How Efficient Is Current Infrastructure Spending and Pricing?

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Congested highways and airports, collapsing bridges, deteriorating roads, periodic water shortages, and suspect waste disposal facilities bear silent witness that the infrastructure of our nation, currently valued at close to $1 trillion, is inadequate. To shore up America's foundations, many economists and policy analysts have urged the federal government to increase spending substantially. The urgency of the problem, however, does not preclude the need to ask whether the current use of facilities is efficient, whether choices about how current facilities are used are possible, and how current use will affect the efficiency of new facilities. In fact, surprisingly large benefits are to be gained from making efficient use of our current infrastructure by pricing it and investing in it efficiently. Efficient pricing and investment will reduce the need for massive public investment and will prevent the recurrence of infrastructure problems. The primary reason why the current facilities are gravely deficient is that they are priced in ways that do not reflect economic costs and designed in ways that result in higher life-cycle costs of use.

In their anxiety to address the infrastructure problem, policymakers are pushing policies that, if adopted, would indefinitely foreclose consideration of efficient pricing and investment. Congressional renewal of the gas tax in 1991, for example, would perpetuate a method of

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charging trucks for interstate highway use that could foreclose consideration of the far more efficient cost-based, axle-weight charge for nearly a decade. It is therefore crucial for policymakers to consider more efficient infrastructure policy before the window of opportunity is closed.

The Theory of Efficient Infrastructure Policy

The nation's infrastructure assets consist primarily of highways, airports, transit stock, water resources, and water supply and waste disposal facilities. At a valuation of nearly half a trillion dollars, highways account for more than half of these assets. Infrastructure supports a community's basic activities and any expansion of them. Putting it slightly more technically and in a transportation context, infrastructure provides *capacity*, in the form of traffic lanes and runways, as well as *durability*, in the form of thick pavement. Users of the infrastructure impose costs on themselves and others by contributing to congestion, which increases travel time, and by wearing out the infrastructure, which necessitates maintenance expenditures to repair pavement and vehicles. Efficient infrastructure policy maximizes the difference between social benefits and the costs of use, including the costs that users impose on others, by specifying pricing guidelines to regulate demand and investment guidelines that will specify design. A mathematical derivation of these guidelines is contained in Winston (1985); a nontechnical discussion is presented here.

Although the theory of efficient pricing and investment was originally developed to analyze transportation problems, and indeed much of the following discussion will draw upon transportation infrastructure, it can be applied to any infrastructure problem.[1] The efficient pricing rule calls for infrastructure use to be priced at short-run marginal cost. Because the user will take only his average cost into account when making travel decisions and ignore his contribution to congestion and infrastructure wear, short-run marginal costs to the public will exceed private average cost. The infrastructure authority must therefore set congestion tolls and charges for infrastructure wear to close this gap. The efficient investment rule calls for capacity and durability to be

[1] Although the literature on optimal pricing and investment has a long and distinguished history that dates back to the writings of Pigou and Knight among others (see Winston (1985) for a survey), Mohring and Harwitz (1962) were the first to rigorously determine optimal pricing and investment policies in a long-run framework. Recent work has extended Mohring and Harwitz's model to account for demand uncertainty, lumpy investment and so on. But the basic insights and usefulness of this model are still intact.

produced to the point where the marginal benefit from increasing investment in each dimension equals its marginal cost. Optimal investment is commonly viewed as being achieved in the long run. The pricing and investment rules jointly constitute an efficient long-run policy, in which a user's marginal cost is determined at the optimal level of capacity and durability.

Mohring and Harwitz (1962) applied existing theoretical results to transportation and showed that the financial viability of a public infrastructure facility under optimal pricing and investment depends upon the technological properties of its cost function. If capacity and durability costs are jointly characterized by constant returns to scale, then the facility's revenue from marginal cost pricing will fully cover its capital and operating costs. If costs are characterized by increasing returns to scale, then the facility's revenues from marginal cost pricing will fall short of its operating and capital costs and it will require a subsidy; if costs are characterized by decreasing returns to scale, then the facility's revenues from marginal cost pricing will exceed its operating and capital costs.

The following discussion summarizes in some detail the economic effects of optimal pricing of, and investment in, highways and airports. The discussion is then extended to other infrastructure facilities.

Efficient Highway Pricing and Investment

A country laced with nearly four million miles of roads, as is the United States, would not appear to have a serious highway infrastructure problem. Road mileage, however, is not the issue. Roughly half of America's nonlocal roads are currently in fair or poor condition, and traffic during commuter rush hours approaches capacity on one-half of the urban interstates and on one-third of the other main arterial highways (Small, Winston and Evans 1989). Most proposed solutions to these problems call for substantial increases in annual highway spending. But efficient highway pricing and investment could dramatically improve the condition and performance of our roads and require only a small increase in capital spending.

Historically, gasoline taxes have been used to charge vehicles for their use of roads and to finance expenditures. Tolls are levied on some roads, and eleven states have adopted taxes that assess trucks according to their total weight and distance traveled, but such charges account for a small share of highway revenues.[2] Although the gasoline tax was

[2] Wyoming, Colorado, and Nevada have recently repealed their weight-distance taxes.

probably a reasonable way to raise revenue as long as roads were uncongested and in good condition, of late, revenue shortfalls have made it increasingly necessary to supplement the gas tax with state and local revenues. The reason for the shortfalls is that fuel tax receipts fluctuate with economic conditions and fuel prices, and the recent trend in fuel tax revenues has been downward in real terms (because of improved fuel economy and increased use of untaxed gasohol).[3] These shortfalls are one reason to move away from the fuel tax as a source of highway revenue. A more important reason is that the fuel tax does not reflect the pavement damage and congestion caused by vehicles.

Charges for Pavement Wear

Pavements do not last forever. They become worn as vehicles pass over them and they eventually require resurfacing in the form of an overlay. Trucks and buses cause most of the damage, cars very little. Pavement damage itself depends on *vehicle weight per axle,* not total vehicle weight. The damage caused by an axle is defined in terms of the number of "equivalent standard axle loads" (esals) causing the same damage; the standard is a single axle of 18,000 pounds. This damaging power rises very steeply with its load.[4] For example, the rear axle of a typical thirteen-ton van causes over 1,000 times as much damage as that of a car.

A marginal-cost pavement wear charge can be assessed by multiplying a vehicle's esal-miles by the marginal cost of an esal-mile. For example, Small, Winston and Evans (1989, p. 42) estimated the marginal cost of an esal-mile on rural interstate highways to be 1.5 cents. Thus a truck equivalent to two standard axles traveling 100 miles on a rural interstate would accrue 200 esal-miles and a charge of $3.00.

Such a pavement wear charge would accurately reflect the damage caused by vehicles using the road. It would also give truckers an incentive to reduce axle weights by shifting to trucks with more axles, thereby reducing highway damage and maintenance expenditures and extending pavement life. The fuel tax currently in use provides truckers with the opposite incentive: the tax *rises* with a vehicle's axles, since trucks with more axles require larger engines and get lower fuel economy. Similarly, many state turnpikes charge more for a given weight if it is carried on a vehicle with many axles.

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[3] This downward trend appears to have reversed in just the past few years.

[4] It was previously thought to rise to the fourth power, but Small and Winston (1988) find that it rises closer to the third power.

Optimal Durability of Pavement

The damage that a truck does to a pavement depends not only on its axle weight but also on the durability (thickness) of the pavement.[5] Historically, pavement thickness has been strongly influenced by design guidelines issued by the American Association of State Highway and Transportation Officials (AASHTO). Recently, Small and Winston (1988) reexamined the recommendations issued by AASHTO with a model that determined optimal thickness by minimizing the sum of capital and maintenance costs. They found that optimal thicknesses were significantly higher than current thicknesses, especially for heavily traveled interstates.[6] Greater road thicknesses would substantially reduce annual maintenance expenditures and, because they would lower the marginal cost of an esal-mile, would also soften the impact of taxes promoting efficient pavement wear.

The economic effects of building roads to optimal durability and of charging truckers marginal-cost pavement wear taxes are shown in Table 1. Optimal durability and the marginal cost of an esal-mile are determined by the Small-Winston model along with extensive Federal Highway Administration data on the inventory of highway types and traffic levels; truckers' vehicle shifts in response to the marginal-cost tax and associated welfare effects are predicted by a truck-type choice model, where truck types are defined by trailer and axle configuration; and freight shifts to or from railroads are predicted by a shipper modal-choice model. The effects of the (first) best policy are shown in the first column of Table 1; columns 2 and 3 show the results of partial implementation. Gains in net welfare from the (first) best policy total $7.75 billion annually (1982 dollars). The source of these benefits is a huge annual reduction in maintenance costs of $9.4 billion, which is achieved with only a $1.3 billion annualized increase in capital costs. This policy is also attractive from a political viewpoint because it entails little redistribution. In fact, all major highway interests gain. Truckers and their customers gain because increased durability *lowers* the efficient road-wear charges from today's levels. The public sector gains because trucking firms distribute their loads over more axles (change vehicle types), reducing standard loadings (esals) by 38 percent, reducing highway maintenance expenditures. Railroads gain slightly from an

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[5] Besides making a pavement thicker, durability can also be improved by improving drainage, using better construction materials and so on. Aging and weathering leave a pavement more vulnerable to heavy loads.

[6] Small and Winston argue that their recommendations differ from AASHTO's because AASHTO failed to incorporate economic optimization into the design procedure and relied on a relationship between pavement life and pavement thickness that was statistically flawed.

Table 1.
Annual Economic Effects of Efficient Infrastructure Policy for Roads
Billions of 1982 Dollars

Item	Change,[a] Relative to Current Practice		
	Efficient Pricing and Investment (1)	Efficient Pricing with Current Investment (2)	Efficient Investment with Current Pricing (3)
Investment costs			
Maintenance savings	$ 9.428	$ 6.441	$ 8.536
Annualized capital savings	−1.276	—	−2.236
Total savings	8.152	6.441	6.300
Trucking firms' and shippers' welfare[b]	0.134	−5.586	—
Government revenues	−0.574	3.884	—
Modal shifting[c]			
Modal surplus	0.029	0.204	—
Rail profits	0.011	0.411	—
Total welfare	$ 7.752	$ 5.354	$ 6.300
Change in standard loadings[d] (Percent)	−38.12%	−48.38%	0.0%

[a] Positive dollar values indicate an improvement.

[b] These estimates do not include changes in user costs (vehicle damage and slower speeds due to damaged pavement). Small, Winston, and Evans (1989) point out there are difficulties in obtaining reliable estimates of this effect. Their rough estimates indicate that under optimal pricing and investment user costs are reduced by $3.03 billion when they are optimized along with maintenance and capital costs. User costs still fall by $1.8 billion under optimal pricing and investment when they are not explicitly optimized.

[c] Modal surplus measures the benefits to shippers who shift freight to or from railroads in response to the change in truck taxes.

[d] The reduction in standard loadings is accomplished with only a small change in ton-miles that results from modal shifting; most of the reduction is from truck-type shifts.

Source: Small, Winston and Evans (1989).

increase in traffic,[7] and the budget balance of the federal government is improved because the reductions in maintenance expenses greatly offset the loss in highway revenues and the increase in capital expenses.

The economic and political importance of combining optimal pricing and investment is also shown in Table 1. Setting efficient pavement wear taxes at current highway durability (column 2) produces a smaller welfare gain and generates substantial redistribution from the trucking industry to the public treasury. This finding confirms that truckers are

[7] Railroads gain because truck charges tend to rise on intercity traffic shipped long distances in large quantities; hence their business grows despite a small overall decrease in truck charges.

currently being undercharged for their use of the roads, but it also reveals how inadequate infrastructure investment can penalize an industry. Building roads to optimal durability while maintaining current pricing (column 3) also produces a smaller welfare gain and requires greater capital outlays. Because optimal investment is a long-run policy and the benefits from reduced maintenance expenses will be seen only several years after initial capital outlays, extra capital expenses could arouse short-term budgetary concerns. Nonetheless, the annualized benefit-cost ratio from optimal investment approaches 4:1, which is a healthy return.

Congestion Charges

Traffic congestion appears to be one of the most intractable infrastructure problems of the nation. Regardless of what policies are implemented—from high-occupancy vehicle lanes to subsidies for public transit—delays become longer and drivers and passengers become angrier. A conclusion being reached more and more frequently is that we have no choice but to build more roads. At first sight, increasing highway capacity appears as sensible as increasing highway durability, but capacity and durability inadequacies have different effects on road users. Few vehicles are discouraged from using a road because of its durability problems. Therefore, optimal durability produces benefits without significantly increasing use. On the other hand, because a lot of motorists are discouraged from using a road when it is congested, traffic will be attracted to it if capacity is expanded to relieve congestion. Benefits may be accrued, but congestion will persist in the long run.[8] The only way to reduce congestion permanently is to set an explicit price for capacity.

Congestion pricing has been advocated by economists for many years. But it has either been ignored by policymakers or been dismissed on political and practical grounds.[9] Small (1982), however, shows that objections by those who protest that lower-income drivers would be unfairly penalized are unfounded if revenues are used properly. If toll revenues are explicitly used to lower property taxes, invest in public transit, replace registration fees or fuel taxes, or invest in central cities,

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[8] This is known as Downs's law (1962, p. 393): on urban commuter expressways, peak-hour traffic congestion rises to meet maximum capacity because commuters shift from less preferred modes and times of day.

[9] For example, congestion pricing is not mentioned in an eight-page cover story on gridlock in *Time* (1988). It is dismissed by Ross Sandler, New York City Commissioner of Transportation, in a 1989 *New York Times* article where he is quoted as saying, "What would you do—put tolls on all the highways?"

congestion pricing can actually work to the benefit of all income classes.[10]

Objections that tolls are impractical are also overstated. Congestion pricing can be implemented without disrupting a traveler's journey. An automated vehicle identification (AVI) system, in which an electronic number plate is mounted underneath each vehicle, can be used to transmit a numbered identification to a control center each time a vehicle passes over a power loop embedded beneath a toll site. The vehicle owner is then sent a monthly bill similar to a phone bill. The technological side of such a system has been tested in Hong Kong and found to perform exceptionally well (Catling and Harbord 1985; Hau 1989).[11] In the United States, an AVI system is currently operating on the North Dallas Tollway.

Because the effects of congestion pricing vary widely by locale, most studies of its effects have been site-specific. But a study by Lee (1982) made a rough estimate of the effect of adopting congestion pricing nationwide and found that it would generate nearly $6 billion (1981 dollars) in annual net benefits, mostly in the form of travel delay savings. If congestion pricing were accompanied by optimal investments in road capacity, annual net benefits would be even higher and the initial redistribution from road users to the road authorities would probably be less.

Highway Finance

Although efficient road pricing and investment would generate substantial benefits, one must estimate the degree of scale economies in highway production to determine whether this policy would enable highways to be financially self-sufficient. Because highways produce two "products," traffic volume requiring capacity (for example, number of lanes) and standard loadings requiring durability (such as thickness), multiproduct scale economies must be estimated. These economies are a function of product-specific economies and economies of joint production, commonly referred to as economies of scope. Small, Winston and Evans (1989) find strong product-specific economies associated with producing heavy vehicle loadings because the ability of a pavement to withstand traffic increases far more than proportionally with its thickness. They conclude from the literature that mild product-specific

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[10] Virginia Secretary of Transportation John G. Milliken recently signalled his state's willingness to use Dulles Toll Road profits for express mass transit service.

[11] Hau also discusses a solution for overcoming some of the objections in Hong Kong to implementing congestion pricing.

economies result from producing traffic volume. They also find diseconomies of scope from jointly producing volume and standard loadings: as the road is made wider to accommodate more traffic, the cost of any additional thickness required to handle heavy vehicles rises because all lanes must normally be built to the same thickness. Multiproduct scale economies are estimated by combining these components.[12] The result is that the product-specific economies are virtually offset by the diseconomies of scope, which leads to approximately constant returns to scale in highway production and a budget for urban roads that approaches long-run balance.[13] For uncongested rural roads, durability economies would lead to a budget deficit, and additional fees would be required to attain a balanced highway budget.

This finding reveals an important additional benefit from congestion pricing. If efficient road-wear pricing is undertaken alone, the road authority would face a deficit for urban roads because of the economies of pavement durability.[14] But when efficient road-wear pricing is combined with efficient congestion pricing, the (marginal) cost of building the pavement itself is effectively charged twice: once from trucks because they require a thicker pavement and once from cars because they require a wider pavement. The result is that losses from pavement durability economies are eliminated.

As a further benefit, congestion pricing could substantially reduce the public transit operating deficit, which, according to the Urban Mass Transportation Administration, approached $9 billion in 1985. The higher congestion tolls will cause some motorists to shift to public transit.[15] This increased ridership will cause an increase in transit

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[12] The mathematical expression for these multiproduct scale economies is:

$$S_m = \frac{wS_V + (1 - w)S_Q}{1 - S_C}$$

where S_V is product-specific returns to traffic volume, S_Q is product-specific returns to durability, w is the proportion of user charges accounted for by congestion charges, and S_C is economies of scope.

[13] Small, Winston and Evans (1989) discuss the possible efficiency gain from a road system that separates truck and auto traffic, which is motivated by their finding of diseconomies of scope.

[14] Small, Winston and Evans (1989) find that the "pavement deficit" is reduced by optimal pavement wear pricing and investment from its current level of $16.16 billion (1982) dollars) to $9.84 billion (1982 dollars). The pavement deficit is defined for the optimal and current policy as the difference between tax revenues and the annualized value of resurfacing expenditures and the cost of the paving material itself.

[15] For example, Viton (1983) finds that congestion pricing in the San Francisco Bay Area would raise mass transit's share of downtown commuters by 10 to 20 percentage points.

capacity, which is usually achieved by running buses or trains more frequently. The increased frequency will lower expected wait times and generate even more ridership. The result is that congestion pricing in combination with appropriate pricing and service responses by transit agencies could raise transit revenues and reduce the need for federal, state, and local operating subsidies.[16]

Efficient Airport Pricing and Investment

Airport congestion and flight delays are increasingly receiving public attention. Many observers argue that the problem stems from a lack of airport capacity, citing the fact that no major airports have been built since 1974. Federal support of the proposed new Denver airport, estimated to cost $2.5 billion, is seen as a constructive step in alleviating air delays.

Congestion has probably not affected air travel choices to the same degree it has affected automobile travel choices, and additional airport capacity is not likely to attract as much traffic as additional highway capacity. But the tremendous growth in air travel during the past decade, partly spurred by deregulation, and the high cost and long lead times associated with building new airports suggest that society will be faced with a difficult and expensive catch-up task if it commits itself to reducing air congestion simply by building more airports. A less costly and more effective long-run solution is to price and invest more efficiently in existing airports.

Efficient Runway Pricing and Capacity

The most common method of assessing landing fees at airports is by aircraft weight. Thus during a given hour a jumbo jet pays considerably more to land than a small private plane. Weight-based landing fees were probably a reasonable way to allocate airport costs and raise revenue when airports were uncongested, but today the principal cost that an aircraft imposes when it takes off or lands is that it delays other aircraft from these activities. Morrison and Winston (1989) found such a delay to be substantial. For example, the elasticity of average departure delay with respect to commercial carrier departures is 2.9; the elasticity with respect to general aviation departures is 2.5. Current landing fees

[16] Winston (1991) discusses how efficient highway pricing and investment will provide additional benefits by improving performance in the deregulated motor carrier industry.

Table 2
Annual Economic Effects of Efficient Infrastructure Policy for Airports
Billions of 1988 Dollars

Item	Change,[a/] Relative to Current Practice	
	Efficient Pricing and Runway Investment (1)	Efficient Pricing and Current Runway Investment (2)
Consumer surplus change from landing and takeoff fees[b]	$ 1.10	$−12.53
Reduced delay to travelers	7.91	3.62
Carriers' operating cost savings	2.77	1.23
Airport revenues less costs	−0.77	11.50
Total welfare change	$ 11.01	$ 3.82

[a/] Positive dollar values indicate an improvement.

[b/] The consumer surplus change measures the effect of changes in landing and takeoff fees on travelers who continue to fly and those who are driven from or attracted to airline travel.

Source: Morrison and Winston (1989, p. 93).

undercharge aircraft in inverse proportion to their weight, because they do not account for the congestion externality.

An airport's capacity is primarily determined by its number of runways.[17] If it already owns the land, an additional runway 10,000 feet long and 150 feet wide can be constructed for roughly $40 million (1987 dollars) (Morrison and Winston 1989). Optimal runway capacity is reached when the marginal cost of an additional runway is equated with the marginal benefit of reduced delay.

The effects of replacing weight-based landing fees with marginal-cost congestion fees and of building the optimal number of runways at airports are shown in Table 2. Marginal-cost fees include delay costs and marginal maintenance, operations, and administrative costs. Optimal runway capacity is determined under the assumption that no additional land is needed for runway expansion. Although this is an unreasonable assumption for some airports, other capacity-enhancing mechanisms are or will be available that could by themselves produce a similar effect or enable runways to be built closer together at airports with limited room for growth.[18] In any case, this assumption produces an upward bias in the estimate of net benefits. An airline carrier choice model is used to estimate travelers' value of the reduced delay and of the change

[17] Terminal facilities and gate space also determine capacity.

[18] These mechanisms include high-speed runway exits, microwave landing systems, phased array radar, and digital pilot-air traffic control communications.

in their surplus in response to the change in landing fees. The effects of efficient runway pricing and investment are shown in the first column of Table 2, and the effects of adopting efficient runway pricing at current runway investment are shown in the second column.

Optimal airport pricing and investment policy could generate roughly $11 billion (1988 dollars) in annual benefits. Travelers would reap $8 billion in reduced delays and face lower fares, because the expansion in runway capacity called for under optimal investment, combined with congestion pricing, would reduce congestion to such an extent that on average landing fees would fall.[19] The annualized cost of the runway investment is only about $1.5 billion. Carriers benefit from lower operating costs, which result from reduced delay. Airports' net revenues would fall slightly, but, as argued below, they would become financially self-sufficient.[20]

The combination of efficient pricing and efficient investment policies is again economically and politically important. If airports adopted efficient congestion fees alone, net welfare would improve by only one-third as much, and considerable redistribution would occur to airports from travelers, who would primarily absorb the higher takeoff and landing fees through higher fares.

Combining efficient pricing and investment would also postpone the need to build expensive new airports. The FAA estimates that the new Denver airport will reduce current delays at the Denver Stapleton airport by 35 to 50 percent. Optimal pricing and investment at Stapleton airport would lower delays by at least that much at lower cost (Morrison and Winston 1989). Continued growth in air travel will eventually necessitate the construction of new airports, but these decisions will be made efficiently only if our current airport capacity is used optimally.

Airport Finance

As a simplification, airports produce two outputs, commercial carrier operations and general aviation operations. Although general aviation usually requires less terminal capacity and shorter runways than commercial aircraft, Morrison (1983) finds that airports are characterized by (overall) constant returns to scale and would therefore be financially self-sufficient under optimal pricing and investment. Their self-sufficiency would help lower the federal government deficit because

[19] General aviation travelers will face higher landing fees. But the Morrison-Winston model does not account for the greater flexibility that general aviation travelers have in their choice of airport and in arrival and departure time, thus their losses are overstated.

[20] Winston (1991) discusses how efficient airport pricing and investment will provide additional benefits by improving performance in the deregulated airline industry.

airports would no longer need funds from the government to finance improvements.

Efficient Pricing and Investment of Other Facilities

Less empirical work is available on the economic effects of efficient infrastructure policy on bridges, water supply, and water resources, but the information that is available suggests that significant benefits could also be derived from more efficient use of these facilities by pricing them and investing in them more efficiently.[21]

In contrast with pavement wear, bridge wear depends solely on *vehicle weight*, roughly in proportion to its third power (Moses, Schilling and Raju 1987). Thus, a fully efficient highway tax would account for a vehicle's contribution to damage from bridge stress by including a charge related to weight. Catastrophic bridge failure is caused by simultaneous passage of heavy vehicles over a given bridge section. Simultaneous passage and thus the likelihood of catastrophic failure could be reduced by congestion pricing, which would spread the traffic flow. Current bridge design could also be economically suboptimal. Design guidelines are not explicitly based on optimization and include arbitrary margins of safety. Efficient bridge investment and design could result in significant cost savings.

Reisner's *Cadillac Desert* (1986) focused popular attention on the nation's inefficient policy toward water use: water is priced below marginal cost, far below for agricultural uses, and laws regarding water ownership provide farmers with a disincentive to conserve water. The current infrastructure stock for water (dams and aqueducts) is inefficiently used, while the price distortions and the absence of a market for water in most states have spurred proposals by some Western locales to build expensive new dams. Benefits would clearly be derived from efficient pricing of and investment in water supply.

Use of the nation's waterways could also be improved through more efficient pricing. Until October 1980, no charges were imposed on users of inland waterways. Some believe that this policy was justified because the rights-of-way are a pure public good. But Boger (1985) has shown positive social marginal costs of waterway use, chiefly caused by congestion at locks. Efficiency could be improved if the current nominal charges were replaced by a marginal-cost congestion fee.

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[21] For an overview of the inefficiencies in waste disposal see National Council on Public Works Improvement (1988).

Summary of Benefits

The potential clearly exists to realize substantial benefits from an efficient infrastructure policy. The annual welfare gain from efficient pricing of and investment in highways and airports alone exceeds $25 billion (1988 dollars). It can be obtained for only about $3 billion (1988 dollars) in annualized capital expenditures to increase road thicknesses and to build more runways. Benefits would actually be higher than these estimates suggest, because performance in the deregulated airline and trucking industries would improve. Optimal pricing of and investment in other infrastructure facilities would add even more to the benefits tally.

Alternatives to Efficient Infrastructure Policy

Many people in public and private life question whether the benefits from efficient infrastructure policy would be achieved in practice and whether they would be worth the cost of politically undesirable redistribution. These fundamental concerns will be addressed in the process of evaluating alternatives to efficient infrastructure policy, focusing on highways and airports. The alternatives include traditional approaches, privatizing infrastructure facilities, and significantly increasing infrastructure spending.

Traditional Approaches

Most policymakers fall back on traditional approaches such as the gas tax or moderate increases in spending to solve current problems. My analysis of efficient pricing showed how current road and airport pricing, which chiefly relies on the gas tax and weight-based landing fees, is highly inefficient.[22] To simply increase spending, especially without charging efficient prices, could also be inefficient. But policymakers find current approaches appealing because they are practical and appear politically safe. Thus they must be convinced that efficient pricing and investment *can* be implemented and will not inevitably be faced with political opposition by stakeholders.

Technological feasibility. Efficient infrastructure pricing and investment can be implemented with proven technologies. The axle-weight

[22] The Bush Administration has recently proposed consideration of passenger facility charges at airports. These charges are not based on the aircraft's contribution to congestion; they are in fact weight-based landing fees under a different name.

truck tax is currently being implemented in Oregon. A 1988 U.S. Department of Transportation study concluded that the administrative and compliance costs of this tax at the national level would be little more per vehicle than the current federal heavy-vehicle use tax. Although the theoretically ideal road-wear charge would vary by road type to reflect the much greater vulnerability of thin roads to damage, Small, Winston and Evans (1989) found that simplified charges, which would be easier to administer, would retain a surprisingly large proportion of the benefits. For example, a two-part axle-weight tax, with one rate applied to freeways and another to nonfreeways, would provide more than 99 percent of the welfare gain possible from the axle-weight tax applied to all road types.

As noted earlier, road congestion pricing could be implemented without disrupting a traveler's journey, using an automated vehicle identification system. This system could permit officials to set a detailed pricing schedule with charges varying by time and locale. Although it would be costly to install, it would represent a far more efficient investment for reducing traffic congestion than the "smart cars–smart streets" technology, which is starting to capture the imagination of the public and the federal government despite having an estimated cost of $18 billion to build and $4 billion a year to operate and maintain.[23] Efficient airport pricing would be easy to implement. Because hourly takeoff and landing activity is recorded by control towers, the current weight-based fees simply could be replaced by a schedule of hourly takeoff and landing congestion charges.

Efficient infrastructure investment would use current construction technology to add thickness to roads and more runways at airports. The best way to upgrade existing highways would be to increase thickness—beyond what would normally be added to restore its original strength—each time a pavement is resurfaced. Small, Winston and Evans (1989) found that the benefits from increased thickness do not depend on unrealistic precision in building design. Even large errors in forecasts of traffic loadings do not affect the benefits by more than 10 percent. New runways should be efficiently added to congested airports that have available land.[24] New landing aids and better technology for air traffic

[23] The smart cars–smart streets technology amounts to computerized displays in automobiles that receive instantaneous traffic updates and detour instructions from a traffic management center. See John Cushman, "Smart Cars and Highways to Help Unsnarl Gridlock," *The New York Times*, April 12, 1990, p. A16.

[24] At least 50 percent of the congested airports have available land for additional runways. Environmental concerns would have to be met. One could argue that noise pollution would be reduced by efficient airport policy because use would be less concentrated during particular hours of the day.

controllers could enable runways to be spaced more closely together. The benefits from efficient airport investment do not have to depend on great precision in airport design. Morrison and Winston (1989) find significant benefits would result at many airports from just one additional runway.

Political considerations. It is widely believed that the radical revision of infrastructure pricing called for under efficient pricing is impractical because it would generate politically unfavorable redistribution.[25] Current approaches to pricing, however, are held hostage so relentlessly by political forces that policymakers are effectively prevented from taking any substantial steps to improve the infrastructure.

The federal government's decade-long aversion to new taxes complicates raising the federal gasoline tax. Individual states face strong voter opposition to proposed gasoline tax increases. Just recently California voters narrowly supported a doubling of their state gasoline tax, but the tax, which had not been raised for years and is now roughly equal to the national average, was part of a widely lobbied proposition to relax stringent limits on state expenditures. Airports are currently limited by law on the amount of revenue they can raise from pricing. Because of budgetary concerns, all levels of government are reluctant to increase—or in some cases even maintain—current spending on infrastructure without a committed source of additional revenue. The impact of politics has become clear: current calls for action have largely triggered finger-pointing.

By comparison, the political difficulties of efficient infrastructure pricing are manageable. The key to overcoming political objections to efficient infrastructure pricing is combining it with efficient investment and publicizing the expected outcome for beneficiaries. In the long run, no major highway interests will be harmed by efficient road wear pricing and investment. In the short run, the trucking industry would be hurt if charges were immediately set to marginal cost at current levels of durability. Political tensions could be minimized if road wear charges were initially set midway between current and ideal marginal-cost charges, with a definite schedule for reducing the charges to reflect planned improvements to road durability. Congestion pricing need not raise political objections if toll revenues are used in part to compensate lower-income drivers, in which case congestion pricing would work to the benefit of all income classes.

In the long run, efficient pricing and investment for airports will

[25] I interpret politically unfavorable redistribution as occurring when a well-defined economic interest, such as the trucking industry, or a social stratum, especially a disadvantaged one such as the poor, is made worse off.

lead to higher user fees only for general aviation. Compensation could be provided by using some of the toll revenues to upgrade navigational aids at general aviation (reliever) airports. This would make these airports far more attractive to fliers driven from commercial airports by higher tolls. In the short run all aircraft would face higher user fees. Thus landing and takeoff fees should be initially set midway between current and ideal marginal cost charges, with a definite schedule for reducing the charges as additional runways are built or as technological aids are implemented. The losses to commercial travelers could also be softened by reductions in the 8 percent ticket tax used primarily to support air traffic control.

Current strains on federal and state budgets have put a damper on proposals that call for an increase in infrastructure spending. But the findings presented earlier indicate that efficient infrastructure investment, coupled with efficient pricing, will generally improve federal and state budget balances in the long run and will lead to an approximately balanced budget for those facilities where some congestion is optimal. Budgetary demands will be fairly minor in the short run because efficient pricing will reduce initial capital outlays and because these outlays will be made efficiently.

Privatization of Infrastructure Facilities

The objective of efficient infrastructure policy is to maximize the welfare of the public. Can this goal be accomplished in the public sector? Some analysts believe it cannot because policymakers typically pursue their own interests, which are frequently in conflict with the efficiency aspects of welfare maximization. Privatization of public infrastructure is therefore advocated on the grounds that policymakers will never implement efficient pricing and investment; efficient pricing and investment would be pursued only by privately run enterprises subject to competitive market forces.

In practice, of course, most parts of the country do not have alternative roads and airports that could facilitate competition. Thus privatization would typically amount to franchised monopolies with regulatory oversight.[26] It is not clear, however, that this type of market organization would improve on publicly provided and priced infrastructure. The argument is that substantial welfare gains would result from legislation requiring the public sector to implement efficient pricing and investment guidelines. Policymakers would not have to implement

[26] For a discussion of privatization of highways see Poole (1988); for a discussion of privatization of airports see Poole (1990).

these guidelines precisely in order to realize most of the benefits, nor would they have much latitude to adjust pricing and investment levels to pursue other objectives.

Shapiro and Willig (1990) have shown that privatization will not improve upon public enterprise unless the political system compelling public officials to pursue public interest objectives fails to reach a given threshold. In contrast, public enterprise could be superior to privatization if public officials have private information regarding the public impact of the enterprise activity.

A fundamental problem with privatization that could lead to serious inefficiencies is that it gives the owners and managers informational autonomy from the regulator of the enterprise. For example, the staff of Virginia's State Corporation Commission recently cited "a number of unknowns and uncertainties" as justification for holding up the progress of a private firm's plan to extend a toll road from Washington, D.C. to suburban Dulles Airport. Another problem is that to the extent that regulators have a final say over pricing and investment, they may not approve efficient levels. However, a privatized facility, such as a toll road, could be used as a demonstration project to show policymakers the effects of an efficient policy.

Privatization is starting to gain the attention of policymakers. But it faces obvious political obstacles and could be inferior to public enterprise. Nonetheless, the privatization movement has helped focus attention on the need to pursue more efficient pricing and investment policies. There is justification for believing, however, that these policies could be implemented effectively in the public sector.

Significantly Increasing Infrastructure Spending

A consensus has developed among many economists, some policymakers, and a large part of the public that capital investment in roads and airports must be increased substantially. The belief of most economists that public infrastructure spending should be substantially increased has been shaped largely by the work of Aschauer (1989), who finds that the decline in public works capital spending has been a major factor in the recent productivity slowdown. His findings suggest that large capital investments in public infrastructure produce enormous benefits.

My 1991 paper questions the accuracy of Aschauer's findings. His estimates imply that a one-time $60 billion increase in public works capital spending would achieve a benefit-cost ratio that exceeds 10:1 and would pay for itself in just one year. This return is implausible. Charles Schultze (1990) argues that Aschauer's findings simply demonstrate that the time patterns of productivity and public investment growth are

similar, and that this correlation generates grossly inflated estimates of the return to public infrastructure investment.

A fundamental flaw also exists in efforts to solve infrastructure problems by making substantial capital investments in new facilities or technologies, as can be illustrated by the following example. Pick any pothole-laden, congested, two-lane road in an urban area. Suppose public funds are used to widen the road to four lanes and repave it. Benefits will immediately flow from this investment in the form of faster travel time and less vehicle damage. But many travelers who previously avoided the road during peak travel periods will now find the road attractive to use. The short-term improvements will also induce irreversible decisions on land use and vehicle purchase. Before long the road will again fill to capacity and will steadily deteriorate. The corresponding social costs of congestion and road wear will be even higher than before the investment because more travelers use the road.[27] To generalize from this example, the money spent on new facilities or technologies would result in expanded transportation capacity that eventually faces the same problems as before but now requires even more money to "fix."

Although the empirical and conceptual basis for making large public infrastructure investments is highly suspect, this approach has generated interest in the social payoff from increased infrastructure spending. I found that the benefit-cost ratio for efficient investment in roads and airports is roughly 4:1,[28] and it can be obtained with only a small increase in annualized capital expenditures. Most importantly, efficient investment and efficient pricing will provide a long-run solution to infrastructure problems, a goal that cannot be met by just increasing spending.

Are Policymakers Interested in Efficient Infrastructure Policy?

My goal in this paper is to proselytize. I realize, however, that many will remain skeptical about the practicability of efficient pricing and investment until it is clear that some policymakers have been convinced.

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[27] The social costs on this road will be partly offset if congestion and road wear are reduced on alternative roads.

[28] Although the benefits from efficient investment represent Pareto improvements and Aschauer's represent productivity gains, this cannot account for Aschauer's benefit-cost ratio (10:1) exceeding the ratio for optimal investment by such a large amount.

To this point, a few have stepped forward and many are thinking seriously about it.[29]

The Bush administration has admittedly set back the cause of efficient policy. The National Transportation Plan (*Moving America: New Directions, New Opportunities*) mentions efficient pricing and investment in only a vague way, if at all, and usually refers to it in connection with inefficient policies.[30]

Although the Administration appears reluctant to take a clear position, it could pressure the states to implement efficient infrastructure policy. In fact, some signs indicate that the Administration would be willing to play this role. Secretary of Transportation Samuel Skinner has argued that if the states are forced to contribute a greater share of highway expenditures, then they will pay more attention to how the money is spent. The government has also proposed a plan that would enable airports to impose new fees to raise money, with the money to be spent only on projects that would increase capacity.

These proposals suggest ways the federal government could encourage highway and airport authorities to make more efficient investments. The authorities and the federal government would be better off if the federal government also encouraged efficient pricing. Many of the authorities would become financially self-sufficient, and the federal government's deficit would be reduced. The debate over each level of government's share of capital expenditures would become irrelevant. The challenge still remains to convince both parties that their interests would be served by efficient infrastructure policy.

Greater interest in efficient infrastructure policy is developing in Congress. A group of representatives, the "House Wednesday Group," has identified the Small, Winston and Evans (1989) proposal for efficient highway pricing and investment as a policy option in addressing highway needs.[31] Because Congress will be debating the Highway Reauthorization Act during 1991, this proposal could receive serious consideration. Legislation has also been proposed in the House that includes consideration of efficient pricing to reduce congestion in airport

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[29] In a highly misleading discussion of this paper at the conference, Alan Altshuler characterized the paper as claiming that efficient infrastructure policy would be implemented in this country. This claim is never made. In this section I do point out encouraging developments that would probably have been unimaginable when many economists began to advocate efficient infrastructure policies in the 1960s.

[30] For example, on page 5 it is stated, "For example, local passenger facility charges at airports and tolls on highways offer significant potential as financing mechanisms where there is heavy travel demand." I pointed out previously that passenger facility charges are inefficient; I cannot tell whether the highway tolls that are referred to would be based on efficiency principles.

[31] See its report *Highway Policy at a Crossroads* (1990).

system planning.[32] Congressional debate over newly proposed passenger facility charges might also provide an opening for efficient airport pricing to be considered.

The greatest encouragement thus far has come from individual states and transportation authorities. On January 1, 1990 Oregon implemented a system in which operators of heavy trucks pay a tax based on axle weight. The new taxes apply only to vehicles operated at gross weights above 80,000 pounds, but the Oregon Department of Transportation is very likely to recommend to the 1991 legislative assembly that this system be extended to lower gross weights.

Congestion pricing is beginning to receive support and interest from various government organizations in California. California Department of Transportation (Caltrans) Director Robert Best favors it, although the official position of the department is that it is still studying the possibility.[33] To this end, Caltrans and the Urban Mass Transportation Administration jointly sponsored a University of California conference on the effects of congestion pricing. In addition, the Southern California Association of Governments instituted a task force on market incentives for land use and transportation that recommended congestion pricing. It is now soliciting proposals for demonstration programs as called for in its latest regional mobility plan.

Various airports have also revealed interest in using the price mechanism to alleviate congestion. Some congested airports have implemented minimum landing charges for general aviation that exceed the inefficiently low weight-based fees. Logan Airport in Boston has gone a step further by significantly raising general aviation landing fees. This policy attracted attention because it was effective in reducing congestion, but it was found to be discriminatory and therefore illegal.[34] The final step is for airports to recognize that adoption of congestion pricing will legally meet the objective of reducing delay.[35]

The interest in and experimentation with efficient infrastructure policy has significant implications for its future. If axle-weight pricing is

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[32] See the legislation proposed by Representative Packard.

[33] See William Trombley, "Caltrans Embarks Upon the Road to Tomorrow," *Los Angeles Times*, July 24, 1989, p. 3.

[34] The revised fees at Logan Airport have been interpreted by some as an example of the political and legal failures of congestion pricing. But these fees were not congestion prices because they were not differentiated by time of day and because they were applied only to general aviation. Fees were actually lowered for larger planes to keep the plan revenue neutral; this added force to general aviation's charge that they were being discriminated against.

[35] Congestion pricing would not face the legal problems that arose at Logan Airport because the prices would be based on costs. Legislation would have to be passed to allow airports to increase the revenue they can raise from landing fees.

successful in Oregon, it could spur adoption by other states and the federal government. Similarly, if a few California cities and some airports adopt congestion pricing, other locales are more likely to adopt it. Given the absence of any other effective long-term solutions, this chain of events could be responsible for nationwide adoption of efficient infrastructure policy.[36]

Finally, the press is starting to become a source of support. In response to the National Transportation Plan, a *New York Times* editorial criticized Secretary Skinner for not advocating congestion pricing of airports and axle-weight taxes for highways.[37] California has also received editorial support for congestion pricing.[38] Favorable media attention would probably have been unthinkable a few years ago. This supportive publicity could bring efficient infrastructure policy closer to the center of the public debate and possibly persuade policymakers that there would be a political payoff from endorsement.

Taken collectively, these are encouraging signs that policymakers and the public will give efficient infrastructure policy serious consideration. But, as in the case of all policies, whether this consideration translates into adoption depends on the momentum generated. Thus far isolated instances of support are found, which could possibly grow into wider acceptance. But waiting for a gradual buildup of support among local, state, and federal policymakers almost surely means at least another decade of waste. It is time to seize the opportunity to improve the nation's infrastructure and at the same time husband scarce federal funds. Efficient infrastructure policy is an issue crying out for a leader.

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[36] Evidence from intrastate airline fares in California and from unregulated produce rates in trucking helped to convince policymakers that nationwide deregulation of airlines and motor carriers would lead to lower prices.

[37] See *New York Times* editorial, "Mr. Bush's Squeeze on Cities," March 11, 1990.

[38] See the editorials cited in Small, Winston and Evans (1989) p. 92.

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Discussion

*Alan A. Altshuler**

Clifford Winston has summarized well the case for economic "efficiency" in infrastructure pricing and investment, and nicely fleshed it out with some highway and air transport examples. Though I might quibble about a few supporting arguments,[1] I have no real disagreement with Winston on the merits.

Fortunately, though—since I might otherwise have been reduced to silence—Winston refuses to be contained by his discipline. He knows full well that for an economist to argue on behalf of marginal cost pricing and investment is scarcely big news. So he proceeds beyond the merits, to explain why he believes the political world may be on the verge of readiness to follow sound economic advice. In so venturing he captured my rapt attention. This *would* be newsworthy! But I remain unpersuaded.

Permit me to explain why, but then also to differentiate among the measures Winston recommends. It strikes me that they vary widely in potential feasibility, even if the political system continues to function about as it has for years.

The main points of evidence that Winston adduces in support of his political optimism are as follows:

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[1] For example, Winston suggests that congestion pricing would, by inducing some motorists to utilize transit, reduce transit deficits. In practice, transit patronage and deficits tend to rise in tandem, because rising demand tends to be accompanied by increased service and every service unit tends to lose money.

- When economists first began to argue for airline and truck deregulation in the 1960s, these ideas seemed as implausible politically as congestion pricing and the other key elements of "efficient" infrastructure policy seem today.
- The specific idea of an axle-weight truck tax has recently been adopted in Oregon, though only for vehicles operated at gross weights in excess of 80,000 pounds.
- Road congestion charges can now be levied by an automatic vehicle identification (AVI) system and periodic billing, like cellular telephone charges. Toll booths, with all the delay and inconvenience they entail, would no longer be required except for occasional users whose vehicles lacked AVI system capability.
- Toll systems need not be regressive. Lower-income drivers could be compensated directly, or the revenues could be used to support programs of primary benefit to lower-income people. Vested interests that are well-heeled might be won over in the same way. For example, general aviation interests would be first-order victims of a congestion fee system at major airports, but they could be compensated by use of some congestion fee revenue to upgrade general aviation airports.
- A few Congressmen and state and local officials, most notably in California, have recently expressed interest in the principles of "efficient" transportation policy. Several congested airports have actually raised their minimum landing fees for small aircraft, though only Boston's Logan Airport sought to implement "significant" increases and these were struck down judicially. Finally, *The New York Times* has editorialized in favor of airport congestion pricing and truck axle-weight taxation.

Two features of this argument stand out. First, the evidence cited is at most weakly suggestive. Second, it is one-sided. Winston, who states openly that his "goal in this paper is to proselytize," makes no pretense of weighing contrary evidence in the balance. Permit me to comment, then, on his points and to suggest a few others that seem pertinent.

The deregulation case is indeed a suggestive precedent, in that economists' arguments for efficiency eventually prevailed over some very entrenched interests. Reference to this episode can too easily become a mantra, however, like the phrase: "If we were able to send a man to the moon . . . ." With respect to the instant case, note that deregulation did not require politicians to take responsibility for any tax, price, or public expenditure increases. Its great political attraction was as an anti-inflation measure that required government simply to do less. Indeed, as John Kingdon notes, a key contextual element was Jimmy Carter's campaign theme of "getting government off your back" (King-

don 1984; and compare, more generally, Altshuler and Teal 1979; Derthick and Quirk 1985; Robyn 1987).

Oregon's adoption of an axle-weight truck tax may prove a harbinger of things to come. A couple of cautionary notes, however. Winston notes that the tax will apply only to vehicles with gross weight in excess of 80,000 pounds. This happens to be the federal Interstate Gross Weight Limit, and few states authorize higher loads at all without special permits. (Compare National Cooperative Highway Research Program 1988, Table B-l.) The Oregon tax will therefore affect a tiny proportion of commercial shipments. Large truckers have long been accustomed to paying higher taxes, fees, and tolls than the owners of lighter vehicles. They have also been egregiously undercharged relative to their impact on road wear, of course, but Winston does not provide any information on the magnitude of the new Oregon fees, or their relation to other motor vehicle taxes. Thus it is impossible to determine whether even this one state, with respect to this one trucking category, has taken a major step toward requiring heavy vehicles to pay their own way.

The technical barriers to congestion pricing have never been central. Singapore, after all, introduced its downtown area licensing scheme in 1975, and local planners recommended a similar scheme for Central London in 1974 (Altshuler 1979, p. 360). It is true that sophisticated systems, varying by time of day and route and extending far beyond downtown, were not feasible until recently. What I find most striking, however, is that only Singapore, a one-party quasi-dictatorship, has been able to implement any form of congestion pricing for a sustained period. I believe the only other city that has even ventured a pilot is Hong Kong. As for recent U.S. experience, New York City Transportation Commissioner Ross Sandler vigorously sought support during the late 1980s for a downtown area license/toll system. He made his argument not simply on grounds of efficiency, but also on grounds of public health and federal air pollution requirements. Technically, he had two major advantages. The Manhattan central business district is the most congested area in the nation, and the main vehicular approaches to downtown are already tolled. Sandler published a fine report, explained it in as many forums as possible, and persuaded Mayor Koch to chair the first set of hearings on this proposal. All to no avail. Business, labor, and nearly all civic groups were intensely hostile, and virtually no support appeared except from environmental organizations and a few academics. The idea quietly died.

We have another recent experience with recommendations to shape motorist behavior by price. The Clean Air Act of 1970 set precise ambient air quality standards to be achieved by the mid-seventies. Industrial processes and new cars were to be made to pollute less, and where these

measures did not suffice, others were to be called into play. Of these, the most promising by far were high gasoline taxes and parking surcharges. As the Environmental Protection Agency moved in 1973 toward imposing such charges, however, Congress voted to prohibit them. President Nixon vetoed the bill in question on unrelated grounds, but the EPA Administrator took the message to heart. All surcharges previously included in regional transportation control plans were immediately suspended. The prohibition on surcharges became law in 1974, nonetheless (Altshuler 1979, p. 195).

The energy crises of the seventies also generated widespread calls for the utilization of price incentives. Winston calls for a national leader to take up the cause. He might have been quite pleased in 1977 when a new President, Jimmy Carter, made reduced oil import dependency his single highest priority. Carter, who cited national security and prosperity as his justifications rather than mere congestion delays, sought an 11 percent reduction in national gasoline consumption between 1981 and 1985, to be achieved by the utilization of price signals. He recommended a tax on domestically produced oil, another on "gas-guzzling" cars, and a standby gasoline tax to be imposed if consumption exceeded the national target. The last was potentially the strongest measure. The standby tax was to rise five cents for every 1 percent that consumption exceeded the prior year's target. It never made it through a single congressional committee. In the end, the only Carter recommendation adopted was a watered-down version of the gas-guzzler tax, expected to apply at most to a few super-luxury European models (Altshuler 1979, pp. 136–40). Carter never recovered from the political backlash he stirred up with these proposals, and the idea of fuel taxation to conserve energy has never again been a serious item on the national agenda.

Winston calls for ingenuity in the structuring of efficient user fee and tax systems, to ensure that lower-income people are shielded from significant harm and that vested interests can be suitably compensated. Numerous advocates of fuel taxation to conserve energy have come up with such schemes, however, to no apparent effect. The public and media seem fiercely protective of existing arrangements. Even the advocates of high-occupancy vehicle lanes have learned from bitter experience to implement them only when new or contra-flow lanes are available, because the public reacts so negatively to having existing peak-direction lanes taken out of service.

While congestion pricing might in theory benefit everyone, one must recall that utility is a subjective matter. Many people fear that they would be driven from the roads during peak periods, others would pay but hate it, and still others would distrust any politician promising that new revenue will be used wisely. The media can be counted on to fan these flames when serious proposals are put forward. Those who would

be happy to pay for reduced congestion are few and too weakly motivated to become politically active. To my knowledge, they never have done so. As I have written elsewhere on this topic, I shall say no more here (Altshuler 1979, pp. 342–52, 355–69).

With reference to Winston's final point, that one can point to a few public officials and editorial writers who support efficient infrastructure pricing, who can doubt it? But how do their numbers and their levels of commitment compare to those who since 1973 have favored higher fuel taxes to conserve energy and reduce air pollution?

During the federal budget battles of recent years, various commentators have remarked that while tax cuts and spending programs have constituencies, there is no significant constituency for a balanced budget. Within most program areas, certainly including infrastructure, one can say the same about "efficiency."

Institutions are organized around key values. And the values around which the American political system is organized routinely conflict with efficiency. These include broad democratic responsiveness, the preservation of individual liberty, the protection of minority groups from majority tyranny, and avoidance of concentrated executive power.

The system's myriad checks and balances channel decision-making toward pluralistic compromise and logrolling. Its openness to popular sentiment, combined with its internal fragmentation and lack of control over the media, tends to preclude effective efforts to challenge ingrained public attitudes. (The courts can do so at times, particularly when constitutional values are at stake, but this need not concern us here.) Its direct democratic elements, which have been greatly strengthened over the course of the present century—nomination by direct primary, legislation by referendum, the decline of political parties, sunshine and citizen participation requirements, vastly increased mobilization of special interest groups—tend to sap both the will and capacity of elected officials to "educate" rather than "respond to" their constituents. On the whole, American politicians are more scared, more dependent on special interest support, more isolated from one another (in the absence of meaningful parties), and less confident of their ability to overcome gridlock on controversial issues than at any time in our recent history.

These are quite conventional points. They represent basic first steps, however, toward understanding why American infrastructure policy has been far more responsive to group pressures and broad popular attitudes than to efficiency arguments, and why it is likely to remain so.

This is not to say that progress toward efficiency in infrastructure policy is inconceivable. It is to suggest, however, that efficiency reforms are likely to fare very differently in the political arena, depending on the types of benefits they confer, which shibboleths they challenge, and

whose oxen they gore. There are not many guides to this estimation problem in which I have confidence, but here are a few simple ones. Reforms with narrow direct impact will be more feasible than those of wider scope. Reforms that call for business regulation and/or taxation will be more feasible than those that would be salient for large numbers of voters. The least feasible reforms will be those that would require politicians to take direct responsibility for imposing significant new charges and regulations on the mass public. The most feasible will be those that would extend familiar arrangements for easily understood purposes (for example, gas tax increases to finance new highways), and those that would confer large, easily understood benefits on well-mobilized groups without requiring politicians to antagonize many constituents.

What are the implications with respect to Winston's proposed reforms? First and foremost, I conclude that road congestion charges remain a political loser. The time to reconsider this judgment will be when some public toll-road authorities have eliminated commuter (read: peak period) discounts in favor of peak period surcharges.

Second, I judge that a shift in the basis of truck taxation from gross weight to axle weight, as Winston and colleagues have proposed, is quite plausible. This would amount to a modest revision of a long-standing arrangement. The more difficult question is whether trucking taxes will increase sufficiently under this scheme to bring about a major reduction in the implicit subsidy heavy trucks have long received. Here I have severe doubts, since the general nature of this subsidy has been well understood for decades. The problem is that commercial truckers are very strongly motivated to preserve this subsidy, while automobile owners and renters, who pay it, are very weakly motivated to oppose it.

Third, I believe that pricing strategies to alleviate airport congestion are forthcoming. Air traffic delays are of interest to large numbers of voters as well as to commercial airlines. It seems unlikely that runway and terminal expansion, or air traffic control improvement, will be sufficient to alleviate airport congestion in the face of rapid traffic growth in the decades ahead. The great question is whether the problem will become so severe that politicians are willing to challenge the general aviation lobby.

I doubt that Winston's proposed compensation scheme will discernibly mitigate general aviation opposition. It is not new. It has never worked before; why should it work now? Three easier paths to airport congestion pricing remain, however. One is simply to conduct periodic auctions of peak-period landing slots at congested airports, while reserving a percentage for general aviation. A second path would be to raise all landing fees proportionately in peak periods at congested airports, without requiring airlines to endure the risk of auctions. The

issue here would be to find an acceptable means of distributing the revenue—rebating it in the form of reduced fees during off-peak periods, using it to reduce other taxes, or using it to finance airport improvements. A third strategy would be for the federal government to deregulate in this area, giving state and local airport authorities wide discretion to manage congestion. This reform would be in tune with deregulation of the private aviation industry and with the Reagan-Bush New Federalism ideology. Within a decentralized framework, authorities in several of the nation's largest metropolitan areas would probably move quickly to adopt runway congestion pricing.

Finally, what about "optimal investment?" Winston's paper makes clear that this is a many-faceted topic. One can easily imagine the argument for thicker pavement that Winston and colleagues have developed triumphing fairly quickly. Pavement thickness is generally considered to be a matter for professional determination. Greater pavement thickness would not inconvenience anyone. And, if Winston is correct, this policy would enable government officials to take prompt credit for monetary savings as well as road quality improvements. Politicians will still be tempted to spread highway paving funds around more widely, but they are likely to accept clear engineering standards if these are forthcoming.

Optimal investment more broadly considered is another matter, however. In the absence of efficient road pricing, it does not make a great deal of sense to talk about optimal highway investment. And even if it did, Winston has not suggested any benefits that would be likely to induce politicians to give up pluralistic bargaining as the main basis for determining highway budget limits and distributing funds within them. Nor are airport authorities likely to build new runways as "rationally" as Winston suggests. Even where airports have land available, new runways generally stir major community and environmental conflict. Winston writes that noise pollution concerns might be met by arguing that additional runways would lead to reduced traffic concentration. The opponents would reply, of course, that increased runway capacity facilitates the accommodation of increased total volume. And they would be correct.

In short, there seems little reason to believe that economic efficiency is about to triumph in the infrastructure policy arena. But the political system is considerably more amenable to some reforms than others. Considerable waste motion may be avoided if one keeps hope in check while striving to discern which are which.

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Discussion

*Michael E. Bell**

These comments will highlight some of the important innovations in the Clifford Winston approach to how to think about infrastructure problems, some areas of possible extension of the author's arguments, and some concerns about how his approach might be applied to other categories of infrastructure (especially those categories relating to environmental protection) and about how the Winston solution might be implemented. In order to put my comments and reactions into perspective, however, I want to first give some background on the National Council on Public Works Improvement.

In the early 1980s, a number of studies raised serious questions about the condition of the nation's infrastructure and its ability to support continued economic development and promote international competitiveness (Choate and Walter 1981; Associated General Contractors 1983; Congressional Budget Office 1983; National Infrastructure Advisory Committee 1984). In response to the concerns expressed in those studies, Congress created the National Council on Public Works Improvement (NCPWI) to report on the state of the nation's infrastructure and to develop a strategy to ensure that this infrastructure will be adequate to support future economic growth and promote continued international competitiveness.

Throughout its two years of activity, the Council kept coming back to one fundamental question: If we as a nation had an extra dollar to spend, should we spend it on infrastructure rather than on health care, education, or the homeless? and, if we spend it on infrastructure,

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should we spend it on operations and maintenance or on new construction, and on what category of infrastructure? The Council recognized that increased investment in infrastructure is just one of many critical claims on the nation's resources. To respond to this and other claims requires coming to grips with the growing imbalance between consumption on the one hand and investment and saving on the other. This imbalance, reflected in the federal budget deficit and in other forms of borrowing against the future, affects all federal spending decisions (NCPWI 1988). Until this imbalance is addressed, the practical question remains how to ensure the maximum level and quality of infrastructure services given available resources, irrespective of whether or to what degree those resources might be considered inadequate. In other words, how can the nation spend limited resources on public infrastructure and avoid past mistakes of building canals or industrial parks that are not used?[1]

In pursuing this line of inquiry, the Council ran into a couple of major roadblocks. First, traditional needs studies provide no information on how specific physical infrastructure facilities are actually used. Rather, if a bridge is determined to be structurally deficient by the federal government it should be renovated to meet agreed-upon engineering standards, whether it handles 1,000 cars or ten cars per day. No useful information was readily accessible on the economic benefits provided by such facilities or, more importantly, the demand for infrastructure services.

Second, no analysis or data provided a link between actual dollar expenditures on new investment and/or operations and maintenance and the level and quality of infrastructure services resulting from such expenditures. For example, real per capita investment in public works decreased from 1965 to 1984 in absolute terms and relative to GNP, but real per capita spending on operations and maintenance increased over the same period at about the same rate as GNP. However, we cannot say how either trend affected the overall level and quality of infrastructure services being provided (NCPWI 1986). The lack of such a linkage is still a major impediment to extracting meaningful policy recommendations from analytical work that relates aggregate dollar flows of infrastructure spending to national productivity, gross state products, regional employment, or other measures of economic activity. Such macro studies can help make the general point that as a nation we need to spend more on infrastructure, but these studies provide little guidance as to how those expenditures should be allocated to obtain the highest level and quality of infrastructure services.

In my view, the Winston approach to analyzing infrastructure

[1] Examples provided by Joel Tarr during his oral presentation at this conference.

issues makes some significant contributions toward filling the informational gaps faced by the Council.

Major Contributions

One of the themes that runs throughout the work of the National Council on Public Works Improvement is the fact that physical infrastructure facilities, the focus of traditional needs studies, are not ends in themselves, but rather are important for the services they provide. Thus

> . . . from a public policy standpoint, it may be equally, if not more, important to consider the adequacy or inadequacy of a community's infrastructure based on the output, or level of service provided, as opposed to its physical condition alone. (1986, p. 12.)

This perspective on the infrastructure problem is a radical departure from the logic of traditional needs studies, but it is critical for developing meaningful policy initiatives because it opens the door to consideration of alternative, low-capital-intensive, means of providing infrastructure services. The Winston approach to the infrastructure issue is consistent with this perspective. For example, Winston states that ". . . efficient highway pricing and investment could dramatically improve the condition *and performance* of our roads and require only a small increase in capital spending." (Winston, this volume, emphasis added.)

Second, the Council found little evidence directly linking dollar expenditures on infrastructure investment, operation, and maintenance and the level and quality of service provided. The Winston paper explicitly links spending on capital investments and operations and maintenance requirements for highways and airports. Thus, Winston is able to discuss an efficient investment strategy and the implications it has for future maintenance requirements. This represents an innovative effort to systematically apply a life-cycle cost approach to questions of investment in and maintenance of the national highway network.

Third, recognizing that infrastructure services and performance are important and depend on how facilities are used, Winston makes efficient pricing of those services a central theme of his proposal. He differentiates components of demand and considers efficient pricing for both system capacity and durability. He extends the discussion of pricing to consider the implications of such an efficient pricing strategy for the demand for transportation services, how the delivery of those services might shift between modes of transportation as a result of changes in relative prices, and how the delivery of services might change in response to such price incentives by more efficiently combining private capital (multi-axle trucks instead of single-axle trucks) with public capital (highways). In essence, the approach moves toward a general equilibrium analysis of infrastructure issues.

Finally, the author raises legitimate questions about the benefits to be derived from privatization. The types of infrastructure categories discussed in the Winston paper, and by the National Council on Public Works Improvement, do have private good characteristics: for example, identifiable users who can be charged a price and excluded from using the facility or service if they do not pay that price. However, this does not create a competitive market for those services. Rather, as Winston points out, it creates a situation for a regulated monopoly that may or may not be efficient, depending on the extent of contestable markets, the incentive structure created by the regulators, and so on. He correctly argues that privatization is no panacea.

In my view, the analysis presented in the paper makes important contributions to the methods by which we should define, describe, and analyze infrastructure problems. Applying this approach to other categories of infrastructure, with a focus on services, how those services are priced, and the implications of that pricing strategy for how the services are provided, would indeed move the nation toward an efficient infrastructure policy. However, it is possible to extend this analytic approach beyond the discussion in Winston's paper.

Extensions of Winston's Analytic Approach

The first area for potential extension is the question of defining the output or product of expenditures on public infrastructure. For example, the author states that highways produce two "products": (1) traffic volume requiring capacity and (2) standard loadings requiring durability. Alternatively, he states that airports produce two "outputs": (1) commercial carrier operations and (2) general aviation operations. The highway definition focuses on physical characteristics of publicly provided capital, such as the number of lanes and pavement thickness. The airport definition focuses on services provided by the combination of public and private capital.

As mentioned above, physical infrastructure facilities are not ends in themselves, but rather they interact with private capital to produce a service. In the transportation area, public capital (roads, bridges or runways) interacts with private capital (cars, trucks or airplanes) to produce a service (mobility). That service, however, has a quantity and quality dimension. In the context of a Lancaster-type good, different characteristics of the service might be considered "products" to the extent that individual consumers value them differently. Durability, speed, and safety (for which pavement thickness and lane width might be possible proxies) are characteristics of transportation services that heterogeneous users might demand and be willing to pay for.

If one accepts the author's characterization that the products of

highways are capacity and durability, other attributes of the network might be considered equally important "products." For example, safety and reliability of the system are increasingly important as usage increases and the economy restructures itself to meet global economic challenges. In order to identify all such potential "products," it is necessary to understand fully the link between infrastructure and economic development. For example, if one accepts the argument, laid out above, that the service produced by the interaction of public and private capital is mobility, then public capital is seen to affect economic activity by complementing, rather than substituting for, private capital. In fact, empirical evidence consistent with this perspective is increasing (Eberts 1990; Duffy-Deno and Eberts 1989). Thus, public infrastructure can be considered an unpaid factor of production within a firm's production function (as an intermediate good) and the demand for infrastructure services is a derived demand that depends on the demand for the final product.

In this context, the elasticity of the derived demand curve is of interest. Assuming for the moment that factor inputs are used in fixed proportions, the derived demand curve will be more inelastic

(1) the more essential the factor input being considered;
(2) the more inelastic the demand curve for the final product;
(3) the smaller the fraction of total cost that goes to the factor in question; and
(4) the more inelastic the supply curve of the other factors (Friedman 1972, p. 153).

To develop an efficient infrastructure policy one must consider the impact of economic restructuring, both in the United States and globally, on the demand for and usage patterns of transportation infrastructure. This link between transportation and the economy is influenced by (1) changes in intra-firm production processes; (2) changes in the structure of the industrial sector, including both institutional structure and the types of products being produced; (3) shifts in the location of various economic activities; and (4) the increasing importance of the service sector in the economy (Bell and Feitelson 1989). For example, if one moves to a just-in-time production process, system reliability becomes important. One might invest in additional system capacity even if current capacity is not congested in terms of travel time.

In this context, the products of the transportation network (capacity, durability, safety, access to remote areas, and reliability) become important in identifying and measuring social benefits from transportation investment. Thus, when Winston argues that efficient infrastructure policy should equate marginal social benefits and marginal social costs, social benefits need to be interpreted broadly to include system and network effects as well as other attributes besides travel time and pavement thickness.

In addition to the definition of output, a second area for potential extension is the notion of efficient pricing. The author argues that users of infrastructure impose costs on themselves and others by contributing to congestion and by wearing out the infrastructure. Thus, his efficient pricing strategy contains a pavement wear charge to promote efficient investment and a congestion charge to regulate capacity. This characterization of the social costs associated with automobile usage ignores a major social cost, namely the environmental cost.

The automobile provides mobility and convenience that are particularly attuned to the American desire for personal freedom. As a result, the automobile dominates the nation's transportation network. Yet the automobile also threatens our quality of life by contaminating both urban air and the global atmosphere (Gray and Alson 1989). Transportation consumes more than 60 percent of all petroleum used in the United States and accounts for over one-half of all hazardous air toxins, including 40 percent of all hydrocarbon emissions and two-thirds of carbon monoxide emissions. As a result, automobile exhaust continues to come under fire from environmentalists (Wright 1990).

Gasoline prices in Europe and Japan are double or triple the U.S. price because of government levies that force consumers to internalize a greater share of the social cost of their behavior. Thus, to hold down oil consumption and the resulting hydrocarbon and carbon monoxide emissions, our pricing policies must be revised to reflect all energy-related costs (Gibbons, Blair and Gwin 1989). In this context, to be a truly efficient pricing strategy, Winston's pricing proposal should be extended to include a carbon or climate protection tax based on Btus generated from burning coal and oil (Ruckelshaus 1989). Such a tax could have a more profound impact on the demand and supply of transportation services than the road wear and congestion charges proposed by the author.

Implementation Concerns

I have two basic concerns about how the strategy outlined by Winston will be applied for both environmental protection categories of infrastructure and transportation. The first deals with the social acceptability of some of his suggestions. The second deals with the application of pricing schemes, common in transportation, to the environmental field where pricing is less common.

The computer industry is full of examples of technologically feasible activities that consumers have just not accepted, such as banking by telephone or personal computer. The congestion pricing scheme suggested by the author may encounter such public resistance. Some would argue that as a nation we have shown a willingness to make personal sacrifices for economic or other security. For example, some argue that our consti-

tutional rights have been compromised by unreasonable airport searches instituted to reduce the risk of hijackings. More recently, some argue that random drug testing in order to secure safer transportation services violates the same rights. However, it is not clear whether individuals will condone the government monitoring individual travel patterns, as suggested by Winston, in order to receive a more accurate bill for their use of the nation's highway network. Will such a monitoring scheme, although it may be technically feasible, be socially acceptable? While the jury is still out on that issue in the United States, it is my understanding that after an initial trial period, a plan to make such a pricing scheme permanent was voted down by residents in Hong Kong.

Assume for the moment that technically feasible means of pricing are accepted. An important implementation issue is how to adapt such fees to the environmental area. It is generally agreed that a pricing strategy similar to that outlined by Winston will improve economic efficiency. That awareness has contributed to the growing acceptance by politicians and others of the notion (or at least the rhetoric) of market incentives as one way to address emerging environmental problems—problems associated with a large number of relatively small, dispersed polluters in contrast to the traditional command and control approach of dealing with a single large identifiable polluter.

Attention is now shifting toward how such strategies might be implemented. One level of concern focuses on the winners and losers from these policy initiatives. Such distributional issues contribute to current difficulties in producing a clean air bill (Hager 1990; Levin 1990). Winston identifies and addresses some distributional implications of his pricing strategy and discusses some potential remedies. However, the issue is more troublesome in the environmental area. The objective of the "polluter pays" principle is to reduce the production, use, and discharge of substances that harm the environment, by equating price with marginal social costs (Winston, this volume). Thus, losers from such a policy could go out of business or incur significant cost increases. Compensation, based on such increased costs, could effectively mitigate the incentive effects of a more efficient pricing policy.

A second concern is the administrative and compliance costs of implementing such economic incentives. For example, for effluent fees to have a meaningful impact on polluting activity, detailed data are required on the industry's cost curves and total releases. My understanding is that no such analysis has been performed to analyze the impact of Super Fund taxes on the chemical industry, or to justify the levels of excise taxes on ozone-depleting chemicals.

More analysis along the lines of Winston's transportation work needs to be done in the environmental area. This will require that significant amounts of detailed data be provided by the private sector and analyzed by

regulators. In addition, the use of tradable pollution prevention permits will require monitoring and enforcement of individual permits, which may change hands a number of times (Feitelson 1990).

A final concern is with the overall effectiveness of economic tools as implemented through a political process. Recent studies provide evidence that some tradable permit schemes have not worked as anticipated and do not lead to more efficient outcomes (Hahn 1989; Malueg 1989). These failures may be related more to how the program was designed and implemented than to the effectiveness of economic instruments generally. However, it is important to consider whether such economic incentives would require fees that would be politically unpalatable if set high enough to affect the behavior of a firm or individual, when new materials represent only a small portion of the cost of most finished products (Levin 1990).

This raises a fundamental question about the political feasibility of implementing an efficient infrastructure policy as outlined by Winston. In his paper he addresses one narrow dimension of the distributional consequences of such a policy, namely how to allocate the revenues generated under an efficient pricing scheme to mitigate the cost to some of the losers, for example low-income highway users, those shifting to mass transit, and others who face a higher cost of obtaining transportation services. However, the paper does not address the larger, and politically more significant, distributional issue of compensating those who lose when expenditures in the transportation area fall from an estimated $20 billion to $25 billion annually to $5 billion or $10 billion as estimated by Winston.[2] It is not clear what motivation a politician will have to step forward and promote such economic efficiency.

Conclusion

In the final analysis, the approach toward infrastructure issues taken by Winston is fundamentally sound and should be extended to other categories of infrastructure. In order to develop the sustainable economic development strategy necessary to support the ten billion people who will inhabit the world in the next century, our consumption of goods and services, including infrastructure services, must reflect the total social costs associated with that behavior. Winston's efficient pricing proposal can play an important role in that strategy, but it must

[2] The presentation of the numbers in the Winston paper is somewhat confusing. For example, he talks about an increase in highway investment of $1.3 billion, but then he adds that to the estimated $1.5 billion total investment for airports. Similarly, Table 1 is misleading to the extent that it represents expenditures and savings in a future year without any discussion of the costs and savings that would be experienced before that year is reached.

be extended to cover total social costs, not just congestion, pavement thickness, or noise. Similarly, before specific policy recommendations can be made regarding future funding requirements, a broader concept of social benefits must be developed that will reflect the total benefits of an adequate transportation network in a changing global economy. Only then will the nation have a truly efficient infrastructure policy.

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