central London by 33 percent and increasing car speeds within and to the central area by 14 to 20 percent. Less well known is that Livingstone gave high priority to simultaneous improvements in public transit, especially bus transit. Clearly, it was politically savvy to connect road pricing and public transit. But my analysis suggests that more and better service was made possible, desirable, and financially viable by congestion pricing itself.

The “virtuous circle” involves a lot of interacting effects, so one might think it impossible to account for them all simultaneously. But we can determine the net outcome by making some simplifying assumptions, applying well-known empirical values, and looking to local data for a few additional needed parameters.

First, we know that transit users incur time costs consisting of time spent in the vehicle and time spent walking to and waiting at a bus stop. Prior research suggests that we can value their in-vehicle time at half their wage rate and their out-of-vehicle time (being more onerous due to less comfortable surroundings) at twice that amount.

Second, let's assume that the bus operating agency reacts to increased patronage by getting larger vehicles, running more of them, or both: specifically, it tries to balance these so as to minimize agency and user costs combined. The result is a decline in average cost as patronage increases.

A third assumption is that the bus agency reacts to changes in its costs or revenues by changing its fares, so as to keep its total operating surplus or deficit the same. This assumption makes little difference to the results and is easier to describe than other options. It implies that fares are *increased* to cover any new service (presuming the new



service loses money), but *decreased* to pass on any cost savings. If congestion pricing is accompanied by a subsidy increase, as it was in London, we assume this subsidy is also passed along via lower fares, after accounting for the cost of serving the additional patronage that lower fares attract.

A final assumption: travelers increase their use of transit by 0.25 percent for every one percent fare decrease, and by 0.30 percent for every one percent increase in number of bus-miles operated. These numbers are medium estimates from empirical studies.

These assumptions and empirical values permit us to calculate the effect of congestion pricing on transit using a surprisingly small number of parameters specific to the city in question. I now turn to the results of such calculations for two cases: ➤





one based on London’s experience in 2003, and the other using parameters more typical of US cities.

Central London is unusual in several respects. First, public transit has long carried a very high share of weekday trips—over 85 percent even before congestion pricing. As a result, even a big reduction in automobile traffic has only a modest direct effect on bus ridership, estimated here at just six percent for the system put in place in 2003. Second, the fraction of bus costs recovered through fares is high, about eighty percent, which means that service expansion can be carried out without adding much to London Transport’s operating deficit. Third, a large share of revenue from the London scheme was allocated to the bus agency, increasing its subsidy by an amount equal to about seven percent of the cost of providing bus transit in central London.

To depict a city more typical of the US, I also calculate a second scenario where these three features are altered: modal diversion from pricing is larger (thirty percent of initial ridership), initial cost-recovery ratio is smaller (forty percent), and there are no additional subsidies to the agency. These two scenarios are described in the “Assumptions” panel of the accompanying table. In both scenarios, I assume bus speeds rise nine percent as a result of reduced congestion, based on observations in central London after the first year of congestion pricing.

Results are dramatic. For London, bus service increases by nearly a quarter and fares are reduced by eleven percent. As a result, the initial six percent increase in transit use—which arose directly from the incentive of high prices for driving in central London—has been magnified to sixteen percent. Average user cost for a bus trip is drastically reduced, due mainly to faster travel but also to more frequent service and increased route coverage. Average agency cost per passenger declines modestly, not enough to overcome the effect of ridership increases on total expenses but enough to allow fares to decline, thanks to more passengers and new subsidies.

#### Effects of congestion pricing on transit

|   | London | Typical US City |
|---|--------|-----------------|
| <b>ASSUMPTIONS:</b>                                       |        |                 |
| Modal shift to bus ( <i>% of initial bus ridership</i> )  | 6      | 30              |
| Speed increase (%)  | 9      | 9               |
| Bus agency initial cost-recovery ratio (%)                | 80     | 40              |
| New subsidies ( <i>% of original total agency cost</i> )  | 7      | 0               |
| <b>RESULTS:</b>   |        |                 |
| Service ( <i>% change in bus-miles</i> )                  | 23     | 21              |
| Fare ( <i>% change</i> )                                  | -11    | -26             |
| Patronage ( <i>% change</i> )                             | 16     | 31              |
| Average user cost ( <i>change as % of fare</i> )          | -48    | -117            |
| Average agency cost ( <i>% change</i> )                   | -5     | -15             |
| <b>BENEFITS TO MASS TRANSIT AGENCY &amp; USERS:</b>       |        |                 |
| From speed increase ( <i>% of total agency cost</i> )     | 35     | 35              |
| From patronage increase ( <i>% of total agency cost</i> ) | 4      | -4              |



In a case more typical of a US city, the results are even larger. Ridership goes up 31 percent and average user cost falls more than 100 percent of the initial fare. Fares can be reduced 26 percent, despite a 21 percent increase in service whose fares cover less than average cost; these reduced fares are possible because of higher bus occupancy (due to patronage rising faster than vehicle-miles) and lower driver costs (due to faster trips).

What are the benefits of these changes? We see in the bottom part of the table that total net benefits, expressed here as percent of initial agency cost, are quite high. This does not include any benefits to automobile users, nor does it include revenues from road pricing. The bulk of the benefits shown arise from the speed increase, suggesting they would be much smaller for a rapid rail system not subject to street congestion. The benefits from the patronage increase alone are positive but small for London. They are slightly negative for the typical US case because, with higher initial subsidies, these transit trips still do not pay their social cost even though average cost per rider decreases—an indication that expansion of patronage is not necessarily a desirable goal in itself, at least within the objectives quantified by this model. Of course, if public transit provides some of the additional benefits mentioned earlier, but not counted here, the patronage increase may still be desirable.

## CONCLUSIONS

The “virtuous circle” of cost savings and ridership increases, triggered by policies aimed at discouraging automobile travel on congested city streets, can give a real boost to public transit, especially bus transit. In London, the evidence backs this up: new service has been added and ridership has gone up notably. London’s mayor may have viewed transit improvements as part of the necessary politics, or as just good management; but we can view them as logically following from the favorable conditions created by congestion pricing.

The benefits to transit users and providers are direct and quantifiable. I don’t need to take a position on the marvelous side benefits often attributed to public transit. But the irony is, to the extent those side benefits are real, they add weight to the arguments not for transit policies *per se* but for good management of street resources through pricing. Transit advocates have every reason to be among the greatest boosters of road pricing. ♦

## FURTHER READING

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# WHICH COMES FIRST: THE NEIGHBORHOOD OR THE WALKING?

BY SUSAN HANDY AND PATRICIA MOKHTARIAN

**T**HESE DAYS IT'S HARD TO MISS the story that Americans spend more time stuck in traffic than ever, that they're fatter than ever, and that the suburbs are to blame—or at least so goes the talk in the public media and in city planning and public health circles. The logic is simple: suburbs were designed for driving rather than walking, leading people to drive more and walk less, thereby contributing to increased traffic congestion and vehicle emissions, declining physical activity, and increasing waistlines. Recent studies show significant connections between suburban sprawl and traffic congestion, air pollution, and obesity. The solution as proposed is simple: redesign suburbs for walking rather than driving, so that people will walk more and drive less, traffic levels will decrease, and physical activity will increase. Problem solved. >



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The evidence at first glance seems plausible. Studies have established statistical correlation between built environment and travel behavior: residents of traditional neighborhoods do drive less and walk more than residents of suburban neighborhoods. But as any good textbook on research methods reminds us, correlation does not necessarily mean causation: a correspondence between built environment and travel behavior does not mean that a change in the built environment will lead to a change in travel behavior. Researchers are now arguing over the role of self-selection in explaining the observed correlations. Do residents who prefer to walk choose to live in more walkable neighborhoods, and do those who prefer to drive choose to live in more drivable neighborhoods? If so, then the built environment is relegated to facilitating preferred behavior rather than causing it. In this case, land use planning still has a role to play in creating environments that facilitate walking and discourage driving, but the effect on those not already motivated to walk more or drive less may be limited.

If we were all-powerful, we could answer the question once and for all. We would pick a group of people, move them randomly into traditional and suburban neighborhoods, measure their travel before they move, and measure their travel again after they move—a true experiment. Lacking such power, we found a more practical way to assess the degree to which self-selection explains the link between built environment and travel behavior. Instead of moving people, we measured changes in travel behavior when people moved themselves, and then measured those changes against their own preferences about neighborhoods and attitudes about travel. Our test group comprised residents who had recently moved into eight neighborhoods in Northern California, four traditional and four suburban. Our control group comprised residents of the same neighborhoods who'd lived there for more than a year. Here's what we found.



*Do residents who prefer to walk choose to live in more walkable neighborhoods, and do those who prefer to drive choose to live in more drivable neighborhoods?*





### DIFFERENT PREFERENCES, DIFFERENT PLACES

A simple comparison of travel behavior between the traditional and suburban neighborhoods in our household survey showed significant differences: residents of traditional neighborhoods drive eighteen percent fewer miles per week than do residents of suburban neighborhoods, and walk to the store more than twice as often. Could the built environment explain these differences? Or is it self-selection?

The built environments in traditional and suburban neighborhoods differ in fundamental ways. Our geographic analysis shows that homes in traditional neighborhoods are, on average, considerably closer to more destinations of more varying types than are homes in suburbs. Residents of traditional neighborhoods are only about a half mile away from the nearest ice cream shop, for example, compared to about a mile in suburban neighborhoods. Residents' perceptions of their neighborhoods also differ: in the survey, traditional-neighborhood residents scored their areas higher on accessibility, sociability, and attractiveness than did suburban residents. Such differences offer a plausible explanation for less driving and more walking in traditional neighborhoods, despite higher scores for safety in suburban neighborhoods.

But attitudes about travel also differ. Residents of traditional neighborhoods tend to be more favorably inclined toward biking and walking, as well as transit, than their suburban counterparts. Suburban residents tend to express more dependence on their cars and also to think traveling by car is safer than walking, biking, or taking transit. Preferences for neighborhood characteristics differ, too. Most significantly, suburban residents put more importance on safety than did residents of traditional neighborhoods, who put somewhat more importance on sociability and attractiveness. Are these differences in attitudes and preferences more important in explaining travel behavior than differences in the built environment, thus supporting the self-selection hypothesis?

We answered this question by looking at changes in the built environment and changes in travel behavior for our test group, while factoring in attitudes and preferences to account for self-selection. If changes in the built environment are associated with changes in travel behavior after accounting for self-selection, we have strong evidence of causation, not just correlation. ➤

*Residents of  
traditional  
neighborhoods  
drive eighteen  
percent fewer  
miles per week  
than do  
residents of  
suburban  
neighborhoods*

## CHANGING PLACES

The most important variable in predicting a change in walking is a change in attractiveness: all else equal, people walk more if they move to a neighborhood with a more attractive appearance, higher level of upkeep, more variety in housing styles, and/or more big street trees than they had in their previous neighborhood. Other changes in the built environment also predict an increase in walking, such as better alternatives to driving (in the form of bike routes, sidewalks, and transit service), better safety (as influenced by low crime rate, low level of traffic, and good street lighting), and more sociability among neighbors. Some socio-demographic variables and a pro-bike/walk attitude also predict more walking, not surprisingly. But changes in the built environment seem to have the greatest effect on changes in walking.

For changes in driving, the role of the built environment is not as strong. While a change in accessibility (e.g., easy access to shopping malls and downtown, stores within easy walking distance) is the most important variable in predicting changes in driving (more accessibility means less driving), the second most important is a change in income (higher income means more driving). A change in safety is also somewhat significant, but changes in other aspects of the built environment do not seem to affect the amount of driving. Changes in the built environment are important, but apparently no more so than other variables, including attitudes and preferences.



*All else equal,  
people walk more  
if they move to a  
more attractive  
neighborhood*



## WHAT TO DO

These observations provide some encouragement that land-use policies designed to increase opportunities to drive less will actually lead to less driving. In particular, it appears that an increase in accessibility may lead to a decrease in driving, all else equal. Policies that could increase accessibility in new areas include mixed-use zoning allowing retail and other commercial uses to be close to residential areas, and street connectivity ordinances that ensure more direct walking routes between residential and commercial areas. Policies that could increase accessibility in existing areas include so-called Main Street Programs designed to enhance and revitalize traditional neighborhood shopping areas, incentives for infill development to increase residential densities, and “grayfield” redevelopment of underutilized shopping centers.

However, we also find that changes in neighborhood characteristics seem to have a greater effect on walking than driving—good news for public health officials interested in increasing physical activity, but not necessarily helpful to planners who are trying to reduce driving. City programs to fill gaps in the sidewalk network and thus increase accessibility, and to slow traffic through neighborhoods and thus improve safety, could lead to more walking, as could programs run by community groups to increase interactions and socializing among neighbors.

We don’t claim that these results are definitive or that they adequately clarify the nature of the causal relationship between the built environment and travel behavior. We plan more sophisticated analyses of these data, using techniques such as structural equations modeling, which may revise the story. Future studies that adopt research designs more closely resembling a true experimental design will provide more definitive evidence yet. These would be along the lines of longitudinal panel studies, of the sort underway in Perth, Australia, that include surveys prior to and following a residential move, and intervention studies, of the sort completed for the Safe Routes to School Program in California, in which walking is measured before and after a change in the built environment. Only with such evidence can we be sure that increasing opportunities for walking more and driving less will actually lead to changes in travel behavior. ♦

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# Discounting Transit Passes

BY CORNELIUS NUWORSOO

**P**UBLIC TRANSIT OPERATORS in the United States have long known that fare hikes do not increase total revenues. Although while fare reductions might boost ridership, they can also reduce total revenues and thus increase reliance on subsidies. Transit operators trying to balance their budgets need new strategies that can produce more revenue than costs. Some transit agencies have tried selling steeply discounted unlimited-ride transit passes to groups, such as students at a university or employees at a large company. Such deep-discount group-pass

programs are paid for either by participants through payroll deductions or school fees, by an employer or school, or by some combination of both. Most existing programs are either employer-based or campus-based. A few neighborhood-based passes are issued through neighborhood associations. Programs typically include: (a) universal coverage of members of an identified group, (b) unlimited rides by group members within a specified period, and (c) deep discounts of from forty to ninety percent of regular pass prices. Some programs also include guaranteed rides home.

The paradox of a net increase in revenue from a deep discount is comparable to the workings of group insurance plans. An insurance company that insures properties against theft



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does not care whose property is stolen; its concern is that total premiums will cover the total cost of replacing any stolen property. The insurance company is thus an intermediary that organizes risk-sharing pools while incurring transaction costs. As the pool gets larger, the risk cost and often the transaction costs become smaller, and premiums lessen.

Similarly, it does not matter to a transit agency offering a deep-discount group pass which members of a group use its services. The group pass covers a large number of people and is paid for the whole year in advance, whether the service is used or not. The agency is concerned only that total group revenue covers the total cost of providing the service. It may be viewed therefore as a facilitator, promoting the pool through deep discounts and incurring transaction costs. As the number of participants increases, unit costs decrease and the price per participant lessens.

While an unlimited-ride transit pass at a deep discount has obvious appeal to those who receive it, there are also benefits to those who pay for it. In some cases, of course, the two are the same, although the organizing body, be it employer or university, frequently pays part or all of the cost. Why would it? There are possible environmental benefits if traffic is reduced because more people ride transit, and a program may relieve an acute parking shortage while helping to expand the geographic extent of affordable or attractive housing for employees and students. Group passes can also serve as inexpensive employee benefits. All these motivations in combination can contribute to the attractiveness of a university or employer to potential students or employees.

#### **INCREASING TRANSIT OPERATING REVENUES**

Case studies of deep-discount group-pass programs consistently reveal either higher revenues per boarding than the systemwide average or higher total revenues from target markets with the program than without it. The following three cases illustrate.

##### *UC Berkeley (UCB) Student Class Pass Program*

A 1997 survey revealed that 5.6 percent of UCB students used AC Transit before implementation of the Class Pass, approximately 1,690 students. Although not all these students rode AC Transit every day and so would not have purchased a monthly pass, assume for simplicity that they all did. The maximum revenue AC Transit would have earned from the UCB student-rider market would therefore have been \$84,500 per month in those months that school was in session.

A survey in 2000 revealed that after implementation of the Class Pass, 14.1 percent of UCB students, or approximately 4,410 students, used AC Transit. The agency had negotiated an annual payment from the University of \$1,251,000 to cover the entire enrolled student population. Assuming a ten-month academic calendar year, the monthly revenue to AC Transit was \$125,100.

Net additional revenue was \$40,600 per month, more than \$406,000 per year, and approximately fifty percent above the pre-Class Pass level. Student ridership and revenue both increased, even though AC Transit made no changes in service to accommodate the student population and thus did not incur additional costs. >



### *City of Berkeley ECO Pass Program*

Approximately 120 employees commuted to work by AC Transit before the ECO Pass program. Some rode infrequently (one to ten times per month), some rode occasionally (eleven to twenty times), and some rode almost every day. If infrequent riders purchased an average number of rides and regular riders purchased the monthly pass, the estimated revenue from city employees before the program would be approximately \$2,410 a month. For the ECO Pass program, the city paid AC Transit \$6,650 (for 1,330 city employees at \$5 each) for each month. This translated to a revenue increase of \$4,240 a month, approximately 175 percent more than without the program. This estimate is consistent with revenue-per-boarding data, calculated by tracing actual use of magnetic-card passes indicating a yield of three times the systemwide average from all fares. Therefore, AC Transit realized a net annual revenue increase of approximately \$50,880 from the program. In this case also AC Transit made no changes in service to accommodate the employee population and thus did not incur additional costs. Instead, it increased efficiency by filling unused capacity on its buses.

### *Denver Regional Transportation District (RTD) ECO Pass Programs*

Every deep-discount group-pass program offered by the RTD yielded more revenue per boarding than the systemwide average from all fares. Together, three major pass programs yielded almost two times as much net revenue as the systemwide average in the year 2000. Among the various programs, the employment-based program generally yielded the highest revenue per boarding, suggesting that wide deployment of deep-discount group-pass programs might increase transit operating revenues. The more revenue transit agencies earn from various fare instruments, the less they need rely on government subsidies.



**INCREASING TRANSIT RIDERSHIP**

Reviews of deep-discount programs reveal successes across the board in boosting transit ridership. At UC Berkeley, student ridership increased approximately 160 percent after the Class Pass was introduced. AC Transit riders among city of Berkeley employees increased by nearly 65 percent in the ECO Pass program’s first year. However, the number of riders as a percentage of total employees remained relatively small compared to other modes, increasing from 6.2 percent to 10.7 percent. A survey of college-based programs at 31 universities around the nation found that, during the first year of program implementation, increases in student transit ridership ranged between 70 and 200 percent.

Table 1 shows a significant shift in mode choice from drive-alone to transit after the University of Washington in Seattle introduced the U-PASS program. The increase in transit patronage is, not surprisingly, higher among students than among faculty and staff. In response to ridership gains, Metro, the transit operator, added 60,000 annual hours of new bus service, the equivalent of ten more buses operating for approximately eighteen hours a day.

Several factors explain the increases observed in transit ridership, among them convenience. Deep-discount passes provide the same notable convenience as other forms of transit passes, including the ability to take a ride without having to worry about having exact change for the fare box.

Further, the ability to use the pass at any time probably encourages transit riding. In campus environments and at employment locations, the pass provides a convenient means of getting to local retail and service establishments. The convenience extends even to those who drive to work or school, for they do not have to move their cars to run personal or work-related errands midday. A fourth of Berkeley ECO Pass participants used the pass at midday, and some workers with staggered or flexible work schedules commuted in the off-peak hours. There was also a substantial proportion of travel both for work and other activities in the middle of the workday. Overall, nearly one in ten rides made with the ECO Pass occurred outside traditional work hours. >



Table 1: Change in mode choice one year after initiation of U-PASS Program in Seattle

| MODE  | STUDENTS |       | FACULTY & STAFF |       |
|---|----------|-------|-----------------|-------|
|   | Before   | After | Before          | After |
| Auto Drive Alone                            | 25%      | 14%   | 49%             | 40%   |
| Transit                                     | 21%      | 35%   | 21%             | 28%   |
| All Other Modes<br>(carpool, bicycle, walk) | 54%      | 51%   | 30%             | 32%   |

Source: Williams and Petrait 1993

## RELIEF FOR ACUTE PARKING SHORTAGE

In areas where parking is in short supply, deep-discount group-pass programs may help alleviate demand for parking by inducing a mode shift away from driving alone. A survey of commuters to the Silicon Valley in Santa Clara County indicates that the ECO Pass program there resulted in a reduction in parking demand by approximately nineteen percent. With the introduction of the BruinGO Pass at UCLA, 1,000 drive-alone commuters living within the Santa Monica Municipal Bus Line service area gave up their parking spaces. These spaces did not remain vacant; the long waiting list for parking permits quickly refilled them.

Reduced parking demand can also potentially reduce the number of new parking spaces needed. At the University of Washington, in Seattle, biennial telephone surveys of faculty, staff, and students about their travel behaviors and attitudes show that the U-PASS program there helped reduce demand for parking facilities. The 12,000 current campus parking spaces are fewer than existed in 1983, despite the addition of 8,000 more people to the campus community since then. The University was also able to avoid building 3,600 new parking spaces, thus saving \$100 million in construction costs.

There may be little or no direct cost to employers or universities if participants pay the entire fare, as at UCB. There is some expense if they subsidize fares, as at the University of Washington, or pay them in full as at UCLA. However, universities and employers could still realize savings if they pay for transit passes instead of constructing new parking spaces. For example, Brown, Hess, and Shoup estimate the total monthly cost (construction, interest payments, and operation) of a single debt-financed parking space in a 1,500-space parking structure at UCLA to be \$223 per month in 2002, similar to the \$227 per month per space of a new parking structure at the University of Colorado, Boulder. At UCLA, the cost per parking space was four times the rate for parking permits. In comparison, UCLA spent approximately \$71,000 a month for the BruinGO pass program, which induced 1,000 drive-alone commuters to give up their parking spaces. At \$71 per parking space per month, the cost of the pass to the University was only a third of the cost per parking space. If new construction can be avoided, the institution stands to save a lot of money.

Reducing demand for parking spaces could also create opportunities to convert available or less-used spaces to daily, short-term visitor parking, which attracts higher



Table 2: Effect of BruinGO Pass on parking demand at UCLA

|            | AUTO DRIVERS    |          |       | STUDENTS ON WAIT LIST FOR PARKING |
|------------|-----------------|----------|-------|-----------------------------------|
|            | Faculty & Staff | Students | Total |                                   |
| Before     | 3,400           | 3,000    | 6,400 | 3,969                             |
| After      | 3,100           | 2,000    | 5,100 | 2,637                             |
| Difference | -300            | -1,000   | 1,300 | -1,332                            |

Source: Brown, Hess and Shoup: An Evaluation, 2002

parking rates. At UCLA in 2002, visitors paid \$2 per hour and \$7 per day to park on campus, while faculty, staff, and students paid approximately \$54 for monthly permits. Assuming a month has twenty weekdays, a visitor parking space could generate as much as \$140 per month if used 100 percent of the time. Even if only used half the time, it would generate \$70 a month, or one-third again as much as a permit. In situations where short-term visitor parking is in short supply, as around UC Berkeley, a deep discount program that frees up parking spaces could help generate more parking revenue as well as increase parking convenience for visitors.

### AN INEXPENSIVE TAX BENEFIT

Federal laws provide significant tax savings to both employers and employees for using public transit. Under existing law, employers can pay for deep-discount passes as benefits, or employees can pay through their places of work as pretax deductions. The combination of benefits and deductions can add up to \$100 per month and take the form of a voucher, a commuter check, a pass, or other medium for the purchase of transit services. Many employers already take advantage of this law through various transit subsidy programs.

Because this benefit is a fully deductible business expense, employers pay less than the full face value of the pass. For example, assuming a thirty percent rate for taxes and other deductions, a \$50 pass would cost an employer about \$35 after tax deductions. When transit services are purchased with an employee's pre-tax salary, employers save money from reduced payroll taxes, including employer-paid FICA, unemployment, workers compensation, disability, pension, and other obligations that can amount to approximately ten percent of salaries. For example, if an employee pays \$50 a month for a deep-discount pass before taxes, the employee's take-home pay is reduced by only approximately \$35, saving \$15 in taxes.

### SUMMARY

Studies of deep-discount group-pass programs consistently reveal *either* higher revenue per boarding than systemwide averages *or* higher total revenues from target markets with the program than without it. With discounts at forty to ninety percent of standard pass prices, it is a bargain for participants.

Besides being an instrument to improve financial efficiency in transit operations, the passes are a source of convenience to users. Other benefits of the programs include the shifts they trigger away from the auto-drive-alone mode, the reductions they induce in parking demand and thus parking-space needs, and their role as an inexpensive employee tax benefit. Employers and universities that institute group pass programs may attract potential employees or students with this benefit.

Under existing forms of subsidy, riders must pay to use the transit service even though they contribute to subsidies through taxes. With group-pass programs, cross-subsidization comes from potential riders in a group, all of whom have equal rights to access the services. The programs therefore offer contributors an opportunity to use the transit service without additional out-of-pocket cost. Even in an auto-dependent society, public transit can provide an alternative mode of travel that group-pass programs can make a little more convenient to use. ♦



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# Economic Consequences of Transport Improvements

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BY T.R. LAKSHMANAN AND LATA R. CHATTERJEE



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RANSPORTATION SPECIALISTS AGREE that investments in transport infrastructure can generate large developmental payoffs throughout society. But *how* those effects come about is not readily understood.

Variables such as the state of the transportation network, the region's stage of economic development, the competitive structure of the region's markets, and technological and institutional changes in transportation, communication, and production systems all affect improvements and the changes they generate, as well as how the overall economy responds. As these contexts vary, so do underlying forces of change, and the consequent social and economic effects.

To study them, we can classify these effects along *temporal* (short-term, long-term) and *spatial* (local, regional, global) scales. Short-term effects tend to be easier to recognize than long-term ones, but many of the richest effects are subtle and take a long time to be realized.

#### SHORT- AND LONG-TERM EFFECTS

Typical transport infrastructure improvements reduce effective distances between origins and destinations by reducing congestion, thereby lowering travel times. Travelers gain directly from travel time savings and lowered vehicle-operating costs. Companies enjoy direct efficiency gains from cheaper and more reliable freight services and reduced assembly and delivery costs. Cheaper and better transportation services provide incentives for firms to reorganize and reduce their inventories, sometimes to just-in-time levels. The advantages of scale economies occur as firms consolidate production and distribution sites and increase outputs.

Assessments of short-term effects from improved transportation typically focus on benefits to and adjustments in transport-*providing* firms, but the changes made by transport-*using* firms can generate economy-wide adjustments and redistributions over the long run. Cheaper and better transportation promotes interregional and international specialization and trade; in turn, gains from trade permeate into the far corners of the economy.

As transport improvements lower costs and increase accessibility among various market actors (input suppliers, labor, and customers), market expansion and integration follow. Opportunities increase for exporting and importing goods, and new channels open for product, land, and labor ➤



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markets. First, export expansion leads to higher levels of output, with higher sales covering operating costs as well as increasing profits. Second, imports put competitive pressure on local prices. Such pressures can weaken local monopolies and also can improve efficiency. The economy is constantly being restructured as firms enter and leave, making for leaner production processes, lower production costs, and higher productivity. Third, lowered transport costs and increased accessibility enlarge markets for labor and other inputs. Firms are able to draw labor from broader areas and with wider ranges of attributes, improving labor supply and lowering its costs. Similar effects occur when transport improvements open up new land for economic activities, as when the Interstate system accelerated suburbanization and when air transportation helped fill ski, beach, and golf resorts. Such economic effects rippling through the economy can be captured by assumptions of imperfect competition and the “new economic geography” theory.

By taking advantage of declining transport costs and scale economies, a firm at a given location can enlarge its market area. Agglomeration economies—i.e., efficiencies resulting from ease of access among related neighboring firms—emerge as companies locate in one area, encouraged by a diverse, skilled labor supply, nearby business services, and growing markets. Cumulating processes reinforce the clustering, and regional specialization develops. Further, in activity clusters (cities) made possible by transport

Evolution of globalization forces and urban development

| UNDERLYING PROCESSES AND URBAN DEVELOPMENT PATTERNS | MERCANTILE ERA   | INDUSTRIAL ERA  | CONTEMPORARY ERA   |
|---|--|---|--|
| TECHNOLOGIES & UNDERLYING PROCESSES                 | New transport technology:<br>long distance ships, sextant, etc.  | Steam power<br>Railroad<br>Steamships<br>Machine fabrication  | New transport and communication technologies<br>Information-rich production technologies   |
| SUPPORTIVE NONMATERIAL INFRASTRUCTURE               | Cartography<br>New means of payment:<br>precious metals, financial innovations of Amsterdam<br>banking systems | Economies of scale<br>Vertical integration of production<br>Factory systems<br>Assembly line<br>Labor unions<br>Property rights<br>Central bank<br>Currency<br>Monetary policies<br>Compulsory education                          | Economies of scope<br>Open trade institutions<br>Logistical innovations to facilitate flows of goods, services, capital, and information   |
| SPATIAL PATTERNS; URBAN FORMS AND FUNCTIONS         | Division of labor brings increasing urbanization<br>Size of major cities increases                             | Massive urbanization<br>Rise of factory towns<br>Average town size increases<br>Problems <i>of</i> cities (housing, infrastructure, spatial organization)<br>Problems <i>in</i> cities (unemployment, health, welfare, education) | New urban regions competing globally for economic activities<br>Relatively fast changes in economic fortunes causing local dislocations<br>Rise of large urban regions around major cities connected to global economy |

improvements, there appear “economies of diversity” (as elaborated by Jane Jacobs), which stimulate innovations, endogenous growth, and a rise in productivity.

Sustained transportation improvements can also lead to major shifts in technology, new production structures, and improvements in aggregate efficiency. For example, the development first of canals and then of railroads in the 19th century made it possible for areas of the Midwest to shift to specialized agriculture and to export commodities to new markets. Consequently, a host of improvements in agricultural technology was induced, at least in part, by the expanded market opportunities made possible by those earlier transport improvements. Improved transport also made it possible to develop production systems that required large-scale movement of raw goods from various production regions to manufacturing centers. For example, cotton traveled from agricultural regions in the US South, Egypt, and India to England and New England. Unlike the example of the Midwest, where transport improvements made it possible for a specialized region to reach broader markets, in this case they made it possible for widely separated but complementary regions to integrate into a specialized production system.

Such long-term changes in the scale, composition, and location of economic activities induced by transport investments are more like *developmental effects* than growth effects. Growth, i.e., getting larger, is a more modest consequence. Development implies a dual structural shift: a new social and technical environment or a new set of economic opportunities emerges, and the pattern of relationships between the environment and social actors changes. Specialized commercial agriculture, the industrial revolution, and the globalization of production are all developmental consequences that would not have been possible without sustained improvements in transportation systems.

This line of thought suggests that the effects of transport improvements are context dependent and not always analytically clear. So, for example, the outcome of a new transport corridor connecting two regions depends on the state of the preexisting transportation network, the state of economic development of the two regions, and the nature of competition in the markets functioning in both regions. Economic assessments of transport improvements must incorporate a broader range of interrelationships and data than are currently reviewed in typical transportation analyses. ➤





## TRANSPORT EFFECTS OVER THE VERY LONG RUN

Over the very long run—encompassing many decades—sustained improvements in transport technology and infrastructure have promoted major structural changes in national economies. They continue to facilitate globalization processes in contemporary times, much as they did in earlier eras. Economic history suggests that transport technologies and infrastructures effect such structural changes hand in hand with parallel improvements in communication and production technologies as well as institutional and organizational reforms. Thus very-long-run transport effects are *joint* consequences of changes in transport systems, communication technologies, production systems, and institutions.

The urban development effects of contemporary globalization parallel those of the earlier industrial and mercantile eras. In each era, the forces propelling globalization were twofold: a set of innovations in physical (transport, communication, and production) technologies and infrastructures and a set of nonphysical innovations in organizational and institutional forms.

During the mercantile phase, the key transport innovation was new sailing technology (efficient, long-distance Caravels and Dutch Flutes), which, complemented by new information technologies (e.g., the sextant), made it possible to navigate without landmarks and thus opened Europe for long-distance international trade with Asia and the Americas. Trade was further stimulated by new means of payment—precious metals from the Americas and new financial institutions supported by the city administration of Amsterdam. World trade and the increasing division of labor led to the growth in size of important commercial cities, with Amsterdam emerging as the capital of world trade.

Effects of transport infrastructure improvements over time

| ATTRIBUTES                                  | SHORT TERM   | LONG TERM  | VERY LONG TERM  |
|---|--|--|---|
| TYPES AND FORMS OF EFFECTS                  | <ul style="list-style-type: none"> <li>Reduced congestion</li> <li>Shorter travel times and lower vehicle operating costs</li> <li>Rising demand and output</li> <li>Logistical reorganization</li> <li>Inventory cost reduction</li> <li>Local and regional growth</li> </ul> | <ul style="list-style-type: none"> <li>Larger markets for products, labor, and services</li> <li>Export expansion</li> <li>Entry and exit of firms</li> <li>Regional/national integration</li> <li>Structural and developmental effects</li> </ul> | <ul style="list-style-type: none"> <li>Promotion of globalization processes</li> <li>Global distribution and production</li> <li>Global flows of goods, services, capital, and knowledge</li> </ul> |
| UNDERLYING PROCESSES AND CONTEXTUAL FACTORS | <ul style="list-style-type: none"> <li>Increased competition</li> <li>Supply and demand forces</li> </ul>  | <ul style="list-style-type: none"> <li>Monopolies may emerge</li> <li>Economies of scale</li> <li>Agglomeration</li> <li>Cumulative causation</li> <li>Endogenous growth</li> </ul>  | <ul style="list-style-type: none"> <li>Confluence of technical and organizational/ institutional changes in transport, communication, and production sectors</li> </ul>                             |
| DESCRIPTION AND MEASUREMENT OF EFFECTS      | <ul style="list-style-type: none"> <li>Benefit-cost analysis</li> </ul>  | <ul style="list-style-type: none"> <li>New economic geography theory</li> <li>Notion of gains from trade</li> <li>Computable general equilibrium models</li> </ul>   | <ul style="list-style-type: none"> <li>Economic history analysis</li> </ul>   |

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Key new technologies during the industrial era were steam power, railroads, steamships, and machine fabrication. Supportive organizational developments included further division of labor, exploitation of scale economies, the factory system, and the assembly line. In addition, newly industrializing nation-states provided basic material (transport, post, telephone) and nonmaterial (legal, financial, educational) infrastructures. The fine division and massive deployment of labor in the industrial era led to extensive urbanization, and the average size of towns and cities increased. Also, growing industrialization created new urban forms such as the factory towns established in every industrializing country.

Two types of problems emerged with the new industrial towns. First, income inequalities led to widespread poverty, low levels of education, and poor health among industrial workers. Since these workers lived *in* cities, these were largely problems in cities. Second, investments in urban infrastructure necessary to support a basic quality of life in dense urban environments (i.e., water supply, sewerage, transportation, energy delivery) lagged far behind the growth of cities, leading to extensive slums. The resulting infrastructure problems, inherent in urban living with its high densities and shared services, are problems *of* cities.

Contemporary globalization is driven by a combination of new transport and communication technologies, knowledge-intensive production technologies, new open-trade institutions, neo-liberal ideologies, and logistical innovations facilitating flows of goods, services, capital, and knowledge. Global network corporations—the major agents of globalization—simultaneously exploit economies of scale in widening markets and economies of scope in information, financial, and marketing networks, while maintaining production units in urban regions around the world to take advantage of lower costs. Global capital thus uses urban regions as organizational structures to enhance returns, while also seeking infrastructure investments that improve accessibility and knowledge sharing. This explains the rapid growth of multinational firms in large metropolitan corridors surrounding such global cities as London, New York, Tokyo, and Los Angeles.

Smaller urban areas, less endowed with global accessibility and knowledge, fare differently in the competition for global production locations. The ability of a smaller urban region to participate in the global division of labor depends on what cost advantages it can offer or what growth strategies it can develop that allow it to export to global markets. The evolution of globally competitive urban centers shifts important aspects of economic policy to the urban level, with an increasing role for urban economic policy.

## CONCLUSIONS

This essay advances two ideas. First, the economic effects of transport improvements are dependent on the *context* in which the improvements are made. Economic outcomes vary according to the state of the preexisting transportation network, the state of economic development, and the nature of competition in the regions. This suggests that economic assessments of transport improvements must incorporate a broader range of interrelationships and data than are typically reviewed in transportation analyses. Second, economic history teaches that sustained improvements in transportation, going hand in hand with parallel improvements in information and production technologies and institutional structures, cause structural and developmental transformations—suggesting that very long-term transport effects are *joint* consequences of the evolution of transport, information, production, and institutional structures.

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 “Neuro-Genetic-Based Universally Transferable Freeway Incident Detection Framework”  
 1996 Diss 82

**Bedsworth, Louise Wells**  
 “Expertise and Uncertainty in Environmental Regulation: An Analysis of California’s Smog Check Program”  
 2002 Diss 104

**Brown, Jeffrey Richard**  
 “The Numbers Game: The Politics of the Federal Surface Transportation Program”  
 2003 Diss 109

**Brinkman, P. Anthony**  
 “The Ethical Challenges and Professional Responses of Travel Demand Forecasters”  
 2003 Diss 106

**Golub, Aaron David**  
 “Welfare Analysis of Informal Transit Services in Brazil and the Effects of Regulation”  
 2003 Diss 108

**Chen, Chienho**  
 “An Activity-Based Approach to Accessibility”  
 1996 Diss 78

**Choo, Sangho**  
 “Aggregate Relationships between Telecommunications and Travel: Structural Equation Modeling of Time Series Data”  
 2004 Diss 112

**Compin, Nicholas Shawn**  
 “The Four Dimensions of Rail Transit Performance: How Administration, Finance, Demographics, and Politics Affect Outcomes”  
 1999 Diss 75

**Cortés, Cristián Eduardo**  
 “High-Coverage Point-to-Point Transit (HCPPT): A New Design Concept and Simulation-Evaluation of Operational Schemes”  
 2003 Diss 110

**Crane, Soheila Soltani**  
 “An Empirical Study of Alternative Fuel Vehicle Choice by Commercial Fleets: Lessons in Transportation Choices and Public Agencies’ Organization”  
 1996 Diss 76

**Crepeau, Richard Joseph**  
 “Mobility and the Metropolis: Issues of Travel and Land Use in Urban America”  
 1995 Diss 83

**De Tiliere, Guillaume**  
 “Managing Projects with Strong Technology Rupture – Case of High-Speed Ground Transportation”  
 2002 Diss 77

**Dyble, Amy Louise Nelson**  
 “Paying the Toll: A Political History of the Golden Gate Bridge and Highway District, 1923–1971”  
 2003 Diss 111

**Hall, Peter Voss**  
 “The Institution of Infrastructure and the Development of Port Regions”  
 2002 Diss 103

**Kang, Seungmin**  
 “A Traffic Movement Identification Scheme Based on Catastrophe Theory and Development of Traffic Microsimulation Model for Catastrophe in Traffic”  
 2003 Diss 85

**Khan, Sarosh Islam**  
 “Modular Neural Network Architecture for Detection of Operational Problems on Urban Arterials”  
 1995 Diss 80

**Khanal, Mandar**  
 “Dynamic Discrete Demand Modeling of Commuter Behavior”  
 1994 Diss 86

**Koskenoja, Pia Maria K.**  
 “The Effect of Unreliable Commuting Time on Commuter Preferences”  
 2002 Diss 102

**Kulkarni, Anup Arvind**  
 “Modeling Activity Pattern Generation and Execution”  
 2002 Diss 87

**Lee, Ming-Sheng**  
 “Experiments with a Computerized, Self-Administrative Activity Survey”  
 2001 Diss 88

**Logi, Filippo**  
 “CARTESIUS: A Cooperative Approach To Real-Time Decision Support for Multijurisdictional Traffic Congestion Management”  
 1999 Diss 90

**Lu, Xiangwen**  
 “Dynamic and Stochastic Routing Optimization: Algorithm Development and Analysis”  
 2001 Diss 91

**Marca, James**  
 “Activity-Based Travel Analysis in the Wireless Information Age”  
 2002 Diss 92

**Marston, James Robert**  
 “Towards an Accessible City: Empirical Measurement and Modeling of Access to Urban Opportunities for Those with Vision Impairments, Using Remote Infrared Audible Signage”  
 2002 Diss 72

**Meng, Yu**  
 “A New Statistical Framework for Estimating Carbon Monoxide Impacts at Intersections”  
 1998 Diss 67

**McMillan, Tracy Elizabeth**  
 “Walking and Urban Form: Modeling and Testing Parental Decisions About Children’s Travel”  
 2003 Diss 107

**Muñoz, Juan Carlos**  
 “Driver-Shift Design for Single-Hub Transit Systems Under Uncertainty”  
 2002 Diss 105

**Nicosia, Nancy**  
 “Essays on Competitive Contracting: An Application to the Mass Transit Industry”  
 2002 Diss 73

**Prozzi, Jorge Alberto**  
 “Modeling Pavement Performance by Combining Field and Experimental Data”  
 2001 Diss 66

**Ren, Weiping**  
 “A Vehicle Transactions Choice Model for Use in Forecasting Vehicle Demand for Alternative-Fuel Vehicles Conditioned on Current Vehicle Holdings”  
 1995 Diss 93

**Rodier, Caroline Jane**  
 “Uncertainty in Travel and Emissions Models: A Case Study in the Sacramento Region”  
 2000 Diss 69

**Ryan, Sherry**  
 “The Value of Access to Highways and Light Rail Transit: Evidence for Industrial and Office Firms”  
 1997 Diss 94

**Sandeen, Beverly Ann**  
 “Transportation Experiences of Suburban Older Adults: Implications of the Loss of Driver’s License for Psychological Well-Being, Health, and Mobility”  
 1997 Diss 95

**Sarmiento, Sharon Maria S.**  
 “Studies in Transportation and Residential Mobility”  
 1995 Diss 96

**Scott, Lauren Margaret**  
 “The Accessible City: Employment Opportunities in Time and Space”  
 1999 Diss 97

**Sheng, Hongyan**  
 “A Dynamic Household Alternative-Fuel Vehicle Demand Model Using Stated and Revealed Transaction Information”  
 1999 Diss 81

**Wang, Ruey-Min**  
 “An Activity-Based Trip Generation Model”  
 1996 Diss 98

**Wang, Xiubin**  
 “Algorithms and Strategies for Dynamic Carrier Fleet Operations: Applications to Local Trucking Operations”  
 2001 Diss 99

**Wei, Wann-Ming**  
 “A Network Traffic Control Algorithm with Analytically Embedded Traffic Flow Models”  
 2002 Diss 101

**Weinberger, Rachel**  
 “Effect of Transportation Infrastructure on Proximate Commercial Property Values: A Hedonic Price Model”  
 2002 Diss 100

**Weinstein, Asha Elizabeth**  
 “The Congestion Evil: Perceptions of Traffic Congestion in Boston in the 1890s and 1920s”  
 2002 Diss 74

**Yan, Jia**  
 “Heterogeneity in Motorists’ Preferences for Time Travel and Time Reliability: Empirical Finding from Multiple Survey Data Sets and Its Policy Implications”  
 2002 Diss 79

**Yang, Chun-Zin**  
 “Assessing Motor Carrier Driving Risk Using Time-Dependent Survival Models with Multiple Stop Effects”  
 1994 Diss 71

**Zhang, Ming**  
 “Modeling Land Use Change in the Boston Metropolitan Region (Massachusetts)”  
 2000 Diss 84

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**Introduction**  
Melvin M. Webber

**Cars and Demographics**  
Charles Lave

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Martin Wachs and Genevieve Giuliano

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Melvin M. Webber

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Daniel Sperling, et al.

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J. Karl Hedrick, et al.

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Raymond W. Novaco

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**Preface**  
Melvin M. Webber

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Donald C. Shoup

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Kenneth A. Small

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Daniel B. Klein

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Gordon J. Fielding

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Patricia L. Mokhtarian

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Robert Cervero

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**Introduction**  
Melvin M. Webber

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Charles Lave

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Mark Delucchi and David Swan

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Allan B. Jacobs

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Brian D. Taylor

**THE ACCESS ALMANAC: Trends in Our Times**  
Charles Lave

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**Introduction**  
Melvin M. Webber

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Peter Hall

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Adib Kanafani

**Will Congestion Pricing Ever Be Adopted?**  
Martin Wachs

**Cashing in on Curb Parking**  
Donald C. Shoup

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Anastasia Loukaitou-Sideris

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Charles Lave

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**Introduction**  
Lydia Chen

**Highway Blues: Nothing a Little Accessibility Can't Cure**  
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John D. Landis

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Amihai Glazer

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**Introduction**  
Lydia Chen

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Genevieve Giuliano

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Daniel Sperling

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Thomas Turrentine

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Joy Dahlgren

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Mark Hansen

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Charles Lave

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Robert Harley

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**Introduction**  
Luci Yamamoto

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Charles Lave

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Michael Southworth

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Martin Wachs and Nabil Kamel

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Sharon Sarmiento

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**Introduction**  
Luci Yamamoto

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Joseph DiMento, Drusilla van Hengel, and Sherry Ryan

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Michael Bernick

**Food Access for the Transit-Dependent**  
Robert Gottlieb and Andrew Fisher

**The Full Cost of Intercity Travel**  
David Levinson

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Robert L. Bertini

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Richard Crepeau and Charles Lave

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**Director's Comment**  
Martin Wachs

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Donald C. Shoup

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Lewison Lee Lem

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Evelyn Blumenberg

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Prina Ohanna Plaut

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Ilan Salomon and Patricia L. Mokhtarian

**THE ACCESS ALMANAC: Speed Limits Raised, Fatalities Fall**  
Charles Lave

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**Director's Comment**  
Martin Wachs

**A New Agenda**  
Daniel Sperling

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Gordon J. Fielding and Daniel B. Klein

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Adib Kanafani

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William S. McCullough, Brian D. Taylor, and Martin Wachs

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Robert Cervero

**THE ACCESS ALMANAC: The Pedigree of a Statistic**  
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**Traditions and Neotraditions**  
Melvin M. Webber

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Randall Crane

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Ruth L. Steiner

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Katherine M. O'Regan and John M. Quigley

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Jane Gould and Thomas F. Golob

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- Nonconventional Research**  
Melvin M. Webber
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Donald C. Shoup
- Global Transportation**  
Wilfred Owen
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David Levinson
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Wenyu Jia and Martin Wachs
- Lost Riders**  
Brian D. Taylor and William S. McCullough

**ACCESS NUMBER 14, SPRING 1999**

- The Land Use/Transportation Connection (cont'd)**  
Melvin M. Webber
- Middle Age Sprawl: BART and Urban Development**  
John Landis and Robert Cervero
- Access to Choice**  
Jonathan Levine
- Splitting the Ties: The Privatization of British Rail**  
José A. Gómez-Ibáñez
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Theodore E. Cohn
- THE ACCESS ALMANAC: Gas Tax Dilemma**  
Mary Hill, Brian Taylor, and Martin Wachs

**ACCESS NUMBER 15, FALL 1999**

- Eclecticism**  
Melvin M. Webber
- Requiem for Potholes**  
Carl Monismith as told to Melanie Curry
- Instead of Free Parking**  
Donald Shoup
- Partners in Transit**  
Eugene Bardach, Timothy Deal, and Mary Walther
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Susan Shaheen
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Patricia L. Mokhtarian and Ilan Salomon

**ACCESS NUMBER 16, SPRING 2000**

- Surprises**  
Melanie Curry
- What If Cars Could Drive Themselves?**  
Steven E. Shladover
- Power From the Fuel Cell**  
Timothy E. Lipman
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Mark Delucchi
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Pravin Varaiya
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Anastasia Loukaitou-Sideris and Robin Liggett

**ACCESS NUMBER 17, FALL 2000**

- Autonomous Decongestants**  
Melvin M. Webber
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Elizabeth Macdonald
- A Question of Timing**  
Rosella Picado
- Taking Turns: Rx for Congestion**  
Carlos Daganzo
- What Can a Trucker Do?**  
Amelia Regan
- The Road Ahead: Managing Pavements**  
Samer Madanat
- THE ACCESS ALMANAC: The Parking of Nations**  
Donald Shoup and Seth Stark

**ACCESS NUMBER 18, SPRING 2001**

- Sustainability**  
Melvin M. Webber
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Daniel Sperling
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Jianling Li and Martin Wachs
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Robert Cervero
- The Value of Value Pricing**  
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Joel Fajans and Melanie Curry
- THE ACCESS ALMANAC: Census Undercount**  
Paul Ong

**ACCESS NUMBER 19, FALL 2001**

- Transportation and the Environment**  
Elizabeth A. Deakin
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Charles Love
- Reconsider the Gas Tax: Paying for What You Get**  
Jeffrey Brown
- Clean Diesel: Overcoming Noxious Fumes**  
Christie-Joy Brodrick, Daniel Sperling, and Harry A. Dwyer
- High-Speed Rail Comes to London**  
Sir Peter Hall
- THE ACCESS ALMANAC: Unlimited Access: Prepaid Transit at Universities**  
Jeffrey Brown, Daniel Baldwin Hess, and Donald Shoup

**ACCESS NUMBER 20, SPRING 2002**

- Nobel Prize**  
Melvin M. Webber
- The Path to Discrete-Choice Models**  
Daniel L. McFadden
- Reforming Infrastructure Planning**  
David Dowall
- In the Dark: Seeing Bikes at Night**  
Karen De Valois, Tatsuto Takeuchi, and Michael Disch
- Roughly Right or Precisely Wrong**  
Donald Shoup
- Transforming the Freight Industry: From Regulation to Competition to Decentralization in the Information Age**  
Amelia Regan
- THE ACCESS ALMANAC: The Freeway-Congestion Paradox**  
Chao Chen and Pravin Varaiya

**ACCESS NUMBER 21, FALL 2002**

- No Lying Game**  
Luci Yamamoto
- Are SUVs Really Safer Than Cars?**  
Tom Wenzel and Marc Ross
- Rethinking Traffic Congestion**  
Brian D. Taylor
- On the Back of the Bus**  
Theodore E. Cohn
- Location Matters**  
Markus Hesse
- Complications at Off-ramps**  
Michael Cassidy
- THE ACCESS ALMANAC: Travel Patterns Among Welfare Recipients**  
Paul Ong and Douglas Houston

**ACCESS NUMBER 22, SPRING 2003**

- Obsolescence Named Progress**  
William L. Garrison
- Putting Pleasure Back in the Drive: Reclaiming Urban Parkways for the 21st Century**  
Anastasia Loukaitou-Sideris and Robert Gottlieb
- Local Option Transportation Taxes: Devolution as Revolution**  
Martin Wachs
- Ports, Boats, and Automobiles**  
Peter V. Hall
- Are Induced-Travel Studies Inducing Bad Investments?**  
Robert Cervero
- Making Communities Safe for Bicycles**  
Gian-Claudia Sciarra

**ACCESS NUMBER 23, FALL 2003**

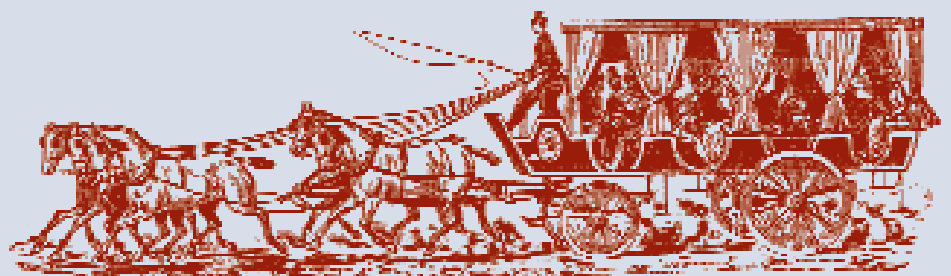
- University of California Transportation Center: 15 Years of Accomplishment**  
Elizabeth A. Deakin
- Turning Small Change Into Big Changes**  
Douglas Kolozsvari and Donald Shoup
- Older Drivers: Should We Test Them Off the Road?**  
Sandi Rosenbloom
- As Jobs Sprawl, Whither the Commute?**  
Randall Crane and Daniel G. Chatman
- Driving Less**  
Susan Handy
- Trends and Policy Choices: A Research Agenda**  
Elizabeth A. Deakin
- THE ACCESS ALMANAC: Transportation Costs and Economic Opportunity Among the Poor**  
Evelyn Blumenberg

**ACCESS NUMBER 24, SPRING 2004**

- Spread-City Everywhere**  
Melvin M. Webber
- Brazil's Buses: Simply Successful**  
Aaron Golub
- Motorizing the Developing World**  
Daniel Sperling and Eileen Claussen
- Keeping Children Safe in Cars**  
Jill Cooper
- Scrapping Old Cars**  
Jennifer Dill
- Reconsidering the Cul-de-sac**  
Michael Southworth and Eran Ben-Joseph

**ACCESS NUMBER 25, FALL 2004**

- Shuttles for the First and Last Mile**  
Elizabeth A. Deakin
- People, Parking, and Cities**  
Michael Manville and Donald Shoup
- The Price of Regulation**  
Daniel Sperling
- Why Traffic Congestion Is Here to Stay ... and Will Get Worse**  
Anthony Downs
- The Private Sector's Role in Highway Finance: Lessons from SR 91**  
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