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## PART 5

### Transportation and Urban Policies

The transportation sector accounts for about three-quarters of all oil use in the United States and roughly a third of carbon dioxide emissions and is therefore at the crossroads of ongoing debates about energy security and climate change. Meanwhile, over 40,000 Americans continue to die in highway accidents each year, about the same level as 25 years ago. And relentless growth in demand for travel and housing from an expanding and wealthier population puts ever greater pressure on urban centers.

There are many fascinating issues of the day, covered in the commentaries in this section, that are at the nexus of transportation, energy, and climate policy, and others that are related to rising congestion of transportation infrastructure and urban sprawl.

Especially timely given funding shortfalls for transportation and large federal deficits, is whether fuel taxes should be increased. Some of the questions that arise include what effect this would have on gasoline demand, whether this would have adverse distributional consequences, and how extra revenues earmarked for transportation projects might be better spent. Of related interest is the net benefit or cost of fuel economy regulations and inducements for pay-as-you-drive automobile insurance. Over a longer time horizon, the penetration of hybrids and possibly even hydrogen vehicles have the potential to substantially reduce reliance on conventional gasoline vehicles, raising the issue of whether these technologies should be subsidized.

Policymakers are also considering new approaches to congestion management. Of particular interest are road pricing programs in California and London, and possible tolls for heavy duty trucks, congestion pricing for air travel, and privatization of airports. At the same time, decisions must be made about whether to renew previous approaches to alleviating congestion, such as telecommuting. And understanding the factors that determine auto fatality rates in different countries provides guidance on the design of highway safety policies. Finally, there is growing interest in the use of market-based policy approaches to striking a balance between urban development and preservation of open space.

## 66. TRIPLE CONVERGENCE TOWARD A HIGHER GASOLINE TAX

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### Kenneth Small

is a research professor and professor emeritus of economics at the University of California, Irvine. He specializes in urban, transportation, and environmental economics.

*The United States taxes highway fuels at very low rates compared with many other countries—in fact, federal taxes have been fixed in nominal terms since 1993, despite inflation. Has the time come for a large increase in gasoline and diesel taxes?*

It's rare that a single policy instrument can solve several problems at once; rarer still that the political and economic motivations to address these problems converge; and almost unheard of that lessons of history lead to the same conclusion. We are in such a situation today with respect to taxes on motor vehicle fuels. It is time for a dramatic, permanent increase in these taxes.

**Problem #1: infrastructure needs.** It is clear that state and federal governments, private investors, local authorities, and others have trouble keeping up with legitimate needs for spending on roads, mass transit, flood control, and other public assets. These needs include maintenance of aging capital, upgrades to accommodate newer standards for earthquakes and extreme weather, and expansion to handle continued population and economic growth. Taxes on gasoline and diesel fuel are the long-standing bedrock of funding for the surface transportation component of this infrastructure. But this bedrock has been eroded by a combination of a shrinking tax base (more fuel-efficient vehicles) and lower real tax rates (rates rising more slowly than inflation). The shrinking tax base cannot be reversed, but there is no reason why tax rates cannot be maintained and indeed drastically increased. Numerous countries already have rates several times higher than in the United States, without stifling their economies.

**Problem #2: petroleum dependence and climate change.** The United States is poised to embark on new programs to reduce dependence on foreign oil and emissions of carbon dioxide. This effort cannot possibly succeed if it ignores the underlying economic motivation for people to use petroleum: quite simply, it is cheaper than alternatives. Higher fuel prices could bring about significant reductions in petroleum use through reduced driving and by harnessing consumer self-interest to the cause of improving vehicle fuel efficiency. Other policies, such as higher fuel-efficiency standards or promoting green technologies, will work more effectively if there is pressure from customers to encourage rather than evade such measures.

**Problem #3: federal and state deficits.** Governments at all levels in this country face a fiscal climate in which revenues lag at just the time when increased spending is needed—both for programmatic goals and to kick-start a weak economy. The massive federal stimulus program relies heavily on public debt, giving pause to many thoughtful observers.

Raising fuel taxes can go a long way toward closing the financing gap without more debt. While tax-financed government spending is less stimulating than debt-financed spending, the well-known Keynesian “balanced-budget multiplier” shows that it remains a potent tool. Put simply, what government spends goes directly into the hands of producers, who mostly spend it on labor or intermediate goods, whereas the tax bite that finances it does not reduce people's spending dollar for dollar. Furthermore, the timing of a tax increase now fits nicely with the expected gradual decline in the desired role of fiscal stimulus as the economy recovers.

### CONVERGENCE WITH HISTORY AND CURRENT EVENTS

Most of the current decade witnessed an apparently relentless increase in gasoline

and diesel fuel prices, hitting about \$4 per gallon in mid-2008. Expecting the rise to be permanent, many consumers, motor vehicle manufacturers, real estate developers, energy technology companies, and others had begun investments for a more fuel-scarce future: sales of large SUVs plummeted, development of battery and hybrid car technologies flourished, truckers invested in more aerodynamic designs, home buyers sought to shorten commutes. However, these efforts are now being undercut by the subsequent collapse in fuel prices. What better time to assure such decisionmakers of the long-term economic wisdom of fuel parsimony by raising fuel taxes?

History supports this analysis by revealing a lost similar opportunity. From 1973 through 1985, fuel prices rose sharply, instigating a 30 percent rise in the average fuel efficiency of the entire U.S. fleet of passenger cars, new and old. Some of this rise can be attributed to the Corporate Average Fuel Economy (CAFE) standards instituted in 1978; high fuel prices made those standards easier to meet because manufacturers did not have to fight consumer preferences. When petroleum prices collapsed in 1985, it did not take long for the market to respond with an unprecedented shift to large, low-efficiency vehicles (aided by a huge loophole in CAFE that treated SUVs and pickup trucks separately from and much less stringently than cars). With no end in sight to low fuel prices, the “big three” U.S. automakers bet heavily that the trend would last—a bet that has now cost U.S. taxpayers and workers dearly.

But the story is even more perverse. Since SUVs and pickup trucks caught on, several factors have maintained their popularity. First, manufacturers committed their designs, assembly lines, and dealership networks in ways not easy to reverse. Second, marketing efforts gave consumers a long-lasting positive image of large vehicles. Third, travelers learned that small cars fare poorly in collisions with large ones, and so turned to “upsizing” out of fear. So even if everyone would be better off with a fleet of mostly small cars, we became stuck with large ones; it will take a sustained policy change to get us out of this rut.

In addition to these factors, it is well established that drivers do not pay for various costs they impose on others, especially congestion, air pollution, and a substantial portion of accident

costs. These costs amount to about 10 cents per mile on average throughout the United States. With motor vehicles now traveling more than three trillion miles per year, even small reductions add up to big cost savings. For example, raising fuel prices from \$3 to \$5 per gallon through a tax increase could be expected to reduce driving long-term by about 6.7 percent according to a conservative estimate; at 10 cents per mile, this reduction would produce \$20 billion a year in fewer congestion, air pollution, and accidents.

## RIGHT TOOL FOR THE JOB?

There are many policies better than fuel taxes for specific problems. An oil tax would do more for energy security by motivating conservation in industrial as well as transportation uses. A cap-and-trade system or broader tax would achieve greater coverage of greenhouse gases. For motor vehicle externalities, direct policies such as congestion pricing, mileage taxes (including on heavy trucks), and tighter pollution control measures are probably more effective. Private tolling initiatives can ease public fiscal stress. But it’s hard to think of a single policy that covers all of these problems so well with a tool already familiar to the public, with administrative mechanisms already in place, and with experience abroad to assure us that an apparently draconian policy will not end life as we know it. At least until broader policies are comprehensively implemented, which may be a long way off, there is an overwhelming case for a large increase in federal fuel taxes.

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# 67. THE PRICE OF GAS AND THE DEMAND FOR FUEL ECONOMY

## Are There Any Links?

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*Many economists advocate higher fuel taxes as a means to reduce oil consumption and carbon emissions from the transportation sector. But just how effective are taxes at reducing fuel demand? Not very effective, apparently, based on the limited responses to the recent run-up in fuel prices.*

In the ongoing public debate over reducing U.S. gasoline consumption for national security and environmental reasons, many economists support an increase in the federal gasoline tax as the most efficient policy. In principle, such an increase should curb gasoline consumption by reducing average miles traveled per household and by increasing the average fuel economy of vehicles on the road. But the empirical evidence shows that the elasticity of miles traveled to the price of gasoline is small (roughly  $-0.1$ ), having almost no effect in the short run.

Consequently, a large increase in the gasoline tax would be needed to substantially reduce consumption—that is, unless average fuel economy of the vehicle fleet responds to the price of gasoline. That response includes many factors, such as at what age vehicles are retired, but an important component is the effect of the price of gasoline on the average fuel economy of new vehicles. Although the roughly three-fold increase in the price of gasoline from 2002 to 2007 significantly affected sales of individual vehicle models, the effect on average fuel economy was quite small.

### PRICE VERSUS DEMAND

Between the beginning of 2002 and the end of 2007, as the real price of gasoline doubled, the market share of SUVs, with a mean fuel economy of about 16.7 miles per gallon (mpg), decreased from 17 to 12 percent. The market share of Chrysler, Ford, and GM, which relied heavily on SUV sales during this time period, decreased from 63 to 52 percent.

After controlling for variables that affect market shares, such as consumer preferences for vehicle characteristics, about half of the decline in market shares of SUVs and U.S. manufacturers from 2002 to 2007 was due to the coinciding increase in the price of gasoline. Despite the strong relationship between gasoline prices and market shares in this one vehicle category, gasoline prices have had only a small effect on the average fuel economy of all new vehicles sold. A \$1 per gallon increase in the price of gasoline is associated with an increase of only about 0.5 to 1 mpg after controlling for other factors.

In the short run, of course, vehicle characteristics are fixed. The simultaneous large effect on model market shares and small effect on fleet average fuel economy can be explained by the fairly narrow distribution of fuel economy of vehicles in the market at a particular time. For example, a sudden increase in the gasoline price could cause a dramatic shift from medium-size to small cars, but the change in overall fuel economy would be small because the average fuel economy of these two market segments is similar, at 26.6 and 30.3 mpg.

### HOW MANUFACTURERS RESPOND

In principle, the long-run effect of gasoline prices on average fuel economy could be greater if producers responded by offering vehicles with higher fuel economy. Some of these adjustments can be rather quick, such as changing the mix of vehicles offered,

but others take some time. When the corporate average fuel economy (CAFE) standards were implemented in the mid-1970s, manufacturers raised fuel economy by making vehicles shorter and lighter and by reducing engine sizes. Consequently, vehicle weight and power (as measured by horsepower) decreased by about 30 percent. Yet the reduction in engine power was quickly reversed as the price of gasoline declined and technology improved. By 1990, average vehicle power had returned to its pre-CAFE level.

It is technologically feasible for producers to significantly increase fuel economy through either an increase in production costs (by substituting lightweight alloys or adding a turbocharger and downsizing the engine) or a reduction in engine power. Given consumers' strong preferences for vehicle performance, firms are hesitant to compromise engine power in order to increase fuel economy.

## POLICY OPTIONS

So where does this leave us? The price of gasoline has a very small effect on the fuel economy of the stock of vehicles on the road. A very large increase in the gasoline tax would be needed to reduce consumption because the price per gallon has so little effect on miles traveled and the fuel economy of the overall vehicle fleet. The political feasibility of such an increase is doubtful at best, and substantially reducing gasoline consumption solely by increasing the gas tax would not seem to be a viable policy option.

Other options do exist, including improving public transportation, increasing the CAFE standard, or offering cash or tax incentives to consumers. Examples of the last include federal and state tax incentives for purchasing hybrids and the recent Cash for Clunkers program.

Ultimately, the full costs and benefits of each policy need to be compared, although such a comparison is far from straight-

forward. In the case of CAFE, its costs are largely hidden from the consumers' view; it is not obvious to consumers the extent to which fuel economy standards affect new and used vehicle prices and cause an increase in driving (that is, the "rebound" effect). But perhaps more importantly, it is necessary to consider how policies and economic forces might interact with one another when comparing costs and benefits and addressing political obstacles. For example, high gas prices can increase public support for raising fuel economy standards, as in the 1970s and perhaps in the past few years, although the reverse would be true in periods of low gas prices. Multiple policies might also interact positively with one another—for example, improving public transportation could increase the sensitivity of miles traveled to the price of gasoline. In such cases, a combination of policies might prove politically and economically expedient.

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## 68. SHOULD DISTRIBUTIONAL CONSIDERATIONS HOLD UP HIGHER GASOLINE TAXES?

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### Sarah E. West

is an associate professor of economics at Macalester College in Saint Paul, Minnesota. Her research analyzes optimal tax policy, with a focus on estimating behavioral responses to policies that reduce gasoline consumption.

*Although gasoline taxes are the most efficient policy to reduce gasoline use, the federal gasoline tax has not been increased since 1993, and inflation has eroded its real value. One common argument against raising gasoline taxes is that they might impose a disproportionate burden on low-income families. Is this a valid rationale?*

Increasing federal or state gasoline taxes would offer clear advantages: consumers would tend to buy less gasoline, thereby reducing greenhouse gas emissions and dependency on foreign oil. Households would have an incentive to drive fewer miles, reducing congestion, accidents, and emissions of local pollutants. Because households do not currently account for all of these costs of driving, gasoline tax rates (now 44 cents per gallon on average) are inefficiently low.

Someone would bear the burden of an increase in gasoline taxes—but who? Policymakers frequently argue that the gasoline tax is regressive by definition—poor households pay a higher proportion of their income in tax than do wealthy households. But is this a valid argument?

Assessing the approximate distributional burden of a gasoline tax is fairly straightforward. Nearly all gasoline is purchased directly by households, so if the gasoline tax is fully passed forward into pump prices, its distributional effect can be assessed by comparing gasoline consumption (relative to income) across different household groupings. At least in the short run, before households make major changes in the kinds of vehicles they drive or in the location of their residences, consumers seem to bear the bulk, if not the entirety, of any increase in the gasoline tax. Over the longer run, the effect might be more complicated as consumers switch between fuel-efficient and fuel-inefficient vehicles, shifting some of the tax burden onto fuel refiners, wholesalers, and gas-station owners. Still, supply is also more flexible in the long run, so a much greater share of the burden remains on the consumer.

Among those households that consume gasoline, the gas tax is indeed regressive. Gasoline-buying households with the highest annual income (in the top 20 percent) pay less than half of what poor households (in the bottom 20 percent) pay, as a proportion of annual income. One reason for this is that lower-income households are more likely to drive older, used vehicles, with relatively higher fuel consumption rates. Another is that vehicle miles traveled does not rise in proportion to income—someone with twice as much income as someone else does not typically drive twice as much.

But annual income is probably not the best measure of household well-being, as poorer households tend to have expenditures greater than their annual income, while other low-income people, like MBA students, are clearly not poor when account is taken of their future earnings potential. For these reasons, economists often prefer to proxy household well-being by the total amount they spend or consume each year, rather than their annual income. It's also important to account for the fact that many poor households neither own nor lease a vehicle, and therefore do not pay gasoline taxes at all.

When the amount of gasoline taxes paid is divided by total expenditures, rather than income, and when households that do not own vehicles are taken into account, highest-income households as a group still spend less in gasoline taxes as a proportion of total expenditures (half a percent) than the lowest-income households (0.7 percent), but the poorest households actually spend less than middle-income house-

holds, providing a murkier picture of just how regressive the gasoline tax actually is.

Another relationship between income distribution and gasoline consumption further mitigates the regressive nature of the gasoline tax: poorer households are more responsive to gasoline price changes than are wealthy households. This may be because gasoline price increases have greater relative impacts on poor households' budgets, or because the poor have less aversion to public transportation and place a lower value on the time savings from automobile travel. Whatever the reason, when gasoline prices rise, we can expect poorer households to reduce gasoline consumption up to twice as much as wealthy households, thereby escaping a greater proportion of the gasoline price increase. Care must be taken to account for the fact that gasoline price increases can make it disproportionately more difficult for poor households to get to work, but failing to account for flexible price-responsiveness can overstate regressivity.

### REBATES CAN COUNTER REGRESSIVITY

Even accounting for the above factors, the gasoline tax still places a disproportionate burden on poor households. But careful recycling of the gasoline tax revenues back to households can mitigate or even completely overcome its regressive nature.

By using the revenues from the gasoline tax to reduce taxes on work hours, the policy can be made significantly less regressive. The overall effect of the gasoline tax rate increase and revenue rebate could be made more progressive by targeting these tax rate reductions toward the poor, or by increasing the earned-income tax credit (EITC). If the revenues are used to give rebates of the same amount to all households, the policy

could be made progressive. With such a rebate scheme, the poorest households could actually be made better off. These lump-sum rebates are analogous to those in "cap-and-dividend" proposals for climate change policy.

While it might seem natural to use gasoline tax revenues to counter regressive impacts, this need not be the case. Public finance economists generally would recommend that policymakers set the gasoline tax at the efficient level, so that motorists face the full costs of driving, regardless of the distributional implications. Then, if they think that the gasoline tax places too much burden on poor and working-class households, policymakers can use the most efficient redistributive tools to attain equity goals, be they lump-sum rebates of gas tax revenue or modifications to the broader income tax and benefit system.

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## 69. DOES THE FEDERAL GOVERNMENT SPEND TOO MUCH FOR HIGHWAYS, OR TOO LITTLE?

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### Winston Harrington

is a senior fellow and an associate director of research at Resources for the Future, specializing in urban transportation, motor vehicles and air quality, and environmental policy cost assessment.

*To what extent is the federal government involved in financing highway construction and maintenance? Are these decisions better left to state governments? Given the large amount spent on highways each year, Americans will bear a substantial cost if this money is spent inefficiently rather than on highway projects with favorable cost–benefit ratios.*

Certainly, there is ample justification for some federal funding of highways. There is plenty of intercity and interstate travel, both commercial and personal, which means that the benefits of a well-integrated road network are not just local. Just note the number of out-of-state plates you see on interstates and other major thoroughfares. But what's the right amount?

Those who say the federal government is spending too much note that the Federal-Aid Highway Program makes grants to the states that cover 80 to 90 percent of the costs of qualifying highway projects. Can anyone claim with a straight face that out-of-staters enjoy 80 to 90 percent of the benefits of the average highway? To this group, which includes a lot of regional planners and antisprawl advocates, this is a major subsidy to build roads. With the federal government paying such a large cost share, the argument goes, local and state governments don't have to make the hard choices about whether projects are really justified.

Others say the federal funding share for specific projects seriously overestimates federal involvement in highways. In terms of total highway spending, the Federal-Aid Highway Program grants for states, which now amount to \$30 billion to \$40 billion, account for only about 25 percent of total spending on highways. Moreover, if federal highway subsidies are excessive, why is it that road use is growing so much faster than capacity? Between 1990 and 2003, for example, road use increased by 2.3 percent annually, compared to a 0.25 percent annual increase in highway lane-miles. One answer is that while your state may get 90 percent of the cost of a new section of interstate, it won't change the total disbursements to your state. That is, the federal subsidy gives a state incentives to change its spending plan without necessarily increasing it.

Besides, the way the question is asked almost equates federal spending with manna from heaven. These funds come from the Highway Trust Fund (HTF), which is financed primarily by federal gasoline taxes, which are, in turn, paid by private and commercial road users. Any annual allocation of HTF funds inevitably results in some states getting less funding than their citizens contribute, and others more. This reality above all others is what makes federal highway spending legislation so contentious and hard to pass. Indeed, chronic complaints from the "donor" states led to the establishment of an "equity" bonus that guarantees each state a minimum percentage of its citizens' contributions. In 2008, this percentage was 92 percent. Clearly, the equity provisions impose a serious constraint on the level of interstate transfers. In 2005, it appears that of the \$37 billion in disbursements to the states, \$3 billion to \$5 billion was spent in a different state from where the money was collected.

However, even though most of the funds end up in the states where they were collected, the current approach to highway funding still gives much influence to the federal government over funding within states. The Federal-Aid Highway Program is really a collection of programs intended for various functions. While a few of these programs are discretionary and distributed by the Federal Highway Administration (FHWA), the vast majority of the funding is in so-called formula programs that de-

termine how much each state will receive annually. For each subprogram, such as the Interstate Maintenance Fund or the Congestion Mitigation and Air Quality Program, there is a formula with objective factors and weights that determines each state's allocation for that program. And, of course, the funds in each program must be spent on program-relevant activities.

Unfortunately, there is another rapidly growing federal government influence on highway funding that probably has adverse consequences for efficiency—the rampant use of congressional earmarks. In SAFETEA-LU, the most recent highway authorization act, there were 6,000 line-item, named projects, valued at almost 10 percent of the total funding allocated. Half the funding was added at the last minute, during the House–Senate conference. Those of us who are not lobbyists think the use of earmarks has gotten out of hand, and no more so than in transportation. Earmarks do not increase the funding available to each state; rather, they direct the allocated funds to particular projects. No one has a clear idea how the earmarked projects are selected; they are simply inserted into the legislation at the last minute, without review or comparison with other projects. The potential for poor decisions, not to mention outright corruption, is pretty high.

So what would be a better approach? One increasingly popular option is road pricing. In the Washington, DC, area, the Dulles Greenway was built with private funds, and plans are moving forward with private funding of HOT (high-occupancy toll) lanes to be added to the Beltway and Interstate 95–395. In addition, there is talk of cities and states selling existing public roads to private operators, as Chicago is considering doing with the Chicago Skyway. On a more experimental level, debate is now under way about implementing road pricing on a large scale in the public sector. For example, New York City is considering implementation of “cordon pricing,” charging stiff daily fees for driving into southern and central Manhattan.

Making users pay the full social cost of road use, including the incremental cost of adding capacity, automatically takes

care of federal concerns about adequate revenue generation, as out-of-state users will have to pay. However attractive road pricing is in principle, it still faces serious political barriers and practical problems, especially as it becomes more widely used. Unless there is a carefully planned transition, it is likely to generate serious affordability concerns, not only for the poor, but also for others who just happen to face huge tolls because of previously made choices of where to live and work.

Absent comprehensive road pricing, information about both the local and national benefits of specific transportation projects would be needed to develop appropriate federal highway subsidies. A subsidy equal to the difference between the two would provide the right incentive. Perhaps there would be a way to combine estimates of the nonlocal benefits of such projects with a demand-revealing pricing mechanism. To put such a plan into action, what would be needed is a notion of the national, as opposed to the local, benefits of specific proposed road construction projects. Estimates of such benefits could come, perhaps, from the prevalence of out-of-state vehicles on roads in the vicinity of the proposed project. Federal officials could use this information to make an offer of a subsidy, leaving it up to the state to decide whether to provide the balance of funds for the project. Even without an estimate of national benefits, a fixed supply of funds could be distributed relatively efficiently by a competitive auction among local or state governments to elicit their willingness to accept certain subsidy levels to begin a project.

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## 70. THE BENEFITS AND COSTS OF TIGHTER FUEL ECONOMY REGULATIONS

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*In the United States, fuel economy standards form the centerpiece of efforts to reduce oil dependence and greenhouse gas emissions from the transportation sector. To what extent can these policies be rationalized on cost–benefit grounds?*

As a result of recent legislation, manufacturers in the United States will be required to meet carbon dioxide (CO<sub>2</sub>) emissions per mile regulations that will raise the average fuel economy of new cars to 39 miles per gallon by 2016, and the average fuel economy of new light trucks (minivans, sport utility vehicles, pickups) to 30 miles per gallon. (Previous standards were 27.5 miles per gallon for cars and 24 miles per gallon for light trucks.) To many people, it seems obvious that fuel economy standards should be tightened to reduce CO<sub>2</sub> emissions and oil dependence. After all, passenger vehicles account for about 20 percent and 45 percent of U.S. CO<sub>2</sub> emissions and oil use, respectively. However, before we can conclude whether or not tightening fuel economy standards is a good idea, an economic assessment of the benefits and costs is appropriate. To think about this, it is helpful to separate out the effect of tighter standards on gasoline use, vehicle miles of travel, and the costs of automobile manufacture.

Higher fuel economy standards would reduce the demand for gasoline, thereby producing “externality” benefits (societal benefits that are not taken into account by individuals) in the form of avoided CO<sub>2</sub> emissions and reduced nationwide dependence on oil. Most estimates of economic damages from future global warming—agricultural impacts, rising sea levels and increased storm intensity, health effects from spreading tropical disease, and so on—are in the order of \$20 per ton of current CO<sub>2</sub> emissions, or about 20 cents per gallon of gasoline (burning a gallon of gasoline produces nearly 0.01 tons of CO<sub>2</sub>). Damages are much higher if, as advocated by some economists, more weight is given to the well-being of future generations or extreme climate risks.

The broader external costs of oil dependence include the risk of macroeconomic disruption costs from oil price shocks that might not be fully taken into account by the private sector, such as some costs associated with the temporary idling of labor and capital. And while the United States as a whole has an influence on the world oil market, individual oil importers do not consider the impact of their own infinitesimal consumption on increasing the world oil price, which imposes an external cost by increasing the amount of money transferred from other oil importers in the United States to foreign oil suppliers. One recent estimate puts the that external costs from macroeconomic disruption risks and U.S. market power amount to, very roughly, 30 cents per gallon of gasoline. Dependence on oil also constrains U.S. foreign policy and possibly undermines national security. Politicians may be reluctant to challenge oil-producing countries on human rights and other issues, and oil revenues may help certain hostile governments, terrorists, and other unsavory groups. Putting an additional dollar figure on these broader foreign policy and national security costs is extremely difficult, however.

Motorists already pay, at least in part, for the external costs of fuel consumption through federal and state gasoline taxes, which add about 40 cents per gallon to the price at the pump. According to basic tax theory, reducing gasoline use produces net benefits to society only to the extent that CO<sub>2</sub> and oil dependence externalities exceed fuel taxes. Our discussion suggests, albeit very tentatively, that external costs that have been quantified might be largely offset by prevailing fuel taxes. However, ac-

counting for national security and other costs would seem to imply net benefits overall from reducing gasoline use, though the magnitude of the gain is very difficult to pin down.

Critics of fuel economy standards sometimes point to the perverse effect of higher fuel economy on lowering fuel costs per mile and increasing the incentive to drive, which can increase highway congestion, accidents, and pollution. However, according to a recent study by Kenneth Small and Kurt Van Dender, less than 10 percent of the fuel savings from better fuel economy are offset by increased driving. While the costs of this “rebound effect” should be factored into an assessment of fuel economy regulations, they are less important than other factors.

Binding fuel economy regulations induce auto manufacturers to incorporate more fuel-saving technologies into new vehicles, leading to higher vehicle production costs and prices. However, a number of studies, such as one in 2002 by the National Research Council, suggest that fuel-saving benefits over the vehicle life would outweigh the up-front installation costs for many emerging technologies. Some analysts argue that these apparent “win-win” technologies may not be adopted without tighter fuel economy regulations, however, because consumers may underappreciate the benefits of better fuel economy if they are preoccupied with other vehicle attributes like power, comfort, and safety. On the other hand, others argue that forcing technology adoption may be costly if consumers would instead prefer new technologies be used to improve other vehicle characteristics, such as increased horsepower, rather than fuel economy. Another possibility is that manufacturers may meet higher fuel economy requirements by reducing vehicle weight and size; this can raise injury risks for occupants of these vehicles, though it makes the roads a little safer for other drivers.

In short, the case for tightening fuel economy regulations can be argued either way, because it is difficult to judge precisely how manufacturers will respond and how consumers will value changes in vehicle technology. But most importantly, the climate and national security benefits from reduced gasoline use are much disputed. Another policy option is to raise fuel taxes, which, unlike fuel economy regulations, would reduce congestion and other highway externalities, through reducing vehicle miles traveled. While the case for

higher fuel taxes is more clear-cut, this option lacks political traction at present.

When I first began studying fuel economy regulations, the case for tightening the standards looked rather dubious to me. However, my perspective has changed somewhat as the difficulties in doing a nice, clean cost-benefit analysis have become more apparent. Moreover, colleagues of mine who have thought hard about the issue—like Carolyn Fischer, Lawrence Goulder, Winston Harrington, Richard Newell, William Pizer, Paul Portney, Philip Sharp, and Kenneth Small—are sympathetic to higher standards, if they are not ramped up too rapidly and reforms permit more trading of fuel economy credits to keep down program costs. My own view is that if the argument comes down to doing nothing or tightening fuel economy regulations, then the latter is what you do. As new technologies are developed over time, a progressive tightening of standards seems to make sense, given that the downside costs to the economy are not that huge, and 20 years from now we may be very glad that serious measures were taken during the intervening years to reduce the dependency of the transport system on conventional fossil fuels.

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# 71. PAY-AS-YOU-DRIVE AUTO INSURANCE

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*Automobile use in the United States is underpriced, as motorists do not pay for the full costs of pollution, congestion, and traffic accidents when deciding how much to drive. Pay-as-you-drive insurance offers a novel approach for reducing automobile use, without raising the private costs of vehicle ownership and use for the majority of drivers.*

Under the current lump-sum pricing structure for auto insurance, drivers who are similar in other respects—age, gender, location, driving safety record—pay nearly the same premiums if they drive 5,000 or 50,000 miles a year, even though the likelihood of being involved in a collision increases with each mile driven. Hardly an efficient approach, to put it mildly.

Just as an all-you-can-eat restaurant encourages more eating, all-you-can-drive insurance pricing encourages more driving because drivers don't face the marginal insurance cost for each mile driven. The extra driving that results imposes significant costs on society: more accidents, congestion, carbon emissions, local pollution, and dependence on oil.

Moreover, the current structure is inequitable. It forces low-mileage drivers to subsidize the accident cost of high-mileage drivers in each risk class, even though the former are responsible for fewer accidents. This problem is particularly disturbing given that low-income people tend to drive less on average.

A simple alternative, known as pay-as-you-drive (PAYD) auto insurance, avoids the problems of the current system. With PAYD, the price of auto insurance would be tied to the number of miles driven. Other rating factors such as location, age, vehicle type, and driving record still would be incorporated into this price, so higher-risk drivers would pay more per mile than lower-risk drivers.

## BENEFITS

Switching to PAYD could yield substantial benefits, according to our recent findings, which are based on data from the 2001 National Household Transportation Survey. The average driver would face a per-mile insurance premium of 6.6 cents per mile, instead of a yearly lump-sum cost of about \$800. Because drivers could save money by driving less, we estimate driving (miles traveled) would fall by about 8 percent.

Achieving a reduction on this scale would yield social benefits of about \$60 billion a year, mostly from reduced accidents and congestion, but also from reduced carbon emissions, local pollution, and oil dependence.

And PAYD could achieve these gains while actually *reducing* the cost of driving for most drivers. Almost two-thirds of households would save money under PAYD, with average savings (for those households that save) totaling \$270 per vehicle. Most of the savings result from the elimination of the current subsidy from low-mileage to high-mileage drivers. The high proportion of drivers that would pay less reflects the fact that a minority of high-mileage drivers is responsible for a majority of driving within each risk class. In fact, we find that the top 20 percent of drivers are responsible for 45 percent of all miles driven.

Our research also shows that low-income families would especially benefit from PAYD, because low-income people tend to drive fewer miles. Every household income group making less than \$52,500 (in 2001) would save money on average. Further, the

savings for low-income groups are significant as a share of their total income, whereas any losses by high-income groups are not significant.

## OBSTACLES

Despite the large social benefits from PAYD, there are currently barriers to its widespread adoption. For one, insurance regulations in many states prohibit or pose significant obstacles to pricing insurance by the mile. Since regulations were always written with yearly premiums in mind, per-mile premiums are sometimes technically illegal even if that was never the intention of the regulators. California, for example, just acted to address this issue and make it easier for firms to offer PAYD.

A second problem is that, even where it is legal, certain costs reduce the likelihood that firms will independently offer PAYD insurance. In order to price insurance per mile, firms or their customers would need to incur the cost of verifying mileage, through either odometer checks or devices that fit in each vehicle. While odometer readings could be inexpensive procedures if done on a widespread basis, there currently is no infrastructure of certified providers that insurance firms can use. And technological devices that automatically monitor and transmit mileage to insurance companies can be expensive, costing as much as \$100 to install. Moreover, to institute PAYD, firms must develop new billing and administrative infrastructures, retool their advertising, and develop new actuarial models to determine appropriate risk-adjusted per-mile prices.

While private firms and their customers would have to bear these costs, much of the benefits from reduced mileage would accrue to other insurance companies and to society as a whole. In our analysis, we find the social benefit to be about \$250 per vehicle per year. This is a classic case of a positive externality, and in these cases the government has a clear role to play in promoting a better social outcome. To address the market failure around monitoring costs, the government could require that odometer readings be performed as part of required safety and emissions inspections or by certifying vehicle service businesses in other states to perform odometer readings.

The government could also offer a tax credit for each new mileage-based policy that an insurance company writes. We

recommend a \$100 tax credit, which would cover the cost of most technological devices that could easily measure and transmit mileage data. The tax credit could be phased out, once roughly five million vehicles (2 percent) are signed up, after which point PAYD is expected to take off on its own. To address the development costs, the government could increase the funding available to PAYD pilot programs.

While we believe that PAYD would be a significant improvement, it is not an adequate policy response to driving-related harms all by itself. It does not force drivers to internalize the external social costs of the congestion, accidents, pollution, and oil dependence they cause. It simply corrects a failure with the way that auto insurance is priced today and the inefficient and inequitable consequences of that pricing structure.

Ideally, PAYD would be complemented with other policies, such as carbon pricing and a congestion charge, which directly target the driving-related social harms. But many of these other policies raise the cost of driving, which is politically challenging, especially in these tough economic times. The promise of PAYD is that it can achieve some of the benefits of these user fees by creating incentives to reduce driving without raising the cost of driving in aggregate, and indeed lowering it for the majority of drivers. What is good for drivers, in this case, is also good for society.

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## 72. WHAT MOTIVATES PEOPLE TO BUY HYBRIDS?

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*The U.S. government has been supporting consumer purchases of hybrid vehicles in the form of federal income tax deductions before 2006 and federal income tax credits since then. Because these credits are set to expire in 2010, it is especially timely to consider how effective they have been in promoting hybrid sales and whether they should be renewed.*

Since hybrid vehicles were introduced into the U.S. market, they have moved from being the rare status toy of green Hollywood actors to a good option for average commuters, or so the media would have us believe. Today, hybrids represent roughly 3 percent of new car sales because of—or perhaps in spite of—federal subsidies, which are due to expire across the board in 2010.

The evidence to support those subsidies is somewhat mixed. For example, while the federal subsidies for the most popular hybrid, the Toyota Prius, have ended, it has continued to gain market share. While most observers agree that federal subsidies were critical to gain market acceptance of what was then a brand-new technology, is that still true today? Or is what matters most the price at the pump?

### HOW HYBRIDS WORK

The level of fuel economy and carbon dioxide (CO<sub>2</sub>) emissions produced by a conventional gasoline vehicle is largely a reflection of the low efficiency of internal combustion engines. Only about 15 percent of the fuel energy consumed by these engines gets used for propulsion, while the rest is lost to engine and drive-train inefficiencies and idling. Hybrid vehicles combine power from both a gasoline engine and an electric motor that runs off the electricity from a rechargeable battery. The battery harnesses some of the energy that would be wasted in typical automobile operations (such as energy from braking) and provides power whenever the gasoline engine proves to be inefficient and is turned off.

A hybrid model typically costs around \$4,000 more on average than its gasoline equivalent because of the battery required for on-board electricity storage and the computer control system that regulates use of the electric motor. Offsetting this is the fuel savings, due to higher fuel economy. For example, a hybrid vehicle achieving a fuel economy of 55 miles per gallon will save \$2,340 over the first five years compared with an equivalent regular vehicle with fuel economy of 35 miles per gallon, assuming the vehicle is driven about 15,000 miles a year and the retail gasoline price is \$3 per gallon. Hybrids are especially attractive to urban commuters who experience stop-and-go traffic on a regular basis.

Hybrids were first introduced in the United States in 2000 when the Toyota Prius and Honda Insight entered the market. Since that time, the number of hybrid models increased to 15 in 2007, and there could be as many as 40 hybrid models by 2012. Sales of new hybrid vehicles increased from less than 12,000 in 2000 to the recent peak of about 350,000 in 2007, with the most popular model, the Prius, accounting for over 50 percent. In 2008, sales of new hybrid vehicles dropped about 10 percent from the 2007 level, likely in large part due to the recent recession. In July 2009, hybrid sales as a percentage of total new vehicle sales set a record at 3.55 percent with the start of the Cash for Clunkers program.

## WHAT EXPLAINS THE INCREASE IN POPULARITY?

One obvious factor is the recent run-up in gasoline prices. For example, the average gasoline price rose from \$1.50 to \$2.60 per gallon in 20 U.S. metropolitan areas between 2000 and 2006. Arie Beresteanu and I estimate that this increase in fuel prices accounts for 37 percent of hybrid sales in 2006. If prices had risen to \$4 (rather than \$2.60) and consumers had expected future prices to stay that high, we estimate that hybrid sales would have been higher still, by about 65 percent, in 2006. And of course, both gas prices and hybrid sales have subsequently risen in 2007 and the early part of 2008.

The Energy Information Administration, for example, projects the hybrid share in new vehicle sales to rise progressively to 17 percent by 2030 as retail gasoline prices rise (in real terms) to \$3.80 a gallon, and consumers become more familiar with the new technology.

The second factor is tax incentives and other forms of incentives at federal, state, and local levels. At the federal level, income tax incentives were modest initially: from 2001 to 2005, purchases of hybrids were eligible for an income tax deduction of \$2,000, which amounted to a subsidy of \$500 for an individual in the 25 percent federal income tax bracket. In 2005, the tax deduction was replaced by an income tax credit of up to \$3,400 a vehicle, with the credit varying based on the savings in gasoline per mile of the vehicle relative to its gasoline counterpart. (If, instead, tax credits were based on differences in miles per gallon, this would imply much larger subsidies for a given reduction in fuel per mile for small vehicles.)

Not surprisingly, we found that federal income tax deductions had a very minor effect prior to 2006, explaining less than 5 percent of hybrid sales. However, the more generous incentives made a bigger difference, spurring some 20 percent of hybrid sales in 2006. If tax credits had been twice as large, the average hybrid sale would have received a subsidy of about \$4,700 and, according to our estimates, hybrid sales would have been 23 percent greater than their actual sales in 2006.

However, due to the small market share of hybrids at present—just 3 percent of the light-vehicle fleet—the federal incentive program has had very limited effects on overall fuel economy of new passenger vehicles. We estimate that the average fuel economy of new passenger vehicles in 2006 is barely noticeably higher at 23.2 miles per gallon with the program, compared with 23.1 miles per gallon without. Even if tax incentives had been twice as large, the average fuel economy of the new passenger vehicle fleet would have been only a further 0.1 miles per gallon higher. To induce the same level of change, a 10-cent gasoline price increase would suffice, without considering its further impact on driving.

Many state and local governments offer their own programs such as sales tax waivers, state income tax breaks, access to high-occupancy vehicle lanes, and exemptions from parking

charges. These programs also likely played some role in contributing to hybrid sales. In the context of these state and local incentives, a study by Gallagher and Muehlegger (2009) shows that up-front sales tax waivers, which are immediate and automatic at the time of purchase, are much more effective than state income tax breaks, which consumers have to understand and apply for during the filing of state tax returns.

## MOVING FORWARD

Federal income tax credit amounts begin to phase out for a given manufacturer once it has sold over 60,000 eligible vehicles. The credit ran out for Toyota and Honda in 2007 and 2008, respectively. In addition to the phaseout rules, the credit policy is scheduled to end after December 31, 2010. Is there still a case for retaining incentives or offering new policies for hybrid vehicle purchases? There exist several arguments for government support of hybrid vehicles, including significant economies of scale in automobile production, advantages of learning by doing on both consumption and production sides, failure to fully take into account the fuel saving of fuel-efficient vehicles by consumers, as well as the political difficulty of raising gasoline taxes in order to correct for the externalities associated with gasoline consumption.

Should the incentives for hybrid vehicle purchases be continued, current research points to several considerations to be taken into account in the future. Our analysis shows that a flat rebate, irrespective of household income tax liabilities, could be more effective than the current income tax incentives. Households with higher tax liability can take greater advantage of the income tax credits for hybrids, although they may not be as sensitive to such incentives as lower-income households with less tax liability. Moreover, a flat rebate program would eliminate the uncertainty in the amount of benefit for consumers at the time of purchase. In light of the finding by Gallagher and Muehlegger that up-front sales tax incentives are more effective than income tax incentives, the rebate would likely be more effective if it is applied at the time of purchase.

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## 73. THE OUTLOOK FOR HYDROGEN CARS

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*What is the potential for hydrogen fuel cell cars to reduce U.S. dependence on gasoline over the longer term? What technological obstacles need to be overcome and policy actions taken before such vehicles could penetrate the U.S. market in large numbers?*

The U.S. automotive fleet will be dramatically transformed over the next several decades as a result of energy and environmental policies being debated right now. Reductions in oil imports to enhance energy security and reduce trade balances will demand greater use of alternatives to gasoline, as will anticipated requirements to reduce carbon dioxide emissions linked to global climate change. Improving the fuel economy of current cars is an important first step, but achieving deep cuts in oil use and greenhouse gas emissions will require a suite of commercially viable alternatives—not just more efficient vehicles (gasoline-battery hybrids, plug-in hybrids, and those powered by fuel cells), but also “decarbonized” fuels, such as renewable biofuels, electricity, and hydrogen produced from low-carbon sources.

Thus far, we have seen a “fuel du jour” syndrome—waves of short-lived enthusiasm first for batteries, then fuel cells, ethanol, and plug-in hybrids. Now the consensus emerging among transportation energy analysts is that a portfolio strategy of options is needed to nurture both near-term and longer-term technologies. One of the most promising options is hydrogen.

The National Research Council has twice assessed hydrogen as a replacement for gasoline in light-duty vehicles. Its 2004 report showed that hydrogen could dramatically reduce oil use and greenhouse gas emissions from light-duty transport by 2050, but only if certain technical and transition barriers could be overcome. The 2008 report (in which we participated) examined a possible transition to hydrogen in detail, offering critical assessments of the timing and resources needed to bring fuel cell vehicles (FCVs) into widespread use.

Fuel cells are at the heart of the hydrogen strategy. They are electrochemical devices, akin to batteries, that combine hydrogen and oxygen (from air) to generate electricity to power a vehicle. The only tailpipe emission is water vapor from the reaction of hydrogen and oxygen. Although fuel cell technology has improved substantially in recent years, it has not yet achieved the performance and cost goals required for large-scale commercial production. The chief technical challenges are making fuel cells as durable and cost-effective as today's internal combustion engine, reducing the use of costly materials, such as platinum for catalysts, and developing a compact, low-cost hydrogen storage system capable of providing a driving range of 300 miles or more.

General Motors, Honda, Daimler, and Toyota are currently introducing precommercial FCVs and hydrogen fueling stations in limited markets, notably California and Germany. If technical progress continues at its current pace, FCVs could be ready for mass production by 2015. Initial costs would be high but should fall quickly as manufacturing volumes increase and vehicles continue to improve. Hydrogen for these vehicles can be produced from a variety of energy sources, including fossil fuels, renewables, and nuclear energy. In the near term, the most economical approach is to manufacture hydrogen from natural gas at individual refueling stations. The projected cost is about \$1.50 per gallon of gasoline equivalent (figured on a mile-per-gallon basis), but actual costs would vary with natural gas prices. Eventually, hydrogen could be produced at large centralized plants and distributed to refueling stations via pipelines or trucks, much like gasoline.

Most hydrogen today is produced from fossil fuels, which release significant amounts of carbon dioxide (CO<sub>2</sub>)—the major greenhouse gas (GHG) linked to climate change. Large central plants that produce hydrogen from coal could capture the CO<sub>2</sub> and permanently sequester it in deep geological formations. Such systems are currently in use at four large industrial operations in Europe, North Africa, and Canada, but their widespread use for climate change mitigation is still at least a decade away, pending further developments in technology and climate policy. Meanwhile, FCVs using hydrogen made from natural gas would still reduce overall (“well-to-wheels”) GHG emissions by half compared with current gasoline vehicles, largely through gains in overall efficiency. Production of hydrogen from biomass also is advancing and could be competitive by the mid to late 2020s. In the longer term, carbon-free renewables, such as wind and solar energy, might be harnessed for hydrogen production via electrolysis of water.

Development of the hydrogen refueling infrastructure is another critical step. Current strategies, developed in close coordination with vehicle manufacturers, focus on targeted introduction of FCVs and hydrogen infrastructure in Los Angeles, New York, and Houston.

The number of hydrogen-fueled vehicles on U.S. roads by 2020 might be no more than about 2 million, out of an estimated vehicle population of 280 million. This assumes that mass production of FCVs gets under way around 2015, all technology goals are met, and FCVs rapidly gain market share, reaching 10 percent of new car sales by 2020. Under such favorable conditions—requiring government support during the transition period—hydrogen cars could become commercially competitive by about 2023. The number of vehicles could then grow rapidly, to 60 million in 2035 and 220 million in 2050—some 60 percent of the future fleet.

In this “maximum practical” scenario, after about 2035, hydrogen cars should reduce oil use and greenhouse gas emissions more than near-term technologies, like advanced internal combustion engines and hybrids, or expanded use of bio-fuels. The speed of deployment of hydrogen cars is uncertain, however: it depends on how soon technological obstacles are overcome, how fast competing technologies develop, and how quickly consumers embrace a new type of vehicle with an initially limited network of refueling stations.

Any significant market penetration of hydrogen vehicles in the next decade or so will require substantial, sustained, and coordinated public support. First, research and development will cost \$16 billion through 2023. About a third would be government funding of basic and applied research, with the remaining funds from the private sector. Current public-private spending for hydrogen and fuel cell R&D totals about \$1 billion per year.

Second—and far more challenging—is the need for gov-

ernment support of FCV production during the transition period, when hydrogen cars cost more than gasoline counterparts. Mass production of new vehicles is essential for lowering unit production costs, but manufacturers will not mass-produce a new vehicle unless they ultimately expect to profit. An estimated \$40 billion in government support will be required for incremental vehicle costs (e.g., vehicle purchase subsidies) until FCVs become competitive, around 2023.

An additional \$10 billion is needed to share the cost of initial investments in hydrogen infrastructure, mainly at existing gasoline stations. Longer-term investments in infrastructure would be more sizable but would be borne by the private sector as FCVs gain acceptance.

Overall, then, the total government investment needed to accelerate a transition to hydrogen cars is roughly \$55 billion over the next 15 years. This averages to \$3.7 billion per year, similar to current government subsidies for other transportation fuels, such as ethanol. Note, however, that this support for hydrogen R&D, incremental vehicle costs, and early infrastructure would not guarantee success: remaining technical and consumer acceptance hurdles must still be overcome.

Finally, to realize the long-term environmental benefits of hydrogen and reduced oil use, government policies to limit greenhouse gas emissions also are essential. These might include a carbon tax, a cap-and-trade program, or performance and portfolio standards. The point is to ensure that hydrogen is produced with minimal or no greenhouse gas emissions.

Given the uncertainties facing all automotive technologies, neither hydrogen nor any other option should be considered a “silver bullet.” A portfolio approach including sustained fuel economy improvements, a rapid phase-in of renewable bio-fuels, plus an aggressive introduction of hydrogen fuel cell vehicles could, by 2050, reduce gasoline use to virtually nothing and cut carbon emissions by 90 percent, compared with business as usual. Hydrogen would play a major role in achieving this outcome. Clearly, a wise national strategy should include vigorous support for hydrogen cars as part of a national portfolio of promising transport options.

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## 74. USEFUL LESSONS FROM CALIFORNIA'S EXPERIMENT WITH CONGESTION PRICING

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*The world's first high-occupancy toll (HOT) lane, which allows drivers of single-occupancy vehicles to pay a toll to join high-occupancy vehicles on a fast-flowing freeway lane, was introduced on SR 91 in California in 1996. This pricing policy could be a better approach than pricing all freeway lanes.*

December 2008 marked the 12th anniversary of the 91 Express Lanes, the world's first high-occupancy toll (HOT) or express toll lanes. A private consortium, operating under a 35-year concession, added four lanes to SR 91, one of Southern California's most congested freeways. Carpools with three or more passengers could use the new lanes at half price; all other cars (no trucks were allowed) would pay a toll set high enough to ensure high-volume but uncongested traffic flow at all hours.

Congestion pricing has turned out to work very well. Initially, the combination of added capacity on SR 91 and the fact that many vehicles switched to the new lanes yielded significant reductions in peak-period congestion on the regular or general purpose lanes (in addition to free-flow conditions in the express lanes). But after about five years, enormous growth in traffic in this commuter corridor led to the return of serious congestion in the general purpose lanes. The concession agreement included a rigid noncompete clause, preventing the addition of any more general purpose capacity. This was at the insistence of financiers, who saw huge risk in toll lanes that had "free" competition literally right alongside. This situation proved politically untenable, leading to the purchase of the express lanes by the Orange County Transportation Authority (OCTA) seven years after they had opened to traffic.

It was hoped by many (who didn't understand congestion pricing) and feared by others (who did) that the agency would be under irresistible political pressure to reduce the gradually escalating peak-period toll rates on the lanes. To their credit, OCTA did just the opposite. Recognizing that correct pricing was the only way the lanes could deliver the promised benefit of a reliable, uncongested trip, they depoliticized the toll-adjustment process. Planners created an algorithm that uses measured traffic density in the express lanes, hour by hour, seven days a week. For any one-hour time block during peak travel times—where set traffic conditions are at risk of becoming more congested, as measured over a 12-week period—the toll rate for that time block is increased accordingly. The adjustment process also checks for under-use and permits automatic downward adjustments.

As of this writing, the maximum morning peak toll for the express lanes is \$4.20. In the afternoon peak, when demand is much heavier, the maximum rate (for a single, one-hour period on a Friday afternoon) is \$10. For most of the weekday afternoon rush hour, tolls are in the \$5–\$9 range. The minimum charge during off-peak hours is \$1.20.

The success of the well-studied 91 Express Lanes has sparked a boom in congestion pricing, encouraged by permissive language in successive federal transportation reauthorization bills and, especially recently, by incentive programs like the U.S. Department of Transportation's Urban Partnership Agreement competition. HOT lanes are in operation in six metro areas and under development in half a dozen others. Many pricing advocates argue that while express toll lanes may be a good introductory measure, the real goal should be to price all lanes on all freeways, at least during peak periods. But recent research suggests that this may not be optimal.

Kenneth Small and others (2006) have documented the enormous variation

among different motorists in their willingness to pay for driving in high-speed lanes; in general, those with higher income or wages are willing to pay more to reduce their commute times and lower the risk of being late for work or other appointments. This variability in willingness to pay among drivers has important implications for road pricing policies. For one thing, it makes economic sense to charge different tolls on different lanes of a freeway, rather than imposing the same toll across all the lanes. Differentiated tolls allow motorists to choose which combination of low-toll/low-speed or high-toll/high-speed lanes they prefer.

Moreover, motorists who place relatively little value on travel time savings may be hit especially hard when their only choice is to drive on the freeway and pay a toll, or not use the freeway at all. In fact, a uniform toll imposed on all freeway lanes with no exemptions may actually do more economic harm overall than good, compared with a baseline situation with no freeway pricing at all. If policymakers are concerned about avoiding excessive burdens on low-income motorists, Small and his colleagues suggest that the best policy compromise might be to have freeway lane alternatives with high and low tolls, and with exemptions for high-occupancy vehicles in the low-price lane. Even in this case, the gains over simply pricing one lane and leaving the adjacent lanes free of charge may not be that great.

In related work, Elena Safirova and colleagues (2004) have studied the conversion of existing high-occupancy vehicle (HOV) lanes in the metropolitan Washington, DC, area to HOT lanes. This appears to represent a win-win policy in several respects. Drivers of single-occupant vehicles are better

off as they can now choose to drive in the faster, premium lane, if the travel time savings more than compensate them for the toll. Drivers who choose to remain on unpriced lanes adjacent to the HOT lane also benefit from reduced congestion on that lane as some drivers switch to the premium lane. And the government benefits from obtaining a new source of transportation revenue.

Based on these results, urban transportation planners should feel confident about moving forward with politically feasible plans for networks of HOT lanes, rather than holding out for the politically difficult (and socially dubious) goal of pricing all lanes.

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# 75. CONGESTION PRICING

## Lessons from London

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*London's area licensing program is arguably the most important pricing scheme to address urban traffic congestion to date. What lessons might be learned by policy-makers considering similar programs for other cities like New York?*

Congestion is steadily increasing on city streets around the world, imposing a heavy cost on urban economies that depend on rapid, reliable movement of people and goods. In the United States alone, the Texas Transportation Institute has calculated that traffic delays cost \$78 billion a year in wasted time and fuel. Taking account of the additional costs of doing business, lost productivity, and unrealized business revenue means that the overall cost of congestion is much higher, as shown in a recent study of congestion in New York City.

Theoretically, economics provides a solution: put a price on congestion paid by the people who contribute to it. There are other ways of trying to deal with congestion, such as building new roads, regulating parking, or subsidizing public transportation, each of which has its role. But only congestion pricing creates the right incentives when individuals are deciding whether, when, and how to travel. The idea has been under discussion for decades, but does it actually work in practice? Over the past several years, London has demonstrated that indeed it can.

But London's experience also makes clear the conditions that a city and its leadership must meet if congestion pricing is to be effective and, as in London, popular.

The first condition is a level of public and business concern about the costs of congestion that puts the problem well up the political agenda. By the end of the 1990s, average speeds in central London were below 10 miles per hour throughout the day and commuters into London spent almost 30 percent of their time stationary during peak periods. In public opinion surveys, public transport and congestion outranked crime as the most important problems requiring action.

Congestion pricing takes strong political leadership. Ken Livingstone, a high-profile London political figure since the 1980s, ran for mayor in 2000 on a platform that emphasized congestion charging. In the United States, New York seriously considered, though in the end rejected, a similar pricing scheme.

To maintain public support, a successful program also needs competent administration and tight enforcement. After he came into office, Livingstone spent two years on careful planning and extensive public consultation. The London Congestion Charge was designed as an area license (or "day pass") scheme. The charging zone, initially an area of eight square miles traditionally defined as central London, was almost doubled in size in early 2007, when it was extended westward to include Kensington and Chelsea. The zone is defined by a ring of roads that provide alternative routes for through traffic, at no charge. For those who cross the boundary, the cost was originally set at five pounds (about \$10) a day, with zone residents entitled to a 90 percent discount on weekly, monthly, or annual payments. In 2005, the rate was raised to eight pounds (about \$16).

The border is enforced by video cameras, which were already common in London. Concerns about civil liberties had been diminished by the cameras' effectiveness in reducing street crime. The cameras read vehicle license plates, and a computer matches them against a list of those who have paid and those exempt (which, in London, includes emergency services vehicles, taxis, buses, low-emissions vehicles, and all two-wheelers). Those who haven't paid are sent a penalty notice that includes a picture of

their car in the charging zone. The detection rate is around 90 percent, and because the minimum penalty for violation is six times the cost of compliance, evasion is unlikely to pay.

The impact of the scheme exceeded expectations. In the first year of the charge, traffic delays in London dropped by 30 percent, journey time reliability increased by 30 percent, and average speeds rose 17 percent, reflecting a sharp fall in traffic jams at intersections (the time spent traveling at speeds less than 6 miles per hour decreased by one-third). The charge also changed who was using the roads: private car trips dropped by 34 percent and trucks and vans by 5 to 7 percent, but bus, taxi, and bike trips all rose sharply. The overall impact was a noticeable improvement in traffic conditions.

The London experience has also shown that it's possible—and important—to spread the benefits of congestion pricing widely. By committing to plow all the revenues raised by the congestion charge into public transportation improvements, London has ensured that congestion pricing didn't just improve mobility for car drivers who can pay the charge (the "Lexus lanes" problem), but also increased access to the city center for everyone. Innovative policies, such as the popular mass bike-share program in Paris, can also help to spread the benefits.

In fact, the shift from cars to buses outstripped predictions. Inbound bus passenger numbers increased 37 percent in the first year, about half of whom had previously traveled by car. This increased the bus share of incoming passengers to almost 10 percent, with most of the remaining passengers split evenly between rail and subway. A key reason for the surge in bus passenger numbers appears to be the "virtuous circle" for bus transport that can result from congestion pricing (Small 2005). The higher cost of rush-hour car trips and increased bus travel speeds, due to reduced congestion, result in increasing passenger numbers and falling average costs—which, in turn, lead to improved service levels and lower fares that stimulate further

shifts to public transport and additional reductions in congestion. With one million people traveling into midtown and downtown Manhattan every day by private car, the potential for a virtuous circle in New York—should congestion pricing ultimately become a reality—is evident.

But London also offers a warning. Because congestion pricing has been more successful than Mayor Livingstone expected, it has brought in less revenue—a problem that was compounded by setup and running costs that far exceeded expectations. Tight control of costs is essential if the increased investment in mass transit and other transport alternatives necessary to make the scheme successful are to prove sustainable.

The central lesson of London's great experiment appears to be that congestion pricing will get and keep public support only if it is part of a larger congestion management strategy that improves public transportation. And it will work only if the impact of the scheme is highly visible and the benefits are spread widely.

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## 76. HAS THE TIME COME FOR TRUCK-ONLY TOLL LANES?

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*Policymakers are increasingly interested in the idea of charging heavy-duty trucks by the mile for road use. What are the pros and cons of these types of tolls, and should trucks have their own freeway lanes?*

Traffic congestion imposes a direct cost on U.S. freight transporters of \$7.8 billion per year, according to the Federal Highway Administration. Recurring bottlenecks accounted for about 40 percent of total delays; the rest can be attributed to random sources of congestion such as accidents and roadwork, which upset delivery schedules and inflict a higher cost per hour of delay than recurring congestion. Truck traffic is growing more quickly than light-vehicle traffic, and trucking is expected to remain the dominant mode of freight transport. Is it time for dedicated truck-only toll lanes?

The potential advantages of truck facilities have not gone unnoticed. Proposals for truck-only toll lanes or truck tollways have appeared in California, Florida, Georgia, Texas, and Virginia. In 2002, Texas developed a plan to build a 4,000-mile Trans-Texas Corridor comprising rail lines, utility right-of-ways, and highways with separate toll lanes for trucks and passenger vehicles. However, in the face of stiff opposition from environmentalists and private landowners, the project has been scaled back. Another proposed project, the I-70 corridor, would span Missouri, Illinois, Indiana, and Ohio. Truck-only corridors connecting the United States and Canada, and truck-only road networks in Britain, Italy, and the Netherlands have also been studied.

### POTENTIAL BENEFITS AND DISADVANTAGES

Dedicated truck-only facilities have several potential benefits. By adding road capacity, new facilities will relieve congestion and make deliveries quicker and more predictable. And by drawing trucks off existing roads, light vehicles will benefit too. Segregating light and heavy vehicles on existing roads could facilitate traffic because they differ in size, acceleration, and maneuverability and therefore get in each other's way. However, on multilane highways without barrier separation, there are trade-offs among average speed, lane speed differentials, frequency of lane changes, and fuel consumption.

Similar considerations determine whether segregating cars and trucks would reduce accidents. Overall accident rates per vehicle mile traveled are lower for trucks than cars, because professional truckers tend to be better drivers, and the actions of truckers are easier to predict than those of "four-wheelers." However, the risk of a fatality is greater in multivehicle accidents involving trucks, and these fatality risks are primarily borne by light-vehicle occupants. Surveys indicate that car drivers would be willing to pay to avoid sharing the road with trucks.

Truck-only toll facilities also generate revenue, which is becoming a priority for building new capacity and rehabilitating existing roads as the Federal Highway Trust Fund goes into deficit. A final and potentially significant advantage from building dedicated truck facilities is that it could reduce long-run infrastructure costs. Trucks require higher road-design standards than do light vehicles. By restricting trucks to part of the road network, the remainder could be built to a lower standard. (For example, lanes could be restriped from 12 feet to 10 or 11 feet, increasing capacity if additional lanes can be squeezed in on urban expressways.)

Obviously, truck-only facilities also have disadvantages. Building new infrastructure is expensive, and continuous rights-of-way may be unavailable. It is impractical—if not impossible—to segregate cars and trucks on all roads leading to and from dedicated

truck facilities. Perhaps most important, because capacity is imperfectly divisible, it is not generally possible to allocate it between light and heavy vehicles in ideal proportions. Even a single dedicated truck lane is not cost-effective if trucks comprise a small fraction of traffic.

## ACCESS RESTRICTIONS AND TOLLS

Truck-only toll facilities embody access restrictions and tolls. To understand their respective roles, it is useful to consider a simple road network. The corridor in which truck-only facilities can be established comprises two parts, “road 1” and “road 2,” each consisting of either a separate right-of-way or one or more traffic lanes (possibly barrier separated) of the same highway. Road 1 has a greater capacity than road 2. There are also untolled alternative routes that may not be designed to handle heavy vehicles.

Access restrictions and tolls can be used to pursue three goals:

- to distribute light and heavy vehicles (henceforth “lights” and “heavies”) that use the corridor efficiently between road 1 and road 2,
- to distribute lights and heavies between the corridor and alternative routes, and
- to generate revenue.

These goals may be at odds; for example, imposing high tolls on the corridor to generate lots of revenue may increase congestion on alternative routes. Even in this simple setting there are many options. Lights and heavies can each be allowed to use both roads or be restricted to one. And tolls may or may not be levied on each vehicle type on each road. Access restrictions alone generally do not meet any of the three goals because they do not generate revenue and they are an imperfect instrument for allocating traffic between the corridor and alternative routes. They allocate traffic efficiently within the corridor only if it is optimal to segregate lights and heavies onto separate roads. Heavies can be allocated to either road 1 or road 2, but in either case, road capacities are unlikely to be ideally proportioned to handle the equilibrium volumes of lights and heavies.

Tolls, on the other hand, do generate revenue, although it may fall short of paying the full capital cost of new infrastructure. Tolls are also more effective than access restrictions because they offer a continuous, rather than discrete, degree of control. But they do have limitations. Tolls cannot influence all margins of driver behavior such as weaving between lanes and driving speed. And shippers may impose constraints on delivery times that prevent truckers from shifting to off-peak hours in response to peak-period tolls.

Light and heavy vehicles differ in characteristics such as size, weight, safety, and emissions, and so to price road use efficiently, tolls have to be differentiated by vehicle type and route. Today, tolls can be differentiated by number of axles. Technological advances may soon permit tolls to be set in real time according to vehicle or axle weight, emissions, and other characteristics of the vehicle or driver.

## PROSPECTS

Assessing the merits of truck-only toll facilities is challenging. For new facilities, there are many design considerations: location, length, numbers of lanes and lane width, pavement thickness, entrances and exits, speed limits, services such as truck stops and refueling stations, and so on. Owner-operators and private carriers differ in the values they place on travel time and reliability and have shown different propensities to use toll roads. Toll road volumes have often been overestimated, sometimes by wide margins. Much of the trucking industry remains skeptical of road pricing as a way to relieve congestion and finance transportation infrastructure.

Nevertheless, the long-term outlook for truck-only toll facilities appears promising. Transportation planners are grappling with growing funding shortfalls for highway spending caused by improving vehicle fuel economy and the erosion of real fuel tax rates due to inflation. Truck-only toll lanes offer a new revenue source, while also complementing the increasing interest in charging motorists by the mile through GPS or other electronic metering, to better address the broader social costs of transportation from congestion, pollution, and accidents.

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## 77. USING THE PRICE SYSTEM TO REDUCE AIRPORT CONGESTION

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*Flight delays are increasingly common as growth in demand for air travel outpaces airport capacity expansion. How might pricing policies address airport congestion, and to what extent, if any, should fees be adjusted when hub airports are dominated by one carrier with market power?*

Driven by the growth in demand for air transportation, flight volumes at many major U.S. airports have increased sharply in recent years. Since the flight capacity of airports has hardly changed, the increase in traffic volume has led to more and longer delays, a trend well documented in newspaper stories and the evening news. In 2007, 24 percent of flights arrived late, up from 15 percent in 2003.

What measures are appropriate for handling airport congestion? Building more capacity is one option, and some capacity expansion will surely be needed despite its high cost as traffic expands. Another response is to cut flight volumes through direct government intervention in airline scheduling decisions, as the Federal Aviation Administration (FAA) did at Chicago's O'Hare Airport. A more systematic approach relies on a "slot" system, where airlines cannot schedule flights as they please but must instead acquire landing or takeoff slots, issued by the airport, in order to operate. Such a system of "slot constraints" has been used at four major U.S. airports and is de rigueur in Europe.

A problem with such quantity controls is that, while they may relieve congestion, they do not guarantee that the available slots are used for the best purposes. For example, airlines may use peak-hour slots to operate smaller aircraft than would be desirable. While slot trading among airlines helps to achieve the highest and best use of slots, frictions in the trading process may still leave room for inefficiencies.

A better way to ensure efficient use of scarce runway capacity is to rely on the most basic economic pricing principle: make airlines pay the marginal cost of using a congested airport. If an airline decides to land under congested conditions, it incurs extra operating costs while subjecting its passengers to additional time costs, and it will take both of these costs into account. But the presence of congestion means the extra flight also increases operating and time costs for all other flights using the airport, and these impacts are also part of marginal cost. A condition for efficient use of congested runway capacity is that the full marginal cost, including the cost imposed on other airlines, must be internalized (taken into account) by the carriers.

But would an airline in fact internalize these costs in deciding whether to operate an extra flight? This question has been much debated among airline economists, leading to the usual answer: it depends. If each airline serving the airport has a relatively large presence, operating a substantial number of flights, then each carrier will understand that its scheduling decisions affect the overall level of congestion. Moreover, carriers will play a scheduling game with one another, with each airline setting its flight volumes to maximize profit, taking account of airport congestion as well as scheduling choices of the other carriers. In this situation, each airline will partially internalize congestion, taking into account the congestion it imposes on itself (additional delays for all its other flights) in deciding whether to schedule an extra flight. However, since the airline will ignore the congestion imposed on other carriers, marginal costs are only partially internalized.

The answer to the internalization question is even less favorable when the big players at the congested airport coexist with a competitive fringe, a collection of air-

lines that individually operate only a few flights. These airlines could be carriers that are large overall but only have a small presence at the congested airport. Rather than being equal players, the fringe carriers follow the lead of the big airlines, adjusting to their behavior while having no individual impact on the overall level of congestion.

In the presence of a competitive fringe, partial internalization of congestion is eliminated. If large carriers restrict their flight volumes to limit self-imposed congestion, the fringe carriers would simply fill the gap, leaving overall congestion unchanged. Therefore, each big carrier's incentive to take account of self-imposed congestion is neutralized, and partial internalization disappears. The FAA observed exactly this kind of "gap-filling" behavior after persuading United and American Airlines to cut their flight volumes at O'Hare Airport.

Since internalization of congestion is either partial or non-existent in these two cases, policy intervention is required. Congestion pricing, which makes airlines pay for the congestion they fail to internalize, is an attractive option. Daniel (1995) calculated congestion charges for the Minneapolis–St. Paul airport, assuming that the competitive-fringe model (and the absence of internalization) is realistic. He found that the congestion charge for each flight should equal about \$1,000 (in 2007 dollars) on average during the day. But once the charges have had their intended effect of reducing congestion by shifting flights to off-peak hours, the average charge would fall to approximately \$360. With partial internalization, con-

gestion charges would have somewhat smaller magnitudes. But regardless of which case applies, some level of congestion pricing would be required at most large airports.

Unlike pouring concrete for more runways, congestion pricing is virtually costless to implement, and by reducing peak traffic volumes, it will make our airports seem magically larger. While airlines strongly oppose congestion pricing, the industry seems not to recognize that congestion charges can replace the current weight-based system of landing fees. With fees dropping to zero in off-peak hours, reflecting the absence of congestion, the carriers' overall costs need not rise by much. In any case, peak-hour congestion charges are likely to be passed on to passengers, widening the current differential between peak and off-peak fares and generating the traffic shift toward less-congested hours.

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## 78. DELAYED

### Is Privatizing America's Airports the Answer?

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*The United States relies on public ownership and heavy regulation of its airports and air traffic control system to address flight delays, carrier competition, and airline safety. How might steps to liberalize this regulatory system help passengers get to their destinations at lower cost and with fewer delays?*

We all know the personal cost of flight delays and airport security: the missed connections, the hassle of going through screening, the annoyance of having to show up so far in advance of the scheduled departure time. In aggregate, in the United States alone, those costs are estimated at \$40 billion annually. Meanwhile, ticket prices keep rising, and periodic reports of breaches of security—the grad student whose fake boarding pass goes undetected, the planted weapons that screeners don't see—undermine public confidence in the system. Is there a remedy?

Air travelers seek value—convenience, price, and safety. In theory, aviation infrastructure policy should reduce travel delays, facilitate competition, and keep flying safe, all at the least possible cost. What we see instead is the failure of publicly owned and managed airports and the federal air traffic control system to introduce innovation—a failure that arises from the paucity of economic incentives and the multitude of institutional and political constraints. Certainly there are lessons to be learned from the efforts of other countries to restructure their airport systems to better address these issues.

The key to reducing delays efficiently is to rid the system of its major inefficiencies and to institute policies that enhance airline system performance:

- Air travel could be safer and faster if ground-based radar systems were replaced with more accurate satellite communications. Travel time would be reduced because planes could fly closer together and take the most direct routes.
- The price of air traffic control services should reflect the marginal costs that a given flight imposes on the system, including delay costs to other users. The current ticket tax that funds air traffic control, however, bears little relationship to those costs and therefore does not reduce congestion.
- Runway pricing should be based on an aircraft's contribution to congestion instead of on its weight or arbitrary quantity controls, like takeoff and landing slots. Replacing inefficient administrative solutions with a potentially efficient market solution would redistribute traffic both temporally and spatially, reducing delays.
- Funding for new runways and terminals should be based on market-derived, rational assessments of which airports would benefit most from additional runway investment, rather than determined by political forces.
- Service could improve and fares fall if restrictions that prevent carriers from using certain airports or gates were removed. Travelers are worse off when incumbent carriers are permitted to slot new entrants into gates only at inconvenient times and locations or at excessive cost, or are able to prevent them from gaining access to gates altogether.
- Innovative solutions to thwarting terrorism may exist but are not likely to emerge in a government bureaucracy like the Transportation Security Administration. Israel has prevented problems by identifying suspicious passengers, for example, and private security firms provide effective but subtle security for millions in the Las Vegas casinos. One very cost-effective approach in aviation was installing bulletproof cockpit doors, which the airline industry did for a mere \$500 million.

Although air travelers are painfully aware of the suboptimal service provided by U.S. aviation infrastructure facilities, regulations and political forces have made reform extremely difficult. The Federal Aviation Administration lacks organizational independence and is prevented by Congress and the administration from using its resources more efficiently. Peak-period pricing for air traffic control, for example, was blocked by pressure from owners of corporate jets. Political pressure is, in fact, the primary cause of misallocated FAA expenditures, and ineffective management is impeding development and implementation of the satellite tracking system, which will consolidate air traffic control facilities. Any effort to replace current funding mechanisms is seen as the first step to taking air traffic control out of the congressional funding process—and taking power away from lawmakers.

Predictions of continued growth in air travel make innovation imperative, but improvements won't happen under the current system: only privatization of the nation's aviation infrastructure is likely to result in constructive reform. Operating in a more competitive environment, privatized airports and air traffic control would have incentives to improve service and reduce the cost of operations while maintaining the nation's outstanding safety record. Privatized airports could even facilitate greater competition among airlines that would lead to lower fares.

Though privatization may appear a drastic and potentially risky solution, examples from other countries already exist—right next door, even. To increase investment in airport infrastructure without government funding, Canada quasi-privatized its airports in the mid-1980s and transferred them to locally based, not-for-profit authorities. The country's biggest

airports then built additional runways and terminals, thereby reducing congestion.

Australia and New Zealand began privatizing their major airports in the late 1990s, specifically to sharpen incentives for efficiency, and lightened their regulation. Today, the prices charged to airlines are high but well below monopoly levels, and the airports are considered to perform well.

The United Kingdom's airport infrastructure is now mainly private. Although regulatory burdens persist, air traffic control services are provided by a public-private organization that took over from a public agency in 2001.

China went from a paramilitary organization to a system of local control of airports, a liberalization that contributed to dramatic growth in air traffic, raised airline productivity, heightened competition, improved air safety, and increased investment in infrastructure.

None of those systems work perfectly, but the examples prove that far from having an adverse effect on aviation system performance, privatization has much to offer. Taken together, the experiences of other countries are a playbook of potential solutions that U.S. policymakers can adapt to American circumstances. Just ask any road warrior: anything that promises better value in air travel—more convenience, lower prices, and an even higher level of safety—is worth a look.

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## 79. TELECOMMUTING

### What Is It Good For?

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*Telecommuting has never really fulfilled the hopes of its early advocates. Why has it been slow to catch on, and how might it potentially help alleviate pollution and congestion? Should the government sponsor programs to promote telecommuting?*

When the phenomenon of telecommuting appeared on the horizon in the 1970s, it seemed to be a godsent panacea. For employees, it promised more time to spend with their families and lower commuting costs. For employers, it dangled the reduction of real estate costs and utility bills and an ability to retain and recruit better employees by using the telecommuting option as a fringe benefit. For society as a whole, telework promised reduced auto trips, less road congestion, lower energy consumption, and cleaner air. Telecommuting seemed to be a win-win solution to everybody, and all it required was a steady growth in information-type jobs and perhaps better phone lines. According to some estimates, by the year 2000, 50 percent of the U.S. workforce was supposed to telecommute. And all that government seemingly had to do was educate both employers and workers about telework and its benefits.

Fast forward to the 21st century. Although the percentage of workers who telecommute has been steadily increasing, it is way lower than what was predicted in the 1970s (according to different estimates, anywhere between 10 and 45 million of U.S. workers telecommute at least once a year, but only a small fraction telecommute at least once a week). At the same time, information technology has undergone significant transformation and is now far more advanced than in the wildest futuristic dreams of the past decades.

#### LIMITATIONS TO TELECOMMUTING

It turns out that the great virtues of telecommuting are often offset by less desirable features. Combining telecommuting and caring for small children at home frequently proved to be impractical and was opposed by most employers. For some employees, telecommuting removed the boundary between work and leisure and increased work stress levels. For others, telecommuting has led to feelings of isolation and lack of social interaction with coworkers. Last but not least, telecommuting tends to reduce workers' visibility in the organization and is likely to decrease their promotion potential.

Employers also found that managing a telecommuting workforce can be quite challenging, especially when worker productivity is hard to measure. When a telecommuter works at home once a week or less, realizing sizable real-estate and utility savings turned out to be quite hard. Also, institutional implementation of telecommuting programs and resolving issues related to workplace safety at home place additional burdens on employers and make promoting telecommuting much less attractive.

Finally, the benefits for the society as a whole don't seem to be as desirable as hoped for. My early research has shown that in the long run, the presence of telecommuting options is likely to make our metro areas larger and more congested than before. In essence, there is an "induced demand" effect—when an opportunity to telecommute arrives and some workers in the metro area start telecommuting, roads become less congested and attract new workers to the urban area until congestion climbs up to the original levels again. Just as we cannot build our way out of road congestion, we cannot telecommute our way out of it either.

Although in the long run, the prospects for telecommuting to reduce traffic

congestion are bleak, in the short run there could be some room for reduction in vehicle miles traveled (VMT), traffic congestion, and air quality. That said, the exact environmental and transportation benefits of telecommuting remain an open question. For one thing, research studies have shown that when telecommuters work at home, they are more likely to make more nonwork trips, thus eroding overall VMT reductions. Also, our research has demonstrated that telecommuters are more likely to drive newer cars than the population in general, and therefore emissions reductions from reduced commuting would be lower than expected.

## GOVERNMENT INITIATIVES TO PROMOTE TELECOMMUTING

Although the majority of U.S. states have some policy regarding telecommuting, most of them concern either provision of information and educational resources to employers interested in starting telecommuting programs or telecommuting programs for state employees. With a few exceptions, such as the Oregon Department of Energy program that offers tax credits to employers with significant percentage of telecommuting workers, states do not provide additional incentives for telecommuting.

For metropolitan planning organizations (MPOs), the goal of most telecommuting initiatives these days is not fighting congestion, but improving air quality, especially in the areas of nonattainment. Many MPOs assume that some fraction of employees in their area will work from home a certain number of days per week, thus reducing the number of work trips and attained emissions. However, the U.S. Department of Transportation recently announced its new comprehensive national strategy to reduce congestion on the nation's roads. Metropolitan areas would commit to pursuit of aggressive strategies under the umbrella of "Four Ts"—tolling, transit, telecommuting, and technology. The goal is to use all strategies simultaneously to achieve the best results. How well these various measures work together is not well understood; for example, promoting telecommuting can potentially undermine other alternatives, such as public transit and carpools, and vice versa.

The most recent attempt to institute national telecommuting policy occurred in the spring of 2009, when the Telework Improvement Act of 2009 (HR 1722) was introduced in the House of Representatives. The bill would require govern-

ment agencies to develop a program allowing employees to telework at least 20 percent of every two-week work period. A counterpart bill in the Senate, the Telework Enhancement Act (S 707), has won the approval of the Senate Homeland Security and Governmental Affairs Committee in May 2009, but is still pending. Unlike other policy attempts, the telework bill is driven more by national security concerns than by transportation and environmental goals and affects only federal employees.

At the same time, in order to promote telecommuting, a dedicated telecommuting policy is only one strategy among many. People's propensity to telecommute very much depends on their industry and type of work, and therefore targeting particular industries may be a better strategy. Because many telecommuters depend on communications technology that allows them to move large amounts of data between home and office, a national broadband policy would increase Internet capacity and therefore also boost telework. Telecommuting also rises with education level, and so government policies that encourage higher education, such as student loan programs, could have a corollary effect here as well.

Should the government be encouraging telecommuting through these types of programs? Although we lack the evidence to answer this question definitively, any transportation benefits from telecommuting policies are probably modest at best. If local governments are serious about reducing urban traffic congestion, there is no way around an inconvenient truth: the most effective way to do it is to charge motorists for using scarce road space during rush hour.

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## 80. DECLINING TRAFFIC FATALITIES

### Lessons for Developing Countries?

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*As countries have developed over time, they have experienced a pattern of initially rising, then peaking, then declining traffic fatality rates. What might be some possible explanations for the downturn in fatalities, and what are the lessons for poor countries currently in the stage of rising accident risks?*

As industrial countries have developed over time, there has been a clear inverted-U relation between the incidence of traffic fatalities and per capita income (a similar pattern is often observed between pollution and per capita income). The initial, positive association between fatality rates and development is straightforward to explain—as motorization takes off, more pedestrians become exposed to the risk of being hit, while occupants of one vehicle are more likely to be involved in a collision as the number of other vehicles on the road rises. What causes the fatality rate to income relation to peak, and then trend downward, is more complex. It is due, in part, to a decline in pedestrian fatalities as pedestrians become vehicle occupants, but decreases in occupant fatalities are likely to require deliberate, safety-focused policies. A better understanding of what has caused the traffic fatality rate to decline in developed countries could provide important lessons for the design of effective auto safety policies in developing countries.

#### TRAFFIC FATALITY PATTERNS IN INDUSTRIAL COUNTRIES

We examined traffic fatality patterns among 32 high-income countries using the International Road Traffic Accident Database (IRTAD). Between 1970 and 1999, total traffic fatalities declined by an average of 35 percent among these countries. The decline in fatalities was most dramatic for pedestrians and cyclists, for whom the average fatality rate (i.e., fatalities per capita) fell some 60 percent, compared with a decline in vehicle occupant fatalities of 21 percent. These trends are even more striking given that vehicle kilometers traveled (VKT) increased by about 250 percent over the period. Thus, pedestrian fatalities per VKT declined 86 percent on average, while occupant fatalities per VKT declined by 76 percent.

#### EXPLAINING THE TRENDS

To explain why these trends occurred, we began by examining the relationship between fatalities and per capita income. A striking fact is that although pedestrian fatalities per capita and per VKT declined as per capita income increased within these countries, there was no significant relationship between occupant fatalities and per capita income. This suggests that reductions in occupant fatalities do not automatically accompany increases in income. What does explain the decline in occupant fatality risk? To answer this question, we examined, in addition to income, the impact of demographic factors, the number of motor vehicles and length of roads, a measure of alcohol abuse, and the availability of medical services on occupant and pedestrian fatality risks.

Demographic factors appear to be especially important: young drivers are likely to be less skilled, less experienced, and less averse to risk, while older drivers have more experience and perhaps drive more carefully (though an offsetting factor is that they may have a slower reaction time to an imminent collision). In fact, we found strong evidence that the share of drivers under the age of 24, which declined by 20 to 40

percent between 1970 and 1999, was negatively associated with occupant fatality risk. This demographic trend alone could account for nearly 30 percent of the decline in occupant fatalities. We also found that the decrease in the share of under age 24 drivers reduced pedestrian fatality risk. On the other hand, an increase in the share of drivers aged 65 and over significantly raised pedestrians' fatality risk, as did the share of the population living in urban areas.

Rising vehicle ownership rates affect fatality risk in a variety of ways. Occupant fatality rates per VKT initially increase as more vehicles on the road raise accident frequencies. However, the faster the fleet grows, the higher the proportion of recent models equipped with advanced safety features, which causes the occupant fatality rate per VKT to decline. Initially, pedestrian fatality rates rise as motorization takes off; however, this trend peaks and then reverses as the share of pedestrian trips in total travel trips declines.

Expanding the total capacity of the road system network over time (for a given vehicle fleet size) reduces occupant fatality risk, as collisions are less frequent when cars have more space. The effect is especially pronounced for pedestrians, perhaps because larger road networks include more motorways that separate vehicles from foot traffic. However, an offsetting effect is that road improvements (e.g., additional lanes, wider lanes) may encourage more risky driving behavior, leading to an increase in collision frequency.

Alcohol abuse (as proxied by a country's incidence of liver disease) is positively correlated with occupant deaths per VKT. Over the study period, the liver disease death rate decreased substantially (by 30 to 60 percent) in the United States and many European countries. These reductions in alcohol abuse contributed to about a 6 percent decline in occupants' fatality rates. Alcohol abuse has an effect that is twice as large for pedestrians as for vehicle occupants. This likely reflects not only drunk driving but also risky behavior by pedestrians under the influence. Changes in alcohol use contributed to nearly a 10 percent decline in pedestrian deaths per VKT.

Finally, increases in the availability of emergency medical care services (as measured by physicians per capita) significantly decreased occupants' fatality risk, but had no statistically significant effect on pedestrians' fatality risk. No matter

how quickly accident victims are rushed to the hospital, it seems, the likelihood of death is higher for pedestrians than for vehicle occupants.

## POLICY IMPLICATIONS

Our study was limited to 32 high-income countries for which we had reliable data. We believe, however, that the findings are relevant to developing countries, whose per capita incomes today are comparable to those of the poorest IRTAD countries 40 years ago. Their patterns of traffic fatalities—in particular, the high rate of pedestrian fatalities—also recall the former situation for industrialized countries.

The decline in the road death rate in industrialized countries is attributable largely to a decline in pedestrians' death rate. It appears that this decline can be attributed to increased motorization and a smaller proportion of young drivers. The factors that best explain the decline in occupant fatalities per VKT are reductions in alcohol abuse, improved medical services, and a shrinking of the young driver population.

Reductions in alcohol abuse and improved medical services are clearly the result of explicit resource allocation decisions. The importance of the demographic factor suggests that in countries where young people constitute an increasing share of the driving population, policies to improve young driver education and reduce speeds will be crucial.

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# 81. PRESERVATION AND DEVELOPMENT

## Can TDRs Improve Land Markets?

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*As expanding population and real income fueled demand for ever greater residential development, in many cases this has led to excessive loss of open space, as developers lacked incentives to account for lost habitat, scenic views, and other natural amenities. Transfer of development rights (TDR) programs offer some hope for striking a balance between development and conservation.*

Conflicts over private and public uses of land have long been part of our history. Private land can provide myriad public benefits—such as habitat for wildlife, scenic views, and preservation of sensitive environmental resources—that are not likely to be fully valued by private landowners. Consequently, some land will be developed that should be preserved. Designing and implementing cost-effective policies to remedy this problem can be difficult.

In private land markets, owners have the right to subdivide and develop land, subject to zoning rules established by local governments that typically limit the number of dwelling units that can be built per acre of land. Some communities have tried tightening these density limits to very low levels, such as one dwelling unit per 25 or 50 acres, as a way to limit development and preserve open space. Purchase of development rights (PDR) programs is another option in which the government uses tax revenue to purchase and retire the development rights to particular parcels of land.

A private market-based alternative is known as a transfer of development rights (TDR) program. Property owners are able to sell their development rights to, most commonly, a developer, who then uses them to build in a different location. The land from which the development rights are sold is preserved from development with an easement or restrictive covenant; the land on which the rights are used is developed more densely than would otherwise be allowed.

TDRs offer several advantages. Because they are voluntary, landowners have more flexibility compared to strict mandates or changes in zoning rules. They can also be used in conjunction with downzoning—that is, reducing the number of dwelling units per acre—to compensate landowners for any lost development potential from such reductions. Another political advantage is that TDR transfers occur through a private market, and therefore no tax dollars are needed for ensuring that land is preserved. And finally, TDRs can achieve land preservation, while still accommodating growth in the region.

Current TDR programs vary widely in their designs, objectives, and outcomes. Many are designed to preserve farmland, but some attempt to protect environmentally sensitive lands and habitat. Still others have “smart growth,” or antisprawl, objectives—namely, to preserve open space and channel development toward more compact, urbanized areas with existing infrastructure. Over 140 jurisdictions around the country have TDR programs on the books.

TDRs sound relatively simple on paper—density is transferred from one property to another—but in practice, they can be quite complicated. The programs create a market for development rights, and many things can affect the profitability of buying and selling those rights. For example, local governments must determine which areas of the community are allowed to sell TDRs and which are allowed to use them to develop more densely, how densely the “receiving areas” can be developed, how trades occur in the marketplace, and the kind of mechanism by which transfers are approved. The underlying zoning in both the “sending” and “receiving” areas, as well as land

values when developed or used otherwise, will influence how well a TDR market works.

A continuing problem in many programs lies on the demand side of the market. Many jurisdictions allow TDRs to be used to increase density only in established urbanized areas and town centers. However, this outcome is difficult to achieve in many communities; possible reasons why include a lack of demand for higher density and opposition by existing residents to more development. Most of the programs where demand has been strong have allowed TDR use in relatively low-density, or less developed, zones.

## WHAT WORKS?

A very small number of programs have effectively created a working TDR market over time and have achieved local land preservation goals. The two programs that are perhaps the most long-running and successful in the country are in Maryland, in Calvert and Montgomery Counties. Although both have focused on protecting farmland, their approaches have been quite different. Both programs were initiated in about 1980, and since that time, the Montgomery County program has protected about 49,000 acres and the Calvert program about 13,000 acres. (Montgomery County is nearly two and a half times the size of Calvert County.)

The Calvert program is unique in that it allowed the additional density from TDR sales to be placed in many different areas, including town centers, residential zones, and even some rural areas. Moreover, it allowed landowners in some of the rural areas to either sell their development rights and preserve their land or use development rights purchased from elsewhere to develop more densely. This overlap in sending and receiving areas is highly unusual in TDR programs and makes the Calvert program one of the most flexible and least restrictive programs in existence.

The Montgomery County program, in contrast, downzoned one 90,000-acre area of farmland in the western part of the county, and the development rights that were taken

away by the downzoning were allowed to be transferred to other areas that were designated for higher density. The receiving areas were all designated in residential areas, but as in Calvert County, the TDRs that were actually used tended to go into the relatively lower-density areas. The Montgomery program is often held up as the best example of a successful program, but it is important to understand the key role played by the downzoning: without the option to use the development rights on their properties anymore, landowners in the sending area were obviously quite willing to sell.

TDRs cannot be expected to achieve all of a community's land-use goals. They work best when used in conjunction with other policies, such as PDRs, land purchase programs for public open space, and zoning. TDRs can help attain land preservation goals at little public cost, but targeting particular properties for preservation with TDRs is difficult as the programs are voluntary. TDR programs also retain land in private ownership and are thus not a substitute for public lands such as parks and recreation areas. Communities would benefit from considering a well-designed and implemented TDR program as one important component of an overall approach to land-use policy.

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## 82. IS THERE AN “EFFICIENT” WAY TO ADDRESS SUBURBAN SPRAWL?

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*Development fees are potentially the best policy to curb excessive urban sprawl from the standpoint of economic efficiency. However, for practical purposes, they are also one of the more challenging policies to implement.*

The predominant pattern of urban growth in the United States over the past half century has been one of low density and employment decentralization that has yielded excessive amounts of sprawl, certainly from an economist’s point of view. To begin with, developers do not take into account the societal losses from the irreversible paving over of large open spaces at the urban fringe. These include the aesthetic benefits existing residents might otherwise enjoy from unspoiled views of rolling farmland, and the possible loss of ecosystems and natural habitat. Also, developers do not consider the broader societal costs of decaying inner cities (such as crime and run-down communities) caused by the flight to the suburbs.

As cities spread out, commutes get longer, leading to more traffic congestion and pollution. This would not be a problem if drivers were fully charged for their contribution to congestion and pollution through, for example, road pricing schemes, but such comprehensive pricing policies are a long way off. Moreover, urban development is frequently subsidized—typically developers do not pay for the infrastructure costs (schools, roads, sewers, and other public services) needed to accommodate residential development. Other policies, such as zoning restrictions requiring minimum lot sizes at the urban fringe may further, exacerbate the problem.

Concern about urban sprawl has led to a variety of “smart growth” initiatives including, for example, urban growth boundaries and other regulations (such as conservation easements, transferable development rights, and designation of priority funding areas) designed to limit expansion of the urban fringe. An alternative approach emphasizes pricing instruments, such as taxes on residential development and property. So how should policymakers choose among these alternatives?

### PROMOTING EFFICIENT DEVELOPMENT

In terms of economic efficiency, an ideal policy instrument would trade off the benefits of land preservation at the urban fringe with the costs in terms of reducing the availability of housing, and producing denser, or more clustered, housing than residents would otherwise prefer. In principle, a tax per unit of land developed could achieve this efficient outcome, by reflecting the full costs of development in the prices of new, suburban housing lots. It would be feasible to approximately measure infrastructure costs and the costs of congestion and pollution from additional driving that should be included in the tax. Even the value of open space might be incorporated into the tax, based on studies that estimate how much extra people are willing to pay for houses in close proximity to open space amenities.

Property taxes would still be inferior to development taxes, even if it were feasible to impose differentially higher property tax rates for housing units at the urban fringe. The key problem with property taxes is that they penalize capital, or housing value, in addition to land. This creates an incentive for lower-density development, which partly undermines attempts to limit urban sprawl. Due to this perverse effect, in work with Sofia Franco and Daniel Kaffine (2006), we found that the economically efficient amount of open space preserved under property taxes is only a minor fraction of the amount that would be saved under an efficient system of development fees.

In principle, urban growth boundaries can be designed to mimic the effects of development taxes. However, this requires knowledge of how much land would be saved under the ideal tax, which is very difficult to gauge in advance.

Moreover, another difference is that development taxes generate revenues that can be recycled in ways to improve the efficiency of the local economy. For example, revenues can be used to fund city-center revitalization programs, which in turn helps to lessen pressure for land conversion at the fringe due to flight to the suburbs. Revenues might also be used to purchase conservation easements that could permanently save large open spaces at the fringe. Additionally, they can be used to cut the rate of preexisting property taxes, thus promoting density over land expansion.

### **PRACTICAL OBSTACLES TO EFFICIENT PRICING**

On paper, development fees seem like the most efficient solution, but there are definite obstacles to putting them into practice. First, the distributional burden borne by developers is greater under the development tax than under the urban growth boundary. The development fee essentially penalizes all developers and subsidizes agricultural landowners. In contrast, an urban growth boundary only penalizes those developers at the fringe that would have converted the land in the absence of this policy. As a result, urban growth boundaries seem to get substantially more political support. Indeed, several communities throughout the United States have implemented urban boundaries, while very few have implemented development fees.

Second, successful implementation of development fees may require coordination among different governments. Currently, most smart growth programs are implemented by local governments, typically cities and counties. However, there is a concern that such programs could actually exacerbate suburban sprawl because communities can use urban growth boundaries almost as an exclusionary zoning restriction. As a consequence, housing prices tend to increase and push individuals to bedroom communities that are often located farther away from their place of work. In this case, smart growth can have a perverse effect by displacing and reallocating growth in ways that exacerbate sprawl and traffic congestion.

Coordination across local governments, to prevent spillover effects from displacing and reallocating growth across neighboring communities, is potentially important. However, this metropolitan-wide approach to managing urban growth will require local governments to, in part, give up some of their power to regulate land use as well as some of the fiscal benefits that can come with some land-use choices. Not surprisingly, this may be the greatest obstacle of all in controlling sprawl.

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