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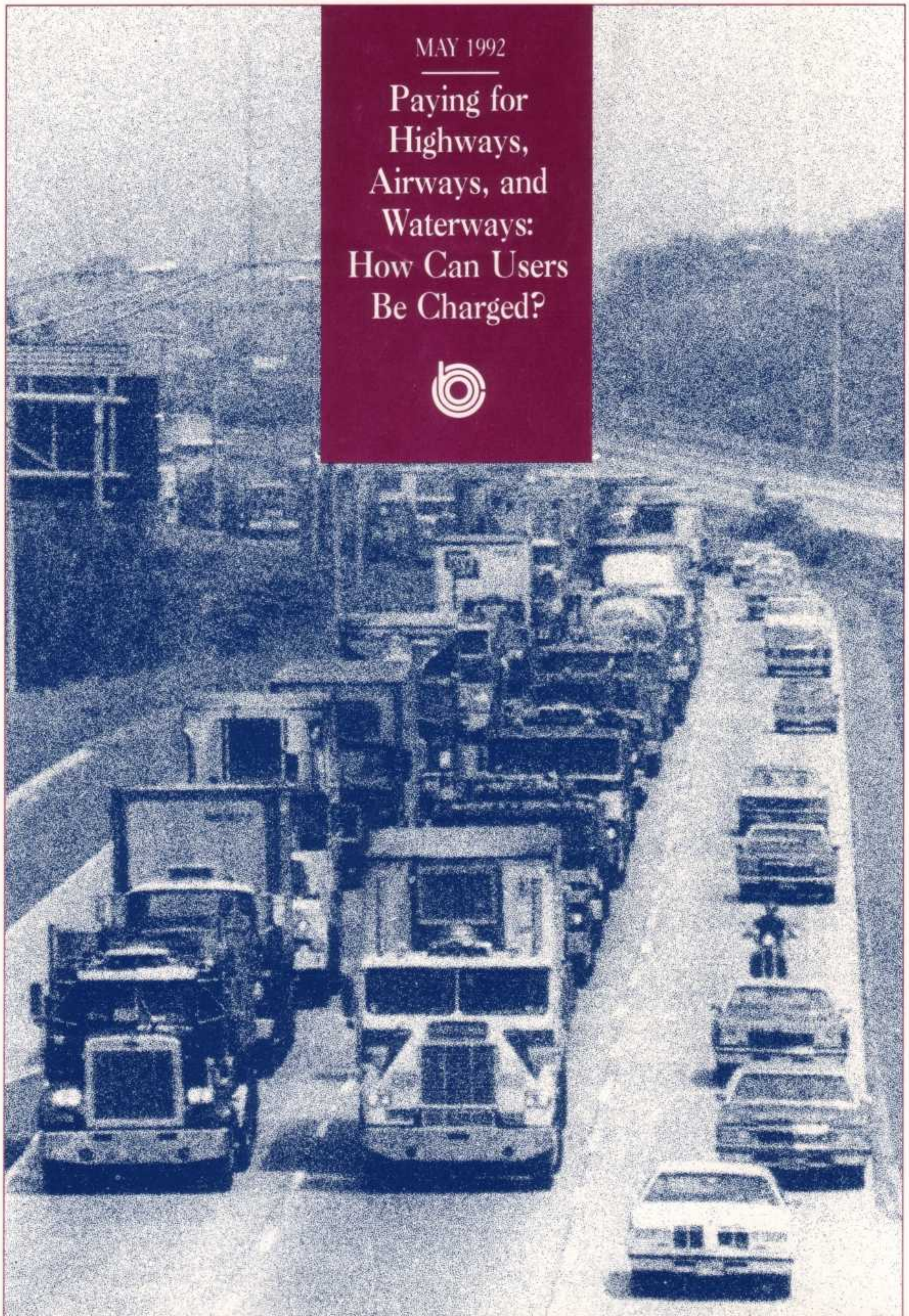
Paying for Highways, Airways, and Waterways: How Can Users Be Charged?



PAYING FOR HIGHWAYS, AIRWAYS, AND WATERWAYS: HOW CAN USERS BE CHARGED?

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NOTES

Unless otherwise indicated, all years referred to in this study are fiscal years.

Numbers in the text and tables of this study may not add to totals because of rounding.

Cover photo: A convoy of 18-wheel tractor-trailers on Interstate 91 in Connecticut in 1979. (UPI/BETTMANN)

Preface

The combination of budgetary pressures at all levels of government and increasing demands on transportation facilities has generated increased interest in directly charging users of highways, airways, and waterways. In response to a request from the Senate Committee on the Budget, this study examines the advantages and disadvantages of alternative user fee structures, including existing taxes. In keeping with the Congressional Budget Office's (CBO's) mandate to provide nonpartisan analysis, no recommendations are made.

Elizabeth Pinkston and Rajagopalan Kannan of CBO's Natural Resources and Commerce Division wrote the study under the supervision of Jan Paul Acton and Elliot Schwartz. Robert Arnold, Maureen Griffin, Theresa Gullo, Marjorie Miller, Linda Radey, Pearl Richardson, and Mitchell Rosenfeld of CBO offered insightful comments and criticism. The authors wish to thank George Antle, Dan Badger, John Fischer, Richard Golaszewski, Stefan Hoffer, Thomas Hopkins, Jeff Hornbeck, Jack Lane, Douglass Lee, James March, Daniel Taylor, William Vickrey, Jack Wells, and Clifford Winston for their helpful comments.

Sherwood D. Kohn edited the manuscript. Chris Spoor provided editorial assistance. Gwen Coleman produced numerous drafts of the study. Kathryn Quattrone prepared the report for publication.

Robert D. Reischauer
Director

May 1992

Contents

TABLES

FIGURES

BOXES

Summary

The methods of financing highways, airways, and waterways influence both the amount of revenue that can be raised and the efficient allocation of resources. The concept of revenue adequacy--whether revenues cover costs--is important to the cash-strapped federal government, but it also has implications for efficient allocation of resources in the long run. If the costs of an investment project cannot be recovered from those who use it, the project's feasibility comes into question. But an investment that benefits society is worth making, even though it may not be possible to charge users for it. This often characterizes goods and services provided by the federal government, and it underlies the rationale for government rather than private activity in certain sectors. Revenue adequacy can provide information about the demand by users for public investments, but it alone cannot be the criterion upon which investment decisions are made.

Economic efficiency is the second criterion by which financing mechanisms are evaluated. The standard definition of allocative efficiency is used here: does the price--the value consumers place on the product or service at the margin--equal the marginal cost--that is, the value of resources used in producing the last unit? If the price is less than the marginal cost, consumers tend to overuse the resource; if the price exceeds the marginal cost, they use it too little.

The objectives of revenue adequacy and economic efficiency sometimes conflict. Economic theory offers some ways of minimizing the trade-offs, and these are included in the discussions of alternative pricing mechanisms.

This study concludes that existing federal taxes produce enough revenue to cover current spending on the nation's system of highways. But the present highway tax structure is not as efficient as it could be. Some users--such as 13-ton single-unit trucks with three axles--pay taxes that exceed their marginal cost, while others--such as 40-ton tractor semitrailers with five axles--pay less than their marginal cost. An alternative approach that would include charging users according to the pavement damage and congestion they cause could cover costs and lead to greater economic efficiency.

Existing federal taxes do not meet the criterion of revenue adequacy for airways--the air traffic control system. As prescribed by law, aviation tax revenues cover all investment spending by the Federal Aviation Administration (FAA), but only part of the operating costs. Taxes paid by commercial air carriers appear to cover their costs, while those of general aviation fall short. Aviation taxes are not particularly efficient either, since they do not closely correlate with the costs of services provided by the FAA. Marginal-cost pricing of air traffic control services

probably could not raise enough revenues to cover costs. When combined with congestion charges, however, it might meet the criterion of revenue adequacy. This study examines ways of mitigating the trade-off between cost recovery and efficiency.

Existing fuel taxes raise less than 10 percent of spending by the Army Corps of Engineers for navigation purposes on inland waterways. On a systemwide basis, fuel taxes appear roughly equal to marginal costs, although a lack of data hinders a detailed analysis of costs. If the federal government could determine marginal costs with confidence and charge users accordingly, revenues would probably be about the same as now, falling far short of covering all costs. In relation to the amount of traffic they bear, some segments of the waterway system cost much more to operate than others. This finding suggests that users of low-cost waterways subsidize those of high-cost waterways. Many tow operators use both low-cost and high-cost waterways, however, thus complicating assessment of the amount of cross-subsidy.

Chapter One

Introduction

In recent years, the combination of budgetary pressures at all levels of government and increasing demands on transportation facilities has generated increased interest in directly charging users of public infrastructure. As a result, alternative ways of setting prices for the use of highways, airways, and waterways, and the advantages and disadvantages of different approaches, are of vital concern.

One key characteristic of the transportation infrastructure is that investments are costly, but once made can accommodate individual users at relatively low marginal costs (up to the point where congestion becomes important, after which the marginal cost rises steeply). Once a highway has been built or a waterway dredged, the cost of accommodating an additional automobile or barge tow is usually quite small. Thus, if users were charged a price equal to the marginal cost--the rule prescribed by economic theory to achieve efficiency in allocating resources--there would not be enough revenue to cover the total cost of the investment.

The dilemma is how to balance objectives of efficiency and revenue when they seem to conflict. Economic theory suggests pricing structures that allow revenues to be raised while preserving most of the economic efficiency derived from marginal-cost pricing. This chapter provides an introduction to the economic principles underlying these schemes.

Federal Financing of the Transportation Infrastructure

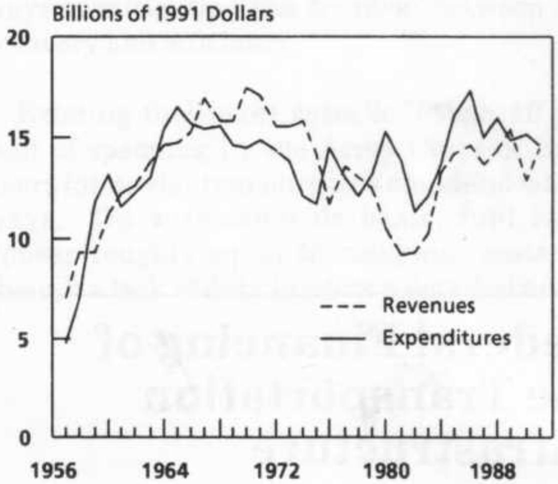
The federal government finances the construction and maintenance of highways, airways, and waterways through a mixture of general revenue funds and excise taxes levied on users. Over the past five years, federal outlays, in 1991 dollars, on these parts of the transportation infrastructure totaled $108 billion.[1] Revenues from excise taxes amounted to $91 billion. General revenues financed the balance of $17 billion. These total figures, however, do not show how much of the costs are recovered in each mode.

Figures 1, 2, and 3 show how trust fund revenues have correlated with expenditures since the formation of the highway, aviation, and inland waterway trust funds.[2] The high-

1. Outlays in a given year also include construction contracts signed in previous years for which money is now being spent. Thus, revenues collected in a year need not correspond exactly with the amount spent on users in that year. Over five years, however, the difference is likely to be smaller than in a given year.

2. As discussed in Chapters 2, 3, and 4, the laws governing the trust funds specify the kinds of spending that are authorized from them. For aviation and waterways, some kinds of spending are authorized from the general fund, not from the trust funds. The figures presented here simply compare spending with revenues from taxes related to use.

Figure 1.
Federal Highway Expenditures and Trust Fund Revenues, 1957-1991



SOURCES: Congressional Budget Office and "Historical Tables" of the *Budget of the United States Government: Fiscal Year 1992*. GNP deflator from the *Economic Report of the President, February 1991*.

NOTE: Figure 1 shows only revenues that go to the highway account of the Highway Trust Fund.

way trust fund began earmarking taxes for spending on roads in 1957, the aviation trust fund started in 1971, and the inland waterways trust fund began in 1980.

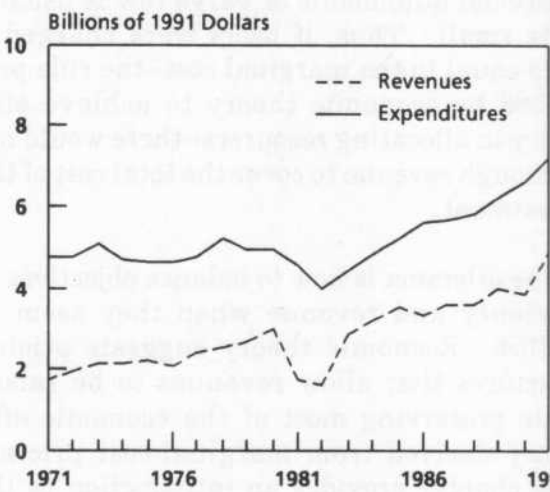
Highway tax revenues have been dependent on the state of the economy--falling, for example, during the recession of the early 1980s (see Figure 1). Spending on highways has fluctuated over the years because of a combination of economic conditions, changes in the scope of the highway program, and changes in the limits on obligations that could be incurred.

Aviation excise tax revenues, of which passenger ticket tax revenues formed the major part, dipped during 1981 and 1982 (see Figure 2). The reasons were a change in the ticket tax rate from 8 percent to 5 percent and the 1981-1982 recession.[3] Aviation expenditures remained at roughly the same level until 1986 (with a small drop in 1981 and 1982 because of the air traffic controllers' strike and its aftermath). Since then, spending has risen steadily, driven by the costs of developing and installing new technologies in air traffic control.

Tax revenues from traffic on inland waterways, shown in Figure 3, have remained about the same, in real terms, since the founding of the Inland Waterway Trust Fund. Spending on inland waterways declined in the early 1980s because of a hiatus for several years in the authorization of new construction projects. Spending rose after new authorization in 1986.

When expenditures are compared with trust fund revenues, federal spending on highways approximately balances federal revenues. Aviation revenues are consistently below expenditures. On a percentage basis, the inland waterway system is the most heavily subsidized of the three modes of transportation, although aviation is more heavily subsidized in absolute terms.

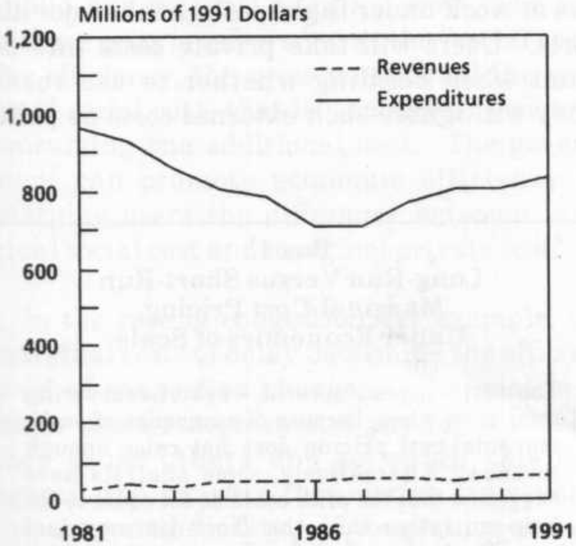
Figure 2.
Federal Aviation Expenditures and Trust Fund Revenues, 1971-1991



SOURCES: Congressional Budget Office and "Historical Tables" of the *Budget of the United States Government: Fiscal Year 1992*. GNP deflator from the *Economic Report of the President, February 1991*.

3. The dip in revenues during 1981 and 1982 was also caused by the expiration or decline of all other aviation excise taxes besides the passenger ticket tax between October 1980 and September 1982.

Figure 3.
Federal Inland Waterway Expenditures and Trust Fund Revenues, 1981-1991



SOURCES: Congressional Budget Office; Army Corps of Engineers, *1990 Inland Waterway Review* (draft); and "Historical Tables" of the *Budget of the United States Government, Fiscal Year 1991*. GNP deflator from the *Economic Report of the President, February 1991*.

Economic Efficiency and Other Goals

Economic efficiency is defined as the allocation of resources that produces the greatest satisfaction of wants within the constraints of scarce resources and technological limits. Resource allocation is considered efficient when no one can be made better off without making someone else worse off.

Cost recovery is also significant in deciding how to allocate resources, and it is especially important to deficit-ridden governments as they attempt to meet growing demands. The need to finance investment in the transportation infrastructure has led officials to seek ways of recovering a larger share of costs from users of the systems. Many previous studies have focused on cost recovery (or subsidy reduction) as the primary purpose of user fees. This study emphasizes economic efficiency and the trade-offs between efficiency and cost recovery.

Fairness is another issue. While efficiency is concerned with increasing the size of the resource pie, equity is concerned with its distribution. Changes in user taxes or user fees are likely to have different impacts on different users. It is important that the results be considered fair.

Finally, in government programs, administrative feasibility is a concern. A fee or tax system designed to increase economic efficiency may be so complex that the costs of collection and enforcement outweigh the benefits. Economic efficiency and administrative feasibility must be balanced.

The Role of Prices in Fostering Economic Efficiency

In a market economy, prices serve three key functions: they provide incentives for efficient allocation of resources, serve as a mechanism to recover the cost of production, and signal whether additional capacity is needed. If the price of a good or service is equal to the value of the resources used in producing it, resources are allocated to their most efficient use. If a good or service is provided free of charge or heavily subsidized, people tend to demand more of it and to use it more wastefully than they would if they had to pay a price that reflects its costs. The federal government can promote efficient and productive use of the goods and services it provides and controls by charging prices that reflect the cost of resources.

Designing user charges would be easier if a single fee structure could satisfy all of the objectives--namely, cost recovery, equity, and efficiency. Unfortunately, a fee structure that satisfies one or two of these objectives often violates the third. But the problem is not surprising. It is often an important reason for government to provide the good or service. If the private sector cannot recover costs by charging users, it usually will not provide the good or service. If society judges that the benefits from the good or service are great enough to justify the expenditure, it is left to the government to provide it.

The Prescription for Efficiency: Set Price Equal to Marginal Cost

To achieve efficiency, the price of a service should equal its marginal cost--or, to be more precise, its marginal social cost in the short run. (See Box 1 for a discussion of long-run and short-run marginal costs.) The marginal cost is the value of the resources used in producing one more unit of service.

On the demand side, users compare the price of a good or service with the expected benefit of buying an additional unit. If the price is greater than the marginal benefit, users will not buy it; if the price is less than the marginal benefit, they will. When the marginal benefit equals the price and the price equals the marginal cost, resources are allocated efficiently and consumer welfare is increased to the maximum. On the one hand, if users are charged less than the marginal cost, they may be encouraged to overuse the service. On the other hand, if users are charged more than the marginal cost, they will be discouraged from using the service, even though they are willing to pay the cost of the marginal unit. Either way, resources will be used inefficiently.

Externalities and Social Costs

Some of the costs of using infrastructure are not incurred directly by the user or producer but by other members of society. These are called "external costs" or "externalities." For example, an additional automobile on a crowded highway imposes costs of delay on other motorists. Motor vehicles emit pollutants that make the air less healthy for motorists and nonmotorists alike. Aircraft noise detracts from the quality of life of people who live or work under flight paths near major airports. Users will take private costs into account when deciding whether to use roads. They will ignore such external costs as pollu-

Box 1.
Long-Run Versus Short-Run Marginal-Cost Pricing Under Economies of Scale

The text suggests several ways of recovering total costs when, because of economies of scale, marginal-cost pricing does not raise enough revenue. Alternatively, some analysts have suggested that the price could be set equal to the long-run rather than the short-run marginal cost. The long run is defined as a period in which all inputs can vary--that is, a period during which capital investments can be adjusted to an optimal level. For instance, in the long run, a highway can be built to the capacity needed to satisfy demand. Since investment can be adjusted in the long run to achieve optimal size, it follows that long-run costs can be viewed as the lowest costs that might occur in the short run for a given capacity. But capacity is not always optimal in the short run. If a shortage of capacity leads to congestion, for instance, the short-run marginal cost will exceed the long-run marginal cost. The efficient price would equal the short-run marginal cost; if the price were set equal to the long-run marginal cost, the result would be even more congestion.

Advocates of charging prices equal to long-run marginal costs imply that this approach will cover investment costs, since the cost of investment is an increment of costs. But this incremental cost applies only to the first use of the new facility. For each successive use--for example, the second and subsequent automobiles on a highway after it has opened--the marginal cost continues to be low in relation to the cost of the investment. Charging the first user of the new highway the entire cost of building it clearly is not feasible.

To get around this problem, some analysts suggest assigning increments of new investment to groups of users and charging a kind of average incremental cost divided by the number of users. But this does not yield the efficiency associated with marginal-cost pricing. The source of the problem remains the increasing returns to scale. Once the fixed capital is in place, the marginal cost of one additional user is often very small.

tion and noise, however, and thus will use more than the efficient amount.

An efficient price must reflect the private, public, and external marginal costs. The sum of these costs is referred to as the "social cost." For efficiency, the price must equal the marginal social cost--that is, the cost to society of consuming one additional unit. The government can promote economic efficiency by charging users the difference between marginal social cost and marginal private cost.

In the case of congestion, for example, the marginal costs of delay determine the efficient level of congestion charges. The goal is to make users recognize and pay for the delay they cause others and to weigh this cost against the benefits they derive from using the congested facility. If congestion charges are set too high, the additional benefits will be outweighed by the price (to the user) and usage will fall below the amount that the facility could sustain. If the charge is too little, the system will be overloaded.

Joint Costs

Although some costs are clearly associated with certain services, many costs of transportation infrastructure are joint costs. Joint costs are those incurred in simultaneously producing more than one service. For instance, a dam may aid navigation and control flooding. After subtracting any costs that are clearly attributable to navigation and those that are clearly attributable to flood control, assigning the remainder of the cost to either purpose is essentially arbitrary.

How, then, could the government charge users for joint costs? If efficiency is the goal, there should be no charge, since the marginal cost is zero. If cost recovery is the goal, the government must devise a way of allocating costs. One widely advocated approach is to allocate costs according to the benefits received by each user or class of users. The Federal Highway Administration, the Federal Aviation Administration, and the Army Corps of Engineers have developed procedures for allocating joint costs among users of highways, airways, and waterways.

Taxes, User Fees, and Marginal Costs

Users of transportation infrastructure are taxed to help finance the facilities. These levies include taxes on gasoline, diesel, and other motor fuel; trucks and equipment; airline passengers and freight; fuel used by general aviation, and fuel used by tow operators on specified inland waterways. If these taxes closely reflected the marginal costs of infrastructure use, they would serve as good proxies for prices and would encourage efficient use. But existing taxes do not generally reflect the marginal costs. They raise revenues, but they do not necessarily provide the proper signals for efficient use. This does not mean that taxes are always less efficient than user fees. Taxes can be designed to be efficient, and user fees can be inefficient in design.

Although taxes imposed on users are sometimes called user fees, a distinction should be made between taxes and user fees. Taxes may or may not be closely related to the cost of using a facility; their primary purpose is to raise revenues. User fees, however, are more closely related to the cost of using a facility. For example, tolls are generally considered user fees, while excise taxes on fuels are considered just taxes.

Cost Recovery Under Economies of Scale

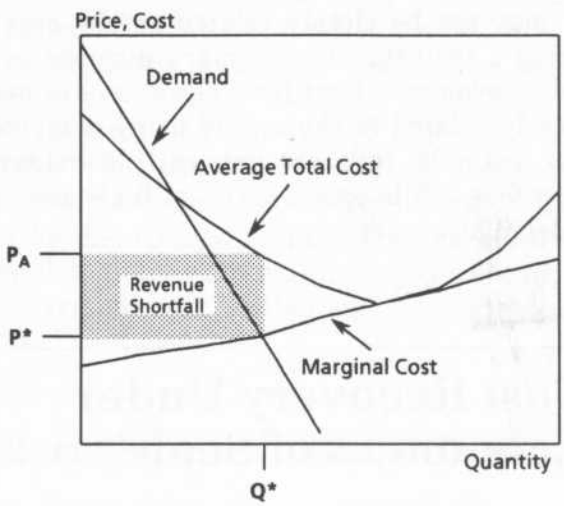
Transportation infrastructure is often characterized by economies of scale (see Box 2). Fixed costs tend to be large compared with marginal costs. The marginal cost of one additional automobile on an uncongested highway is quite small when compared with the cost of

Box 2.
Costs, Revenues, and Economies of Scale

"Economies of scale" means that the cost per unit falls as greater numbers are produced. One implication is that the marginal cost is less than the average total cost. Setting the price to be equal to marginal cost fails to cover the average total cost.

The cost structure of a firm characterized by economies of scale is illustrated in the figure below. The demand curve--which shows the quantity demanded at each price--intersects the marginal cost curve where the average total cost is greater than the marginal cost. The efficient quantity of output is shown as Q*, the quantity at which the demand (price) equals the marginal cost. But, as the figure shows, at this price and quantity, total costs (equal to quantity Q* times the average total cost of producing that quantity, shown as P_A) exceed total revenues (quantity Q* times price P*). The revenue shortfall is shown as a rectangle. The objective is to find a way of producing an efficient quantity while also covering total costs.

The Cost Structure of a Firm Characterized by Economies of Scale



SOURCE: Paul A. Samuelson and William D. Nordhaus, *Economics*, 12th ed. (New York: McGraw Hill Book Co., 1985), p. 525.

NOTE: The marginal cost curve intersects the average total cost curve at the latter's minimum point.

building and maintaining the highway. Once a waterway is dredged, the cost of one additional tow or ton-mile (the movement of one ton the distance of one mile) is small. One additional airplane in uncongested airspace imposes little cost on the air traffic control system. Because marginal costs are relatively low, charging a price equal to the marginal cost usually will not raise enough revenue to cover the total cost.

Deciding on a trade-off between efficiency and cost recovery when there are economies of scale is essentially a political choice. But there are ways of decreasing the inefficiencies of diverging from marginal-cost pricing while raising additional revenue.

General Subsidy

One way to recover costs is to charge users the marginal cost and make up any shortfall in revenues with subsidies from general government funds. This approach employs a simple pricing structure to encourage efficient use. One disadvantage is that the taxes used to raise general fund revenues may themselves distort incentives for efficiency. For example, individual income taxes--the source of 45 percent of federal receipts in 1991--may affect people's decisions about investing or dividing their time between work and leisure in ways that reduce productivity in the economy. Another disadvantage of using general revenues is that people who pay for something they do not use may perceive that financial policy as unfair.

Price Discrimination

Another approach to cost recovery is to divide users into different classes and charge them different prices. Airlines, railroads, telephone companies, electric and gas utilities, and other industries with large fixed costs practice price discrimination extensively. The idea is to charge a higher price to--and recover a greater share of costs from--users whose demand is relatively inelastic, while charging a lower price to attract marginal customers.

Ramsey Pricing

Ramsey pricing, which calls for charging users according to their elasticities of demand (the percentage change in the quantity demanded in response to a percentage change in price) is a technique that uses price discrimination.[4] It is a "second best" pricing rule in the sense that it departs minimally from the "first best" rule of price being exactly equal to marginal cost. Ramsey pricing increases economic welfare while meeting a revenue constraint (typically that the organization break even or earn a target rate of return). It is an efficient pricing mechanism because each use is charged a price that is as close as possible to the marginal cost of supply. Users who value a commodity most (as reflected by inelastic demand) receive larger adjustments to price in order to equate needed total revenue with total cost. Ramsey pricing transfers some of the consumers' surplus to the producer--in the case of highways, airways, and waterways, the federal government. It allows total costs to be covered while meeting the efficiency criterion of setting the price equal to the cost of the marginal unit.

Ramsey pricing has some disadvantages. One is the information requirement. Estimating different users' elasticity of demand is often difficult, as is administering a system that employs different prices for different users. Another disadvantage of Ramsey pricing is that it often cannot be sustained over the long run because users who are charged higher prices seek alternatives. When railroad rates were strictly regulated, for example, the relatively high rates charged for transporting manufactured goods induced many shippers to switch to trucks.

Users with inelastic demands might complain about the inequity of paying more for a service because they have the fewest alternatives. But as long as the price paid for each unit of output exceeds the marginal cost, all users benefit; the excess of price over marginal cost contributes to overhead costs and makes it possible to continue providing the service.

Two-Part Tariffs

A two-part pricing mechanism is still another way to handle the problem of high fixed and low marginal costs.[5] Users could be charged a flat rate--a kind of admission fee allowing them access to infrastructure--to cover the fixed costs and a per-use price to reflect the marginal cost. Barge companies, for example, could be charged a fixed fee for a license entitling them to operate on the inland waterway system (or part of the system) plus a fee per use reflecting the marginal cost.

This approach preserves the incentives for efficiency of marginal-cost pricing while raising revenue to cover fixed costs. One disadvantage might be a perception of inequity arising from the fact that all users would face the same fixed fee, regardless of whether they used the service regularly or only occasionally. Another disadvantage is that some users who might be willing to pay the per-use price might not be willing or able to pay the fixed fee. A two-part tariff loses efficiency if users who are willing and able to pay the marginal cost are denied service. These disadvantages could be tempered by allowing users

4. Frank Ramsey, "A Contribution to the Theory of Taxation," *Economic Journal*, vol. 37 (March 1927), pp. 47-61. See also William J. Baumol and David F. Bradford, "Optimal Departures from Marginal Cost Pricing," *American Economic Review*, vol. 60 (June 1970), pp. 265-283; Elizabeth E. Bailey and Lawrence J. White, "Reversals in Peak and Offpeak Prices," *Bell Journal of Economics and Management Science*, vol. 5, no. 1 (Spring 1974), pp. 75-92; and Stephen Brown and David Sibley, *The Theory of Public Utility Pricing* (New York: Cambridge University Press, 1986), p. 50. The last offers a numerical example as well as a complete exposition of Ramsey pricing.

5. For an early discussion of two-part pricing, see Walter Y. Oi, "A Disneyland Dilemma: Two-Part Tariffs for a Mickey Mouse Monopoly," *Quarterly Journal of Economics*, vol. 85, no. 1 (February 1971), pp. 77-90. See also Brown and Sibley, *The Theory of Public Utility Pricing*.

If existing infrastructure services are priced, the reaction of users can provide information about their demand for new services.

to choose between paying a large entry fee and low unit price, or no entry fee but a relatively high price per use.

Average-Cost Pricing

An alternative to marginal-cost pricing as a way of raising enough revenue to cover costs is to charge users the average cost of the services.[6] By definition, this approach ensures that total costs will be covered by revenues. But some efficiency is lost, since the average-cost price exceeds the marginal cost. Users who value an additional unit of service at more than the marginal cost but less than the average cost will not be willing to pay a price as high as the average cost. Thus, they will not buy more of the service, even though they place a higher value on it than it costs to produce. The resulting output will be less than the efficient amount.

The main advantage of average-cost pricing is that it raises enough revenue to cover total costs. It also may be perceived as equitable, since all users pay the same price for a service.

Equity Considerations

Adopting a more efficient system of user fees would probably have distributional consequences. Some users would wind up paying more, and some less, than they do now.

Economists use several concepts of equity in assessing taxes or user fees. One is that similarly situated individuals should be treated similarly. Another is that individuals who have more money should pay higher taxes than those who have less. A third concept of equity is that people who derive benefits from a service should pay for it.

Administrative Feasibility

One of the disadvantages of alternative pricing schemes is that they are difficult to administer. There are well-developed systems for collecting and enforcing taxes on users of transportation infrastructure. New administrative mechanisms would be needed if user fees reflected marginal costs.

As discussed in the following chapters, marginal costs associated with use of infrastructure have been estimated, but additional refinements would be desirable if the estimates were to be the basis for user fees. If the Congress expressed interest in pursuing cost-based user fees, however, researchers would probably step up their efforts to determine the efficient level of fees and to develop collection and enforcement mechanisms. Increased interest by policymakers in toll roads, for instance, has stimulated development of electronic toll collection, and the concern of the states about truck weights has prompted development of mechanisms to weigh trucks while they are moving at highway speeds. Efforts of states to comply with the Clean Air Act have generated research on the costs of vehicle emissions.

6. Where there are joint products, however, average costs cannot be precisely defined.

At the federal level, improved cost accounting is needed to generate the data that would make efficient charging possible. The Chief Financial Officers Act of 1990 calls for improved accounting systems and procedures. Although the focus is on financial management, the law also provides for developing and reporting cost information.

Finally, more information about the demand for transportation infrastructure would illuminate the expected responses to alternative pricing arrangements. This outcome would be especially helpful for designing efficient schemes of pricing and estimating the revenue impacts. Efficient prices also would help predict how users might change their patterns of use--including possible shifts between rail and barge or trucks and rail.

Efficiency in Investment

This study focuses on using prices to create incentives for efficient use of the existing infrastructure in the short run. But prices can also play a role in making efficient investments in new infrastructure.

Benefit-Cost Analysis

Investment decisions typically are guided by benefit-cost analysis, which estimates expected benefits and costs over the life of an investment. Estimating the benefits of a public investment project can be difficult, however, especially if indicators of demand--how much users are willing and able to pay--are not available. If existing infrastructure services are priced, the reaction of users can provide information about their demand for new services. The amount users are willing to pay to alleviate congestion delays, for instance, can suggest how expanding capacity would be beneficial.

In some cases, there may be an economic rationale for not charging users the full cost of the system. If an investment provides benefits to nonusers, such as economic development or national defense capabilities, the beneficiaries of these external benefits could be charged or taxed accordingly.

Charging for Prospective Investments Versus Past Investments

In considering efficient pricing mechanisms, a distinction should be made between existing capital and future investments. Past investments can be regarded as sunk; that is, whatever resources have gone into them have already been spent. What is relevant for economic efficiency is that prospective resource allocation be cost beneficial. If the marginal cost of using a past investment is zero, economic efficiency would require that users not be charged because even a small fee might cause use to decrease when the resource cost of doing so is less than the value. That would diminish efficiency.

This leaves open the question of whether the prospect of having to pay fees for using a new investment can help shape the demand for that investment. If users expect to pay fees for an investment, they may press more vigorously for an efficient investment than if it were paid for out of general tax revenues.

The Transition from Taxes and Subsidies to Prices

Any change in user fees could impose significant costs on whole industries or individual classes of users of transportation infrastructure. The questions then arise: how great would the difficulties of transition be, and what steps could be taken to ameliorate them?

The Costs of Transition

Many of the user fees considered in this study would not greatly increase the total economic burden on users. Since highway expenditures are already in balance with highway excise taxes, user fees would only redistribute the burden of its cost among the classes of users. Similarly in aviation, the revenues from passenger ticket taxes appear to cover the costs that commercial airlines impose on the aviation system.

For some groups, however, the burden of user fees would increase substantially. If asked to cover their costs, barge operators would face much larger fees than they now pay in fuel taxes. General aviation users would also face a steep increase in their operating costs if fees were set to recover the costs they impose on the aviation system.

In addition, many private-sector investment decisions are based on the existence of public subsidies, and imposing user fees to reduce these past subsidies could create difficulties. Barge operators on the inland waterway system have come to expect the subsidies they receive. Large increases in user fees could jeopardize some of their operations and the businesses of their suppliers and customers. Similarly, trucking companies have made decisions about investments in trucks and trailers in part on the basis of the current tax structure, as well as on federal and state policies regarding truck size and weight. If fees based on axle weight and distance traveled were imposed, trucking companies would incur the costs of altering their fleets to reduce costs.

Easing Transition Problems

Gradually imposing user fees could help such users to adjust to new cost conditions. Fees phased in over a period of years could allow users to absorb new operating costs. But phasing in user fees would delay the benefits of recovering federal costs and realizing gains in economic efficiency. Such delays, however, might be worthwhile if they would ease the transition to a system that would yield the net long-term gain to the economy that user fees on transportation infrastructure would deliver.

Conclusion

The economic principles set forth in this chapter provide a framework for assessing the current set of taxes imposed on users of transportation infrastructure. As discussed in the following chapters, the existing taxes fall short on the efficiency criterion. Alternative financing mechanisms that more closely resemble marginal-cost pricing could promote greater efficiency in infrastructure use.

Chapter Three

Airways

The federal government provides numerous services to owners and operators of aircraft to ensure safe flights through the nation's airspace. In 1991, the Federal Aviation Administration (FAA) spent an estimated $4.8 billion on air traffic control and related services and on supporting facilities, equipment, research, engineering, and development.[1] Revenues from taxes on passenger tickets, international departures, cargo, and fuel generated about $4.9 billion in 1991.[2]

The air traffic control system has been under increasing pressure in the past decade. Airline traffic has burgeoned under deregulation and overwhelmed the capacity of increasingly antiquated equipment used for tracking and communicating with aircraft. The FAA forecasts that takeoffs and landings by major air carriers and regional airlines will increase from the current level of 22 million annually to almost 30 million by the year 2000.[3] The result could be delays caused by congestion when the airports and air traffic control are unable to handle demand at peak periods. Assuming that the demand for aviation services continues to grow at current rates and that capacity or new technology does not, by the year 2000 congestion and bad weather together will account for 20,000 hours or more of delay annually at each of the nation's 41 major airports.[4]

In 1981, the FAA embarked on a major investment program to replace outmoded air traffic control facilities and equipment. The object was to achieve more efficient use of the nation's airspace by 1991. This program, originally called the National Airspace System (NAS) Plan and now called the Capital Investment Plan (CIP), is expected to expand the capacity of the air traffic control system and alleviate delays. But until the new equipment is in operation, the air traffic control system will face increasing challenges in handling the rising volume of traffic.[5]

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1. Total FAA spending in fiscal year 1991 was $7.2 billion. The difference of $2.5 billion includes grants to airports and funding for aviation safety regulations, aviation security, and management programs.

2. Aviation excise taxes are levied on users in the private sector only. Public-sector users such as the military are not charged for using the air traffic system, although they contribute to its costs. These costs are covered by the general fund of the U.S. Treasury. In this chapter, unless otherwise noted, public-sector users are treated on an equal footing with other users so that the FAA costs referred to include both private- and public-sector costs.

3. Committee for the Study of Long-Term Airport Capacity Needs, *Aviation System Capacity*, Special Report 226 (Washington, D.C.: Transportation Research Board, National Research Council, 1990), Table 1-1.

4. Delays are based on the difference between the time that a flight would take if it did not have to wait at gates or runways and the actual flight time. Air traffic controllers make judgments about the cause of delay and report delays that exceed 15 minutes. Schedule delays that occur because of mechanical problems are not counted as delays. For more on the two ways in which the FAA measures delays, see Committee for the Study of Air Passenger Service and Safety Since Deregulation, *The Winds of Change*, Special Report 230 (Washington, D.C.: Transportation Research Board, National Research Council, 1991), pp. 210-215; and Department of Transportation, Federal Aviation Administration, *1990-91 Aviation System Capacity Plan*, DOT/FAA/SC-90-1 (September 1990), pp. 1-11 to 1-16.

5. The Capital Investment Plan is a continuing series of projects and does not have a single completion date. Several major components of the plan are scheduled for completion by the year 2000.

Congestion can be considered a shortage; it occurs when more services--of the air traffic control system or airport landing space--are demanded than can be supplied at a given time and place. When there is a shortage of a good or service, the economic solution is to raise the price. Charging a higher price forces users to reevaluate their demand, and only those who value the good or service enough to pay the price will continue to demand it. If aviation users were charged extra for peak-hour use, some would shift to less busy times, thereby alleviating congestion at the peak periods.

Some observers argue that aviation system users should cover the entire costs of the FAA.

Pricing can do more for efficiency than just alleviate congestion. Even when the airways are not congested, each flight imposes costs on the air traffic control system. If users recognize these costs and factor them into their operational decisions, the air traffic system as a whole can become more efficient. The prices that users are willing to pay for air traffic control services can also serve as signals indicating which additional investments will have the greatest payoffs. These signals can help the FAA set priorities in phasing in new equipment.

In response to perceived inadequacies in the air traffic control system, some observers have proposed privatizing it. Although examining the merits of privatization is beyond the scope of this study, the discussion in this chapter of alternative pricing mechanisms suggests some of the problems.

The proposals for privatization indicate how much the aviation system has advanced since the days when the federal government's policies were chiefly designed to promote air travel. The federal government continues to subsidize aviation from the general fund of the U.S. Treasury. Revenues from taxes imposed on aviation users over the past five years contributed about 60 percent of the FAA's total annual spending--including safety regulation and grants to airports--and 80 percent of estimated spending for air traffic control services. In light of the large federal budget deficit, there appears to be increasing sentiment for aviation users to pay the entire cost of the services they receive.

One argument in favor of continuing subsidies to aviation is that the safety of the aviation network can be considered a public good because even nonusers of planes face catastrophic consequences if there are accidents. It is difficult to charge users for the well-being of communities located below their flight path; therefore, a federal subsidy to help airlines and other users minimize the dangers to nonusers on the ground may be justified.

Background

The airway system, also called the air traffic control system, is designed to ensure the safe movement of aircraft through the nation's airspace. It includes traffic control at and between airports, weather advisories, and other services to help pilots plan their routes. Excluded from consideration in this study are federal aid to airports and such nontraffic-related FAA activities as certifying aircraft and pilots, setting safety standards, and other headquarters activities.

Why Are Airports Not Included?

Airports are not generally considered part of the air traffic control system. They are run by state or municipal governments, and the federal role is limited to providing grants-in-aid.

Federal actions can affect efficiency at airports, however. Terminal congestion can be reduced by expanding capacity and using existing capacity more efficiently. In addition, air traffic control (ATC) services are linked with runway capacity, so if that capacity is inadequate, ATC will also be constrained. It is more likely, however, that the greatest payoff from federal activity lies with efforts to improve air traffic control technologically and to find appropriate prices for ATC services.

The Users of the Air Traffic Control System

For purposes of this study, the direct users of the air traffic control system are the operators of commercial and private aircraft, not the passengers or freight carried by the aircraft. The aircraft is the element whose safe movement is of concern to air traffic controllers, regardless of who or what is on board. A study of airport costs would have to consider passengers (as well as pilots and other employees) as users, since they impose demands directly on airport facilities that entail costs to the airports.

The Services that the Federal Government Provides to Aviation

The major components of FAA spending include operations and capital improvements (see Table 7). About 55 percent of the FAA's outlays in 1991 were spent on operations. The largest component of that spending was for the air traffic control system. The FAA's capital spending is divided almost evenly between the Airport Improvement Program, which provides grants to airports, and facilities and equipment (F&E) used to keep track of aircraft and guide them safely to their destinations. A small amount of capital spending goes for research, engineering, and development (RE&D) to find ways of improving the FAA's air traffic control services.

The FAA's outlays for air traffic control services include all expenditures for F&E and RE&D plus spending on five categories of operations that seem most directly related to operating the air traffic control system: operation of the traffic control system, National Airspace System logistics support, design and management, maintenance of traffic control, and leased telecommunications services. The federal budget does not show outlays for these individual components of ATC. It does, however, show obligations, and since outlays track obligations over time, they can be used to

Table 7.
Federal Aviation Administration and Air Traffic Control Spending, Fiscal Year 1991 (In millions of dollars)

	Amount	Percentage of Total
Capital Account		
Airport Improvement Program	1,541	21
Air traffic control		
Facilities and equipment	1,512	21
Research, engineering and development	179	2
Subtotal	3,232	45
Operations Account		
Air traffic control share of operations[a]	3,063	42
Non-air traffic control share of operations[a]	950	13
Subtotal	4,013	55
Total	7,241[b]	100
Memorandum:		
Spending on Air Traffic Control	4,754	66[c]

SOURCES: *Budget of the United States Government, Fiscal Year 1993*, Appendix One, p. 746 and Table 12, p. 128.

a. Estimate from Table 12 on p. 128.

b. Includes a credit of $3 million for the Aviation Insurance Revolving Fund.

c. Percentages may not add up to subaccount totals because of rounding.

show the composition of spending on air traffic control. The estimated amount spent by the FAA on air traffic control in 1991 is shown in Table 7.

Some observers argue that aviation system users should cover the entire costs of the FAA. But the costs that are relevant to this study are those that relate directly to air traffic control. Therefore, federal grants to airports, administration of safety regulations, and headquarters services are excluded for the purposes of this analysis.

The services provided by the FAA for a typical flight begin well before takeoff and continue until the pilot has turned off the "fasten seat belts" sign at the airport gate. Air traffic controllers and other skilled personnel perform these services at a variety of facilities including:

- o Flight service stations;
- o Airport traffic control towers;
- o Terminal radar approach control facilities; and
- o Air route traffic control centers.

Flight Service Stations (FSS). FAA personnel at flight service stations help pilots plan their flights. They provide weather predictions, maps, and other information that helps pilots select the best routes and altitudes for their particular aircraft. The flight service stations are especially useful for general aviation--corporate jets and pleasure aircraft--which relies heavily on the FAA. Large commercial air carriers typically have their own sources of information and use their own computer models to determine the best flight paths. Airlines file flight plans electronically with air route traffic control centers. Therefore they do not use many FSS services.

Airport Traffic Control Towers. Airport tower traffic controllers are responsible for the safe movement of aircraft on the ground and in the air within a few miles of an airport. They direct departing aircraft from gates, along taxiways, to runways, and give permission for takeoff. After an aircraft is airborne, the tower controller relinquishes control to another controller who then tracks it by radar in the terminal radar approach control facility (TRACON). For incoming aircraft, the process is reversed; the tower controller directs the aircraft from the time it is relinquished by the TRACON controller until it is parked at the arrival gate.

Tower controllers observe the movements of aircraft from glassed-in enclosures high enough for them to see the airport's runways and taxiways. Thus, they can track aircraft both in the air and on the ground.

The FAA is buying new equipment to monitor aircraft on the ground more effectively and to provide warnings of potential collisions. For instance, better equipment might have prevented recent accidents in Los Angeles, where a commercial jet and a small commuter aircraft collided on a runway, and in Detroit, where a pilot lost in fog taxied onto a runway from which another jet was taking off.

In 1989, the FAA operated control towers at about 400 airports, including all major commercial terminals. Many small airports used primarily by general aviation do not have towers.

Terminal Radar Approach Control Facilities. Once an aircraft is airborne, the tower controller hands it over to the controller in the TRACON, who monitors it on radar, guides it some 30 to 50 miles out from the airport, and then relinquishes responsibility to a controller at an air route traffic control center (ARTCC). For incoming flights, the TRACON controller receives control of an aircraft from an ARTCC controller and guides it until it is close enough for the tower to take over.

At hub airports, many aircraft arrive at about the same time from one direction, and after an interval for unloading and loading passengers, depart en masse on continuing flights. For example, a number of flights from the East Coast may arrive at a hub within minutes of each other, give passengers three-quarters of an hour to catch connecting flights, and take off for the West Coast. At such times, TRACON controllers face tremendous pressures in lining up the aircraft on approach paths and keeping them safely separated. In areas with several fields, one TRACON is usually responsible for aircraft approaching and leaving all the airports. For instance, the TRACON at Chicago's O'Hare International Airport is also responsible for traffic at Midway, Meigs, and several other smaller airports in the region.

There are 188 TRACONS in the continental United States, all of which employ highly sophisticated tracking and communications gear. The FAA is trying to upgrade the facilities and equipment at all TRACONS as part of its long-term capital investment plan.

Air Route Traffic Control Centers. Controllers at ARTCCs monitor and guide aircraft until they near their destination and are handed to the local TRACON. The FAA operates 22 ARTCCs throughout the country, and together they cover virtually all of the nation's airspace.[6]

An aircraft may be handled by more than one ARTCC in the course of its flight.[7] A flight from Washington to Chicago, for example, is passed from the local TRACON to the Washington ARTCC at Leesburg, Virginia. From there it is passed along to controllers in the Cleveland, Indianapolis, and Aurora, Illinois, ARTCCs before being directed by the TRACON at O'Hare.

Commercial carriers constituted about half the operations handled by ARTCCs in 1988. The balance were general aviation, commuters, and government (mainly military). General aviation pilots may elect not to use the services of ARTCCs when flying in good weather under visual flight rules.

As sophisticated as ARTCC radar and communications equipment is, it is still inadequate under certain conditions. When the system begins to get overloaded, traffic controllers must juggle demands, directing aircraft to change altitude or course, or asking neighboring ARTCCs or TRACONs not to send any more aircraft to their sector until congestion eases. With better equipment, provided under the FAA's capital investment plan, the ARTCCs can handle more operations without sacrificing safety. At some facilities the newer equipment will require fewer controllers, thereby lowering operating costs as well. (See Table 8 for the traffic associated with each type of facility organized by class of user.)

In addition to airport towers, TRACONs, and air route centers, the FAA operates a central flow control facility that monitors aviation activity nationwide. Its purpose is to smooth the flow of traffic from sector to sector across the country. If, for instance, late-afternoon thunderstorms in New York City bring operations to a standstill even for a short period, waiting aircraft queue up in the air and on the ground. In order to minimize the number of circling airplanes, the FAA's flow control facility issues instructions to keep on the ground those bound for New York until they can be safely accommodated at their destination.

The Federal Aviation Administration's capital investment plan was launched in 1981 as the National Airspace System Plan to modernize the FAA's equipment and facilities. As it replaces outmoded and overloaded computers and communication equipment, the FAA will be able to manage many more operations than it can now. But the program has encountered numerous technical difficulties and

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6. Some airspace used for testing aircraft or conducting training missions is under military control.

7. As used by air traffic controllers, a "handle" consists of an instrument flight rules entry and departure from a sector and the guiding of an aircraft over the sector controlled.

Table 8.
Operations Conducted by the Federal Aviation Administration in 1990, by Facility and Class of User (In millions of operations)

	Operations by User Class									
	Commercial Carriers		Commuters and Taxis		General Aviation[a]		Public Sector		Total	
Facility	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Operations	Percent
ARTCC	18.5	49	5.6	15	7.9	21	5.5	15	37.5	100
ATCT[b]	12.9	20	8.8	14	39.0	21	2.8	4	63.5	100
FSS[c]										
Pilot briefs	n.a.	n.a.	n.a.	n.a.	11.5	47	n.a.	n.a.	n.a.	n.a.
Instrument flight plans	n.a.	n.a.	n.a.	n.a.	5.3	22	n.a.	n.a.	n.a.	n.a.
Visual flight plans	n.a.	n.a.	n.a.	n.a.	1.6	7	n.a.	n.a.	n.a.	n.a.
Air contacts[d]	n.a.	n.a.	n.a.	n.a.	6.1	25	n.a.	n.a.	n.a.	n.a.
Total	n.a.	n.a.	n.a.	n.a.	24.5	100[e]	n.a.	n.a.	n.a.	n.a.

SOURCE: *FAA Aviation Forecasts, Fiscal Year 1992-2003*, (February 1992) Chapter X, Tables 27, 32, 34, and 35.

NOTES: ARTCC = air route traffic control centers; ATCT = air traffic control towers; FSS = flight service stations; n.a. = not applicable.

a. Data on flight service stations, pilot briefs, instrument flight plans, visual flight plans, and air contacts apply only to general aviation.

b. The FAA has consolidated the information from air traffic control towers and terminal radar approach control facilities in recent years.

c. These services are used predominantly by general aviation. No breakdown by user class is given.

d. An air contact is a radio communication between an aircraft and a controller at the flight service station.

e. Total may not equal 100 because numbers are rounded.

is well behind its original schedule.[8] Although originally expected to cost $12 billion, the cost of the plan is now estimated at $27 billion.[9]

While the CIP is being carried out, charging users according to the costs they impose on the traffic control system could serve two purposes: it could help alleviate congestion and could suggest which elements of the plan would yield the greatest benefits and should be given top priority.

8. The General Accounting Office has published a series of reports on the NAS Plan, including *Air Traffic Control: Challenges Facing FAA's Modernization Program*, GAO/T-RCED-92-34 (March 1992); *Air Traffic Control: Status of FAA's Effort to Modernize the System*, GAO/RCED-90-146FS, (April 1990); *Issues Related to FAA's Modernization of the Air Traffic Control System*, GAO/T-RCED-90-32, (February 1990); and *Continued Improvements Needed in FAA's Management of the NAS Plan*, GAO/RCED-89-7 (November 1988).

9. Committee for the Study of Air Passenger Service, *The Winds of Change*, p. 297.

Current Financing Policy

The FAA gets its money from two sources: the general fund of the U.S Treasury and a set of aviation excise taxes. Almost all of the revenues from the aviation excise taxes are deposited in the Airport and Airway Trust Fund (AATF), from which the FAA makes all capital and some operations expenditures.[10] The AATF serves as a dedicated source of funding for the aviation system and facilitates comparing the amount of tax revenues collected from aviation sources and the amount of federal spending on aviation activities.

When the trust fund was established in 1970, it was intended to finance investments in aviation and, if funds were available, to help finance operations. Early attempts by the Nixon Administration to restrict capital spending while using the trust fund to finance operations led the Congress to impose limits on the amount of spending on operations that can be financed by the trust fund.[11] This study is concerned with both capital and operations spending for air traffic control; however, it does not consider the current legislative and institutional constraints on sources of financing for the different activities.

The Tax on Passenger Tickets

The federal government taxes passenger tickets at 10 percent of the ticket value for domestic flights on commercial airlines.[12] In 1991, revenues from the ticket tax were $4.3 billion and accounted for 88 percent of total revenues from aviation taxes (see Table 9).

Although the tax on passenger tickets raises substantial amounts of revenue, it does not effectively promote efficiency. To begin with, it does not correspond closely to the FAA's cost of handling a passenger aircraft through the air traffic control system. The cost to the FAA is linked to the movement of the airplane, not the passenger. To air traffic controllers, it does not matter whether an airplane is empty or full; they handle it the same way and it imposes the same costs on the system. With the wide variety of discount fares available to passengers, moreover, ticket prices--and the resulting taxes--paid by different passengers on the same airplane may vary widely.[13]

Table 9.
Aviation Excise Taxes, 1991
(In millions of dollars)

	Amount	Percentage of Total
Passenger Ticket Tax[a]	4,341	88
Freight and Waybill Tax[b]	222	5
Fuel Tax[c]	140	3
International Departure Tax[d]	217	5
Refund of Taxes	-10	[e]
Total	4,910	100[f]

SOURCE: *Budget of the United States Government, Fiscal Year 1993*, Appendix One, p. 749.

a. Tax rate of 8 percent in 1990 on the value of domestic passenger tickets. The rate changed to 10 percent on December 1, 1990.

b. Tax rate of 5 percent in 1990 on the value of air cargo shipments. The rate changed to 6.25 percent on December 1, 1990.

c. Twelve cents per gallon of aviation fuel and 14 cents per gallon of jet fuel used by general aviation in 1990. The fuel charges changed to 15 cents and 17.5 cents per gallon on December 1, 1990.

d. Six dollars per person on international flights effective January 1, 1990.

e. Tax refunds were less than one percent of taxes collected.

f. Percentages do not add up to 100 because numbers are rounded.

10. The revenues from the increase in taxes on aviation fuels enacted in the Omnibus Budget Reconciliation Act of 1990 for the period December 1, 1990, through December 31, 1992 remain in the general fund. Thereafter, these revenues are dedicated to the Airport and Airway Trust Fund.

11. The AATF is described in detail in a Congressional Budget Office special study, "The Status of the Airport and Airway Trust Fund" (December 1988), and a CBO Staff Memorandum, "The Effects of Alternative Assumptions about Spending and Revenues of the Airport and Airway Trust Fund" (July 1990).

12. Title 26, U.S. Code, Section 4261(a). The rate increased from 8 percent to 10 percent on December 1, 1990, under provisions of the Omnibus Budget Reconciliation Act of 1990.

13. In April 1992, airlines began experimenting with simplified fare structures. The smaller variation in ticket prices implies passenger ticket taxes for the same flight will not vary so widely in the future.

A commercial airliner departing from Washington National Airport imposes the same demands on airport tower and TRACON personnel regardless of whether it is carrying business passengers paying full fare and bound for New York, vacationers paying discount fares and bound for Florida, or a mix of passengers bound for Dallas. But the total fares and taxes paid may vary greatly among those flights. For these reasons, the passenger ticket tax is not likely to serve as a good index to the FAA's cost.

It would be only coincidental if the aviation excise taxes equaled marginal costs.

There are, however, some factors that affect air traffic control costs, ticket prices, and ticket taxes in the same way. Ticket prices are usually higher for long flights than for short ones; correspondingly, air traffic control costs are higher for flights that pass through many sectors of airspace and make intermediate stops that require extra handling by controllers. Airplanes that operate when the air traffic control system is busiest and congestion costs are highest are likely to be filled with business travelers paying full fares--and correspondingly high taxes. These effects are coincidental, however; they do not reflect an intentional effort to tie passenger taxes to costs imposed on the aviation system.

International Departure Tax

The federal government levies an international departure tax of $6 a passenger on every international flight originating in the United States. The tax applies to commercial flights on both domestic and foreign carriers.[14] Revenues in 1991 were $217 million, about 4 percent of revenues from aviation-related taxes. Because the international departure tax, like the passenger ticket tax, is imposed on passengers rather than on aircraft, there is no reason to expect that it would closely reflect the FAA's costs for handling international flights. The cost to the FAA of handling a large jet is the same regardless of whether it is carrying 300 passengers, paying a total of $1,800 in departure taxes, or just 150 passengers, paying a total of $900 in taxes. In addition, the tax does not reflect congestion costs.

Freight Waybill Tax

Freight transported within the United States by commercial air carriers is subject to a tax of 6.25 percent of the waybill.[15] Revenues were $222 million in 1991, about 5 percent of total revenues from aviation excise taxes. The waybill tax does not necessarily correspond to the services provided by the air traffic control system, but it comes closer than the taxes on passengers. Air freight rates typically depend on the size, weight, distance traveled, and time sensitivity of the shipment. Some freight is carried in the cargo holds of passenger aircraft, while other freight moves on dedicated planes. Often the dedicated aircraft, such as those of Federal Express or United Parcel Service, operate at night. This pattern eases the demands imposed on the air traffic control system by peak-hour passenger flights, but it may increase the number of controllers on duty at night.

Aviation Fuel Tax

Fuel used by general aviation is subject to an excise tax of 15 cents a gallon for aviation gas-

14. Title 26, U.S. Code, Section 4261(c). The tax increased from $3 on January 1, 1990.

15. Title 26, U.S. Code, Section 4271. Until December 1, 1990, the rate was 5 percent.

oline and 17.5 cents a gallon for jet fuel.[16] Revenues from these taxes were $140 million in 1991, about 3 percent of total revenues from aviation excise taxes.

Of all the aviation excise taxes, fuel taxes are most likely to correlate closely with costs imposed on the airway system, since fuel use is linked with distance traveled. Still, a small airplane flying between two small airports serving only general aviation and lacking control facilities would place few demands on the system--the pilot might check the weather with the flight service station and file a flight plan--but the same airplane flying the same distance (and using the same amount of fuel) between congested airports would cost the system much more. The fuel taxes paid would be the same for both flights.

The relationship between fuel taxes and costs is even more important. Although fuel taxes may be more closely correlated with costs than other aviation excise taxes, taxes do not necessarily cover costs. Total revenues raised from passenger ticket taxes may come much closer to covering the ATC costs associated with commercial airline transportation than do fuel tax revenues to covering ATC costs associated with general aviation. As for marginal costs, it would be only coincidental if the aviation excise taxes equaled marginal costs--a condition for efficiency.

The Relationship of Taxes to Costs of ATC

In 1991, aviation tax revenues were $4.9 billion, while spending to equip, operate, and maintain the air traffic control system was estimated to be $4.8 billion. The FAA's airport improvement program received $1.5 billion of aviation tax revenues. During the last five years, FAA outlays for the ATC system averaged $4.2 billion annually, while revenues from aviation excise taxes were $4 billion.

Cost allocation studies by the FAA estimate that the public sector is responsible for about 15 percent of FAA costs.[17] If aviation activity by the public sector is considered separately from that of private users, FAA costs to private users would be reduced by 15 percent. Assuming that private-sector users were responsible for 85 percent of estimated ATC costs (about $4.1 billion in 1991), aviation excise taxes would have been sufficient to cover ATC expenses. But it should be kept in mind that the excise taxes are used for other expenditures such as grants to airports. In 1991, private users imposed total costs of about $6.2 billion on the FAA. The result was a shortfall in cost recovery of about $1.3 billion.

Taxes Paid and Costs Imposed, by User Class

Different classes of users are taxed in different ways and impose different costs on the air traffic control system. Some studies have been undertaken to determine the relative costs and tax revenues and to discover whether some users are subsidizing others. As with highways, two approaches have been taken. One is the top-down approach, which allocates all FAA costs--including those not directly associated with air traffic control--among the various classes of users. An alternative, bottom-up approach has been taken by Gellman Associates (Richard Golaszewski in particular), who estimated the marginal costs of individual operations by users from different

16. Title 26, U.S. Code, Section 4041(c). Until December 1, 1990, the rates were 12 cents a gallon for aviation gasoline and 14 cents a gallon for jet fuel. In 1991, $14 million of revenue from the fuel tax--the projected amount attributable to the tax increase--will remain in the general fund, as provided by the Omnibus Budget Reconciliation Act of 1990.

17. Daniel Taylor, *Airport and Airway Costs: Allocation and Recovery in the 1980s*, FAA-APO-87-7 (Washington, D.C.: National Technical Information Service, February 1987), p. 8.

Table 10.
Marginal Costs of Air Traffic Control Services in 1985 (In 1985 dollars)

Facility Type	Activity Measure	Air Carrier	Commuter	General Aviation	Public Sector
Air Route Traffic Control Center	Total handles[a]	13.93	13.93	12.63	21.30
Terminal Radar Approach Control	Operation, seconds and over[b]	12.80	12.80	3.44	12.80
Air Traffic Control Tower	Operation[c]	7.91	1.86	1.44	4.45
Flight Service Station[d]	Pilot briefs	6.86	6.86	6.86	6.86
	IFRFP	6.86	6.86	6.86	6.86
	VFRFP	13.68	13.68	13.68	13.68
	Air contacts	3.87	3.87	3.87	3.87

SOURCE: Richard Golaszewski, "The Unit Costs of FAA Air Traffic Control Services," *Journal of the Transportation Research Forum*, vol. 28 (Arlington, Va.: Transportation Research Forum, 1987), pp. 13-20.

NOTE: IFRFP = instrument flight rules flight plan; VFRFP = visual flight rules flight plan; air contacts = a radio contact between the pilot and the flight service station.

a. In a "handle," a controller receives an aircraft operating under instrument flight rules from a terminal radar approach control facility (TRACON). The controller then guides the aircraft through airspace that the air route traffic control center is monitoring, and hands it over to a TRACON.

b. A TRACON operation occurs when the plane lands at the primary airport associated with the TRACON. Seconds and overs refers to aircraft that have traveled to another airport and were handed over to another TRACON or airport control tower.

c. An air traffic control tower operation is defined as a landing or takeoff by an aircraft.

d. The costs of the various flight service station services were the same for all users.

classes.[18] The marginal cost approach is more relevant to this chapter, since the focus is on efficiency.

Marginal Costs: The "Bottom-Up" Approach

Understanding the costs associated with use of the air traffic control system entails breaking down aircraft operations into the parts that use FAA services.

18. Richard Golaszewski, "The Unit Costs of FAA Air Traffic Control Services," *Journal of the Transportation Research Forum*, vol. 28 (Arlington, Va.: Transportation Research Forum, 1987), pp. 13-20.

Marginal Costs to the FAA. It is difficult to determine the marginal costs of services provided by the air traffic control system. A typical flight makes use of a variety of services, each of which imposes a marginal cost on the FAA. The study by Richard Golaszewski estimated the marginal costs of various FAA services provided to different classes of users (see Table 10). In some cases, the estimates of marginal costs were identical for different classes of users, such as handlings by TRACONs of air carriers, commuters, and government flights, because the available data did not distinguish among them statistically. (See Box 3 for an explanation of how Golaszewski used econometrics to estimate the marginal costs.)

Golaszewski's estimates do not distinguish between peak and offpeak marginal costs. The FAA is likely to incur greater costs at peak hours because more controllers are needed to direct additional traffic, but it is not clear whether peak traffic raises marginal costs to the FAA. It is clear, however, that in peak periods additional aircraft impose additional marginal costs in the form of delays on other users of the system.

Box 3.
Using Econometrics to Measure Marginal Costs

The relationship between costs and units of FAA service can be estimated by linear regression techniques.[1] One study by airline analyst Richard Golaszewski used sites as his reference points: an air route traffic control center, a terminal radar approach control center, an airport traffic control tower, or a flight service station. For each type of facility, he regressed the cost of operating the site against the numbers of operations of the different classes of users--air carriers, commuters, general aviation, and the public sector. The estimated coefficient for each class of users is the marginal cost of that class, and the constant term in each estimated equation represents the fixed cost--not specific to any individual class of users--of the facility. The marginal costs of facilities are estimated, although because of data limitations, capital costs (buildings and air traffic control equipment) are not represented in the marginal cost coefficients. Underlying the cross section statistical analysis is the assumption that each facility is the optimal size for the work it does.

Although Golaszewski's estimates of marginal costs are somewhat out of date--they are based on 1985 data--his work provides a methodology that can be used to calculate marginal costs and show roughly the size of marginal costs compared with total costs of the air traffic control system. Golaszewski estimates marginal costs to be between 20 percent and 40 percent of total costs; the other 60 percent to 80 percent of costs include joint costs at the various sites, equipment maintenance not allocated to the sites, general overhead, and capital spending on facilities and equipment and research and development.

1. Richard Golaszewski, "The Unit Costs of FAA Air Traffic Control Services," *Journal of the Transportation Research Forum*, vol. 28 (Arlington, Va.: Transportation Research Forum, 1987), pp. 13-20.

Marginal Costs to Other Users. When the aviation system is not congested, the marginal cost is the addition to the total cost to the FAA of handling one additional user. Alternatively, the marginal cost is the cost that could be avoided if the additional use was forgone. With congestion, however, the marginal cost includes additional costs of delays experienced by other users. When the airways system is congested, each additional user increases the time that others must wait before being served.

Congestion Costs. When the system is congested, the costs of delay may be large. At these times, only users who value the service very highly, such as aircraft carrying a couple of hundred business passengers, will be willing to pay the high social marginal cost. Users who place less value on flying into a congested airport at a busy time will be encouraged to make alternative arrangements. For example, general aviation users can shift to a less congested airport, and general aviation or commercial aircraft carrying a high proportion of vacation travelers whose time is more flexible than that of business travelers can choose other travel times. In that way, congestion at peak hours will be alleviated.

Congestion can also impose high costs on the airlines if delays are severe enough to interfere with their schedule of operations. Late arrivals into hub airports, for example, can produce a domino effect, spreading delays throughout the system.

Numerous studies have estimated the value that travelers place on their travel time--or, in other words, how much they would be willing to pay to get to their destinations more quickly. On the basis of these studies and its own research, the FAA estimates that the average value of time for business trips is $44.24 an hour. For nonbusiness trips, the estimated value is $38.03 an hour.[19]

19. These values are expressed in 1991 dollars and are derived from FAA's estimates of $37.06 for business and

(Continued)

Consider, for example, a flight departing from a busy airport during the late afternoon peak. Each aircraft added to the queue awaiting clearance for takeoff contributes to delays for aircraft behind it in line. If there are five aircraft in the queue, each carrying 100 passengers who value their time at $40 an hour, and if the average delay is 6 minutes (0.1 hour), the first aircraft imposes a delay cost of $1600 on the other four. Similarly, the second aircraft in the queue causes congestion costs of $1200, the third $800, and the fourth $400. If surcharges corresponding to these amounts were imposed for takeoffs at the peak hour, some aircraft--particularly those with fewer passengers or more vacationers with discounted fares--would probably shift their flights to less congested, less costly hours.

The delay time is the same regardless of the type of user; a corporate jet would impose the same delay cost on others as a larger airplane.[20] To promote efficiency, the congestion charge should be the same regardless of aircraft type or user class. At offpeak hours, when there are no queues, the delay cost and congestion charge would be zero.

Bad weather heightens delays. Maintaining an extra margin of safety when visibility is low requires keeping aircraft farther apart than in clear weather. This step reduces the number of aircraft that the air traffic control system can handle in a given period of time. Pricing for congestion would highlight the cost of delays at specific locations and would help locate places where improvements in the air traffic control system would reduce delays.

The FAA has estimated that congestion and delays add about $5 billion annually to the airline operations. It is unlikely that charging users for the congestion they cause would raise that much in revenues. The revenues that could be expected from congestion pricing are more likely to be between $1 billion and $2 billion.[21]

Environmental Costs. Pollution is another social cost that should be taken into account. Noise pollution is an important factor in an airport's decision to increase the number of runways and operations. Air pollution from jet fuel may need to be priced as traffic expands. At present, however, there is stronger agreement among analysts about the practicability of pricing for congestion than for other social costs.

To achieve efficient use of the system, users should be charged the sum of the marginal cost to the FAA and the marginal cost of delays and pollution. This total is called the marginal social cost.

Comparison of Revenues Raised from Taxes and Marginal Costs for Selected Types of Flights

The FAA's Cost Allocation Study concluded that some classes of users pay more than their

19. Continued

$31.86 for nonbusiness trips (in 1987 dollars), using the consumer price index. The estimates from studies reviewed by the FAA ranged from $20 an hour for military business travelers to $140.47 an hour for general aviation travelers using turbine powered aircraft, and from $26.97 an hour (for domestic passengers on commercial air carriers) to $210.71 an hour (for general aviation travelers using turbine powered aircraft) for nonbusiness trips. The high-end estimates accounted for a very small percentage of all users. See Stefan Hoffer and others, *Economic Values for Evaluation of Federal Aviation Administration Investment and Regulatory Programs*, FAA-APO-89-10 (Federal Aviation Administration, October 1989), p. 11.

20. There may be some differences in delay time for various types of aircraft because of the need to provide proper spacing between aircraft.

21. This range of revenues from pricing for congestion at crowded airports is based on some assumptions. The FAA found that in 1988, commercial airlines experienced delays of more than 20,000 hours at each of 21 airports. The passengers on these aircraft (about 100 passengers per aircraft) might have been willing to pay for reducing the amount of delay. Depending on how much congestion is deemed optimal, how much congestion is due to weather, and how much time is worth to passengers, the revenues from charging these passengers could vary from $1 billion to $2 billion. For the FAA estimates of the value of time to passengers, see footnote 19 in this chapter. In 1989, bad weather accounted for 57 percent of all delays.

share of costs and some pay less (see Box 4).[22] One can also ask whether individual aircraft are paying enough to cover the marginal costs they impose on the system. The most efficient use of the system occurs when the price is equal to the marginal cost.

There is, of course, no typical flight with which marginal costs and tax revenues may be compared, but a commercial airline flight from Washington, D.C., to Chicago will serve as an illustration. As it moves through various portions of air space, the flight imposes marginal costs on each ATC facility it traverses. Using Golaszewski's 1985 estimates, if those costs rose at the same rate as the gross national product (GNP) deflator, the cost would be about $135 in today's dollars. If the aircraft carried 100 passengers paying an average of $150 apiece, the passenger ticket tax (10 percent of the ticket price) would yield revenues of $1,500 for the trip.[23] If the flight were filled with full-fare business passengers, the tax revenues would be much higher; if it were carrying mostly tourists paying deep-discount fares, revenues would be lower.

If the aircraft carried freight instead of passengers, tax revenues would depend on the size of the waybill, which in turn would depend on such shipment characteristics as volume, weight, fragility, and priority.

A general aviation aircraft flying from Washington to Chicago would make somewhat different demands on the air traffic control system, depending on whether it went by instrument (IFR) or visual flight rules (VFR). If the aircraft followed IFR, the cost to the air traffic control system would be about $105. If it followed VFR rules, the cost would drop to $30. A small plane for transporting executives might use about 250 gallons of aviation fuel, paying a tax of 17.5 cents a gallon, thus yielding about $45 in total revenues.

22. Taylor, *Airport and Airway Costs.*

23. Most passenger carriers also carry freight, in addition to passengers' baggage. Revenues from the waybill tax should be included in total revenues.

It is therefore possible that a general aviation aircraft, not maintaining much contact with the ATC, may pay more in aviation excise taxes than its marginal cost. But if it operates under IFR, it could pay much less.

Although there is no average or typical experience, these examples help illustrate that the existing tax structure does not reflect marginal costs to the FAA. As a result, users of the system get no signals encouraging efficient use.

Alternative Financing Mechanisms

As the preceding discussion suggests, the present system of aviation excise taxes does not provide strong incentives for efficient use of the airways. The taxes imposed on each user group do not reflect marginal costs, and total revenues from all aviation taxes are insufficient to cover the FAA's costs for air traffic control services. Moreover, cost allocation studies suggest that some classes of users pay more of their share of the costs than others. Are there alternative financing mechanisms that would provide incentives for efficient use of and investment in the airways?

Marginal Cost Pricing

One option is to charge each user the marginal cost of using the airways. Charging users the social marginal cost provides incentives for efficient use of the system. Users who value the service enough to pay the costs associated with it will use it, while those who do not will find alternatives.

The marginal costs estimated by Golaszewski could serve as a starting point for setting efficient prices for users of the air traffic control system. Users could be charged a price equal to the marginal cost of each service they received. Charges could be based on the

Box 4.
The "Top-Down" Approach

FAA Cost Allocation Study

The Federal Aviation Administration periodically conducts studies to allocate costs among users. (See the table at right for the findings of the FAA's most recent cost allocation study.)[1] The main user classes are air carriers, general aviation, and the public sector. The air carrier class as a whole did not pay all the costs for which it was responsible. Passengers on domestic airlines paid more in ticket taxes than the air traffic control costs caused by the planes carrying them. But the commuter subclass had a deficit per operation of $108.82, and the deficit per operation for international flights was $32.33.[2]

The general aviation deficits and deficits per operation are substantial. Turbine-engine aircraft generated the largest deficit per operation ($111). Piston-engine aircraft flew a large number of operations--more than three times the number of domestic commercial flights--thereby generating the largest overall deficit.

Since the revenues for the public sector come from the general fund, revenues from aviation charges cannot be compared with the costs generated by the public sector. An alternative approach assumes that taxpayers pay for two kinds of aviation costs: the cost of public sector aviation and the cost of making up the deficit of the other users. About $704 million is associated with public-sector users. The remaining $887 million (shown as the surplus of the public sector in the table) is a subsidy by the general taxpayer to the other users of aviation infrastructure.

To summarize, the FAA found that in 1985 taxes paid by all users of the aviation system did not cover the FAA's cost of providing aviation services. But tax revenues from domestic air carriers exceeded their FAA costs. Commuter carriers and all categories of general aviation contributed substantially less in tax revenues than their costs.

Methodology of the Study

The FAA study analyzed all aviation system costs--including the airport grant program, regulatory activities, and administrative overhead--not just air traffic control, since the purpose was to determine how much users of the entire aviation system pay and how much the FAA spends on their behalf. The study is thus concerned more with equity than efficiency--whether users are paying their fair share of the costs they impose.

The FAA study's general approach was to determine which costs were attributable to each user group. If a given FAA activity was directly linked to just one user group, such as commercial passenger carriers, the study assigned all the costs of that activity to that user group. If an FAA activity was performed for all types of aviation, the study allocated the joint costs according to several criteria, including each group's use of the aviation system, the marginal costs associated with each group, and a markup based on the elasticity of each group's demand. Overhead and other indirect costs not associated directly with operations were assigned to users in much the same way as direct joint costs.

The FAA study used two methods of allocating joint costs--that is, those that cannot be directly attributed to any individual user group. The first--the "full-cost allocation method"--allocated joint costs among all the user groups. The second--the "minimum general aviation allocation method"--allocated joint costs only among commercial and government users. This method regarded general aviation (GA) as marginal users of a system that would be in place anyway to serve commercial aviation, and so it allocated to GA users only the costs directly attributable to them. The costs attributed to GA under the minimum GA allocation method correspond to the marginal costs of GA as a class.

The costs reported in the table reflect the full-cost allocation method. Even under the minimum general allocation method, however, none of the categories of general aviation was found to contribute more revenues than its costs. That is, even under this method, which minimizes the costs attributed to it, general aviation does not pay its way.

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1. Daniel Taylor, *Airport and Airway Costs: Allocation and Recovery in the 1980s*, FAA-APO-87-7 (Washington, D.C.: National Technical Information Service, February 1987).

2. When analyzing tax revenues, the FAA classifies air taxis as general aviation because they are subject to the fuel tax imposed on general aviation. Passengers who hire air taxis are not subject to the passenger ticket tax. When counting numbers of operations, however, the FAA includes air taxi operations with commuter air carriers.

Allocating Aviation Infrastructure Costs to Users and Revenues Collected from Users, 1985

	Cost (Millions of dollars)	Revenues (Millions of dollars)	Deficit (Millions of dollars)	Number of Operations (Millions)	Cost per Operation	Tax per Operation	Surplus or Deficit per Operation
Air Carrier							
Domestic	2,176.0	2,419.0	243.0	9.03	240.88	267.78	26.90
International	121.2	108.3	-12.9	0.40	303.75	271.42	-32.33
Freight	122.9	134.1	11.2	0.70	175.46	191.45	15.99
Commuters	713.0	89.8	-623.2	5.73	124.50	15.68	-108.82
Total	3,133.1	2,751.2	-381.9	15.86	197.55	173.47	-24.08
General Aviation							
Air Taxi	131.7	12.7	-119.0	2.96	44.56	4.30	-40.26
Piston	683.0	23.5	-659.5	30.48	22.41	0.77	-21.64
Turbine	520.2	60.9	-459.3	4.14	125.70	14.72	-110.98
Rotor	63.8	3.0	-60.8	2.12	30.03	1.41	-28.62
Total	1,398.7	100.1	-1,298.6	39.70	35.23	2.52	-32.71
Commuter and Air Taxi	844.7	102.5	-742.2	n.a.	n.a.	n.a.	n.a.
Air Carrier and Air Taxi	3,264.8	2,763.9	-500.9	n.a.	n.a.	n.a.	n.a.
Public Sector	703.8	1,591.0	887.2	3.09	228.01	228.01	287.42
with No Subsidy	703.8	703.8	0.0	3.09	227.77	0.0	0.0
Total (Carriers plus general aviation plus public)	5,235.6	4,442.3	-793.3	58.65	89.27	75.75	-13.53
Without Subsidy	5,235.6	3,555.1	-1,680.5	58.65	89.27	60.62	-28.65
Alternative Cost Allocation: Minimum General Aviation Allocation							
General Aviation							
Air Taxi	48.3	12.7	-35.6	1.53	31.61	n.a.	-23.30
Piston	323.6	23.5	-300.1	30.62	10.57	n.a.	-9.80
Turbine	186.1	60.9	-125.2	4.10	45.34	n.a.	-30.50
Rotor	21.8	3.0	-18.8	2.21	9.86	n.a.	-8.50
Total	579.8	100.1	-479.7	39.64	14.62	n.a.	-12.10

SOURCES: Congressional Budget Office calculations and Daniel Taylor, *Airport and Airway Costs: Allocation and Recovery in the 1980s*, FAA-AP087-7 (Washington, D.C.: National Technical Information Service, February 1987).

n.a. = not applicable.

operation of the aircraft and the expected use of the control facilities. But charging for each contact with the ATC may be costly to audit, and operators might skimp on such contacts, thus decreasing the safety of the airways.

Examples of Attempts at Marginal Cost Pricing

Although the FAA could, in principle, impose charges for congestion as a way of allocating scarce capacity of the air traffic control system, in practice such charges have been attempted only by airport authorities in connection with landing fees. From the economic standpoint of allocating scarce resources efficiently, it does not appear to matter which unit--the airport or the FAA--imposes the congestion fee, although both would be concerned about who gets the revenue.

Two attempts to impose congestion charges have had very different receptions. In 1968, the Port Authority of New York and New Jersey (PANY) imposed surcharges for peak-hour use by small aircraft at Newark, Kennedy, and LaGuardia airports.

PANY raised the peak-period minimum takeoff or landing fees for aircraft with fewer than 25 seats from $5 to $25, while keeping the off-peak fee at $5. Larger aircraft did not have to pay the fee but continued to be assessed according to their weight. Peak hours were defined as 8 a.m. to 10 a.m. on Monday through Friday and 3 p.m. until 8 p.m. on all days of the week. The PANY case demonstrated that peak/off-peak pricing differences were administratively feasible.

As a result of the surcharges at the New York and Newark airports, general aviation activity decreased by 19 percent overall and 30 percent during peak hours. The percentage of aircraft operations delayed more than 30 minutes declined markedly.[24]

The Aircraft Owners and Pilots Association (AOPA) took legal action in 1969 to have the fees canceled. The core of AOPA's argument was that the fee was openly discriminatory and infringed on the equality of access to air facilities. AOPA argued that PANY could not distinguish among aircraft from the point of view of their right of access to these public airport runways for landing and taking off, and that even if PANY had such a power, the present fee system was discriminatory.

The United States District Court found in favor of the Port Authority, ruling that the defendants were justified in distinguishing different classes of aircraft, on the grounds of safety and efficient use of landing facilities.[25] The court further recognized that the fee was meant to induce aircraft operators to use other times of the day or other facilities.

The PANY experience contrasts with that of an attempt by the Massachusetts Port Authority (Massport), the agency in charge of Boston's Logan airport, to reduce congestion by increasing landing fees for smaller aircraft. In 1988, Massport proposed a new formula for calculating landing fees. The formula was intended to reduce use by general aviation aircraft that were contributing to congestion. The main difference between the PANY surcharge and Massport's fee was that Massport's applied during both peak and off-peak periods. The authority's old fee was based solely on landing weight--$1.31 per thousand pounds with a $25 minimum. The new formula consisted of a relatively high base charge for landing--$88--and a smaller charge based on weight--47 cents per thousand pounds. The new fees resulted in smaller aircraft paying more than before and larger aircraft paying less (see Table 11).

The state of Maine and several associations complained that the new fee structure discriminated against general aviation. The U.S. Department of Transportation filed a suit

24. Office of Technology Assessment, *Airport System Development* (August 1984), pp. 118 and 131-132.

25. *Aircraft Owners and Pilots Association v. Port Authority of New York and New Jersey*, 305 Federal Supplement 93, S.D.N.Y. (1969).

Table 11.
Old and New Fees at Boston's Logan Airport for Selected Aircraft

Type of Aircraft	Weight (Pounds)	Old Fee (Dollars)	New Fee (Dollars)
Beechcraft Bonanza F33 A/C	3,400	25.00	89.60
Boeing 737-200	107,000	140.17	138.29
McDonnell Douglas DC-10	421,000	551.51	285.87
Heaviest Aircraft Paying Minimum Under the Old Fee	19,000	25.00	96.93

SOURCE: *Investigation into Massport's Landing Fees, Opinion and Order.* Federal Aviation Administration Docket 13-88-2; and Federal Trade Commission, *Proposed Comment on Massport's Program for Airport Capacity Efficiency,* Memorandum (February 18, 1988).

against Massport charging that the new fee structure unduly discriminated against small aircraft. An administrative law judge found that the new fee structure was unreasonable and contrary to federal statute and ordered Massport to revert to its old fee schedule. The judge also commented that "it would have been more credible for Massport to have adopted the surcharge type fee that the Port Authority of New York has imposed for peak hour small aircraft usage at Newark, La-Guardia, and Kennedy airports . . ."[26]

Revenues from Marginal-Cost Pricing

Since charging users their marginal costs is economically efficient, the next issue is how much revenue can be raised from marginal-cost pricing. In 1985, if users had been charged the marginal costs estimated by Golaszewski, revenues would have been about $1.1 billion.[27] The corresponding revenues in 1991 would have been about $1.4 billion.[28] The estimated revenues could be less if airlines raise ticket prices to pass on some of the marginal costs to consumers. This could reduce the demand for flights and hence the revenues.

How do these revenues compare with total spending on the air traffic control system? FAA spending on air traffic control services is broken down in Table 12 into operations, facilities and equipment, and research, engineering, and development; the table also shows the estimated revenues from marginal cost pricing and total outlays during 1985 and 1991.

Table 12 shows that marginal-cost pricing would have failed to recover costs of operations or total air traffic control costs in 1985 and 1991. The estimates of spending on ATC were derived from the amounts obligated, and spending for operations was based on assump-

26. *Investigation into Massport's Landing Fees, Opinion and Order,* FAA Docket 13-88-2 (1988), p. 9.

27. Golaszewski, *The Unit Costs of FAA Air Traffic Control Services,* Parts I-III.

28. This estimate was calculated by converting the 1985 marginal cost for each service to 1991 dollars using the GNP deflator. The costs were then multiplied by the number of operations, pilot briefs, air contacts, times the aircraft was handled, and so forth, for each user class at each type of facility in 1991. The estimate assumes that public-sector users are paying the marginal costs for their use of the air traffic control system. This assumption is valid here because the intent of this section is to compare total ATC expenditures with the possible revenues from marginal-cost pricing. The information on air traffic control activity for 1991 is contained in various tables in the *FAA Aviation Forecasts,* 1992-2003.

Table 12.
A Comparison of Spending on Federal Aviation Administration Air Traffic Control with Revenues from Marginal-Cost Pricing (In millions of 1991 dollars)

Category	Amount 1985	Amount 1991
Total Federal Aviation Administration Outlays	5,061	7,241
FAA Spending for Air Traffic Control[a]		
Operations	2,671	3,063
Facilities and equipment	523	1,512
Research, engineering, and equipment	322	179
Total	3,516	4,754
Estimated Revenues from Marginal-Cost Pricing, Excluding Congestion Pricing	1,308	1,399
Difference (Between FAA spending on air traffic control and revenues from marginal-cost pricing, excluding congestion revenues)	2,208	3,355
Estimated Revenues from Marginal-Cost Pricing, Including Congestion Pricing	n.a.	2,900
Difference (Between FAA spending on air traffic control and revenues from marginal-cost pricing, including congestion revenues)	n.a.	1,854

SOURCES: Budgets of the United States Government, Fiscal Years 1987 and 1993; FAA Aviation Forecasts, February 1992; FAA cost allocation model; and CBO calculations.

NOTE: n.a. = not applicable.

a. Estimated spending on air traffic control operations, research engineering, and development and facilities and equipment. The calculations were based on FAA's cost allocation model and number of operations at FAA facilities in 1985 and 1991.

tions about which operational activities are most closely related to the ATC system.[29] The FAA budget does not explicitly separate spending for air traffic control from such other spending as programs for safety, activities at headquarters, and other aviation activities that do not impinge directly on air traffic control.

The difference between FAA spending on ATC and revenues from marginal-cost pricing, excluding congestion revenues, increased from $2.2 billion in 1985 to $3.4 billion in 1991. The rise is partly explained by the increase in capital spending by the FAA during this period. Since capital expenditures are not usually counted as part of marginal costs, revenues would not have increased correspondingly.

29. Obligations for ATC operations are fairly close to outlays. Obligations for facilities and equipment, which can be commitments to spend on capital for many years into the future, can differ greatly from outlays, which are monies paid out during the year to contractors, possibly for work obligated in the past.

Problems with Marginal-Cost Pricing

The advantages in efficiency of marginal cost pricing must be weighed against several drawbacks. First, estimating marginal costs is not easy. Although Golaszewski has shown one way to estimate marginal costs, he cautioned that he had to make certain assumptions about use of capacity and other specific characteristics of the various facilities be studied. He apparently was unable to obtain enough data to distinguish between peak and off-peak periods, to determine whether marginal costs to the FAA varied by time of day.

It is likely, however, that congestion costs have a stable component that can be used to set fees that do not vary unpredictably. Users would benefit from stable fees when making their decisions about when to use the system.

A second problem is how to administer a system of marginal-cost charges. Although the FAA keeps detailed records of aircraft handled, a system of billing commercial air carriers and general aviation for their use of FAA services would have to be devised.[30]

Finally, the estimates made by Golaszewski and the FAA's cost allocation study suggest that if users were charged only the component of marginal costs incurred by the FAA, revenues would not cover the FAA's costs of operating the air traffic control system. With additional charges for congestion, revenues might be sufficient to cover total costs, but distributional problems might arise if excess revenues from congested locations were used to cover costs at those that were not congested. Thus, it could be argued that the commercial air carriers and their passengers, who would pay the lion's share of congestion charges, would be subsidizing owners of private aircraft.

Congestion charges could be levied on aircraft at airports. Using the average value of time for aviation users, and the FAA's estimates of delays at congested airports, the revenues from congestion fees would be around $1 billion to $2 billion, an amount that could increase estimated revenues from marginal-cost pricing to between $2.4 billion and $3.4 billion.[31]

This estimate is subject to several qualifications. If congestion is a local phenomenon--that is, a crowded airport at New York can coexist with an uncongested airport in Iowa--the fees would be collected only at congested airports.[32] In addition, if airlines are required to pay these charges, they will pass on some of the costs to consumers, reducing congestion, demand for flights, and, consequently, the revenues from congestion charges. Finally, if the FAA is successful in making needed improvements at airports, congestion at the major airports would decline, reducing the estimated revenues from congestion fees.

If the purpose of congestion fees is to reduce congestion to an acceptable level, revenues from pricing for congestion could be used to finance improvements in capacity at congested airports. It has been estimated that increases in IFR arrival capacity at the top 25 airports (by number of operations) will require about $825 million.[33] The expected revenues of $1 billion to $2 billion from congestion fees could be used to finance these improvements and air traffic control as well.

Whether marginal-cost pricing covers total costs does not matter for the efficient allocation of resources in the short run, but it has long-run implications for investment decisions. Revenues greater than cost add strength to arguments that more spending is warranted on air traffic control. The excess of revenues over costs is likely to be greatest where the most congestion delays are experienced--and thus where investments to reduce delays would be most valuable.

If marginal-cost pricing would never yield enough revenue to cover the total costs of some activities, additional investment may or may not be justified. Cost-benefit analysis might help guide the investment decision. The gen-

30. The countries in the European Community are trying to put in place a single air traffic control system. It appears that collecting user fees in this system is administratively feasible. See Gellman Research Associates, *Towards a Single System for Air Traffic Control in Europe* (Jenkintown, Pa.: Gellman Research Associates, September 1989).

31. Department of Transportation, *1990-91 Aviation System Capacity Plan*, Table 1-5, p. 1-16.

32. Delays at a hub airport can cause delays throughout the system.

33. Committee for the Study of Long-Term Airport Capacity Needs, *Aviation System Capacity*, Table 3-5. These projects should lead to about 230 additional hourly IFR arrivals at those airports.

eral rule is that if users would be willing to pay for the investment--whether or not they are actually charged to cover its total cost--the investment is worth undertaking.

Charging to Recover Total Costs

Even if charging all users the marginal cost of air traffic control services does not yield enough revenue to cover costs, there are several ways to make up this shortfall:

- o Ramsey pricing;
- o A subsidy from the general fund;
- o Raising existing aviation excise taxes; and
- o Raising marginal costs proportionately to the percentage of total costs.

Ramsey Pricing

Applying Ramsey pricing to air traffic control services entails lowering or raising charges according to the reactions of users to price changes. Classes of users who would cut back sharply on their consumption of ATC services in response to a price increase would be charged either the marginal cost or only a small markup over it. (If charged the marginal cost, they would not fly less; a small markup would cause them to cut back.) Price markups would be higher for those users who were less sensitive to price increases--those who would continue to fly nearly as much as before, even if prices rose considerably. The difference between the price they would pay and the marginal cost for each unit would help cover the overhead costs.

This approach has different distributional consequences from simply charging marginal costs because some users would face higher prices than others. Commercial airlines probably would be less responsive to price changes than general aviation.[34] If so, under Ramsey pricing they could be expected to pay more for ATC services than general aviation.

Charging Marginal Cost and Making Up Revenue Shortfalls from the General Fund

Another way to cover the costs of air traffic control while maintaining the advantage of marginal-cost pricing is to draw on the general fund of the U.S. Treasury to make up any difference between total costs and revenues from marginal cost pricing. In 1991, as Table 12 shows, the estimated contribution from the general fund would have been about $3.4 billion. If congestion charges had also been levied, the subsidy would have been about $1.9 billion.

Charging Marginal Cost and Making Up Revenue Shortfalls with Existing Aviation Excise Taxes

In 1991, marginal-cost pricing would have yielded revenues of about $1.4 billion. Aviation excise tax revenues were about $4.9 billion. Thus, a combination of revenues from marginal-cost prices and taxes would have more than covered the $4.8 billion spending on FAA air traffic control. Revenues would be even higher if congestion charges were included in marginal costs. The surplus would then have been available to cover some of the FAA programs outside of ATC, primarily the Airport Improvement Program, which required outlays of $1.5 billion.

34. In its cost allocation study, the FAA assumes that general aviation users are twice as sensitive to price changes as commercial airline users. See Department of Transportation, Federal Aviation Administration, Office of Aviation Policy and Plans, *Allocation of Federal Airport and Airway Costs for FY 1985* (December 1986), Appendix A, pp. 5-9.

These numbers assume that users of the air traffic control system would not have cut back on use after paying the user fees. If they did cut back significantly, both fees and expenses would be less than the amounts given above. This option also assumes that the various aviation groups would agree to pay both the taxes and user fees for ATC when they had been paying only taxes for such services.

Increasing Current Taxes Proportionately to Cover All Costs

This option dispenses with the efficiency of marginal-cost pricing; its sole objective is cost recovery. What aviation tax rates in 1993 would cover estimated total FAA outlays (FAA spending on both ATC and airports) for the private sector? Assuming that public-sector users account for 15 percent of FAA costs, total FAA outlays on the private sector in 1993 are estimated to be $7.3 billion. The tax rates in 1993 and the rates needed to recover these outlays are shown in Table 13. It is assumed that the ratio of each tax collected to the total tax collected remains the same. For example, since the passenger ticket tax receipts are about 88 percent of total taxes collected in 1991, the new rate of 13 percent yields about the same percentage of FAA outlays on the private sector.

The advantage of financing all costs through aviation excise taxes is that subsidy of private-sector users by the general fund would be eliminated. In addition, the misleading surplus in the trust fund would no longer grow. This surplus makes it appear that total FAA outlays have been less than aviation excise tax revenues. In fact, operations costs have been partly subsidized by the general fund, and therefore such a conclusion is unwarranted.[35] Finally, the federal deficit would be reduced by the amount now coming from the general fund to finance the costs imposed by private users.

If one of the objectives of the government is to promote aviation, the main disadvantage of raising aviation excise taxes is that levels of use could decline. Also, the commercial air carriers may object to an increase in the tax on passenger tickets when they are already paying more than the costs they impose on the FAA.

It should be emphasized that this option is at variance with the other approaches that aim at efficient use of the aviation network. It is mentioned primarily as a logical addition to the option of raising aviation taxes to cover the revenue shortfall from marginal-cost pricing.

Table 13.
Tax Rates Needed to Recover Estimated Federal Aviation Administration Outlays for Fiscal Year 1993[a]

	1991 Rate	Rate Needed to Recover Outlays
Passenger Ticket Tax (Percentage)	10	13
Freight and Waybill Tax (Percentage)	6.25	8.125
Fuel Tax (Cents per gallon)[b]	16.8	22
International Departures Tax (Dollars)	6	7.80

SOURCES: *Budget of the United States Government, Fiscal Year 1993*, and CBO calculations.

a. Assumes all rates are raised proportionally so that revenues collected from aviation taxes equal FAA outlays for the private sector, which are estimated to be $7.3 billion in fiscal year 1993.

b. The fuel tax in the table is a weighted average (weighted by amounts of aviation fuel and jet fuel consumed by general aviation) of the aviation fuel tax of 15 cents per gallon and the jet fuel tax of 17.5 cents per gallon.

35. For an analysis of the aviation trust fund, see Congressional Budget Office, *The Status of the Airport and Airway Trust Fund* (December 1988).

Marking Up Marginal Costs Proportionately to the Percentage of Total Costs

Total costs of the ATC system may also be recovered by charging each group a multiple of its marginal costs. The value of the multiplier is determined by the ratio of marginal costs to total costs incurred by each group. For example, in 1985, the marginal costs incurred by air carriers were about 21 percent of their total costs.[36] Thus, under a cost recovery scheme in which marginal costs form the base, air carriers would be charged about five times the marginal cost for services offered at ATC facilities.

For example, an air carrier flight from Washington, D.C., to Chicago imposes marginal costs of about $135 on the air traffic control system. If all ATC costs (including capital equipment and overhead) were to be covered by raising this marginal cost in proportion to the costs caused by air carriers, the total cost of the Washington, D.C., to Chicago trip would rise to $985. This total cost is greater than the proportionate increase in marginal costs mentioned above because of the high capital costs attributed to an IFR departure; such costs were not included in the marginal cost of a "handle," which is defined as two IFR departures plus guidance by air route traffic control centers.

If costs are allocated by a proportionate increase in marginal costs as in the example above, air carriers may pay less on an average flight than the revenues currently being collected through the passenger ticket tax. However, commuter air carriers would probably raise prices to defray the new costs, thereby causing a decrease in demand for their services. General aviation users would also be adversely affected by this procedure since they would have to pay more on a typical flight than the fuel taxes they are currently paying.

36. Golaszewski, *The Unit Costs of FAA Air Traffic Control Services*, Table 2.

For example, a corporate jet now pays about $43 in fuel taxes for a flight from Washington, D.C., to Chicago. If all ATC costs were to be covered by raising the marginal cost in proportion to the costs generated by general aviation for an IFR flight, the fee would be about $445. If it flew under visual flight rules and avoided contact with ATC centers en route, the fee would drop to $140. (This example merely serves to illustrate the difference between user fees for IFR and VFR. For efficient operation, a jet would have to cruise above 25,000 feet; thus, in practice it would fly IFR.)

Since users would pay more than marginal costs under this mechanism, levels of use would be lower than the efficient levels associated with marginal-cost pricing. There is also no attempt to tailor prices to demand while recovering costs, as under Ramsey pricing. The advantage of this method is that once costs have been allocated to the different classes of users, it is easy to administer.

Average-cost pricing is similar to the above method with the additional advantage that it does not require a determination of marginal costs. Under average-cost pricing, total costs to a service used by each group in the previous year are divided by the number of operations associated with that group in that year to get the fee.

Conclusion

Existing federal taxes on users of the air traffic control system and other parts of the aviation system do not promote the efficient use of aviation infrastructure. Charging users their marginal cost could improve efficiency. The data for determining such fees is readily available.

Aviation taxes also do not raise enough revenues to cover the total expenses of the FAA. If the aim is to recover all costs of air traffic control, two main options are available. Existing taxes could be increased proportionately for each class of users. Alternatively, a combination of new fees that correspond to additional costs caused by users and existing aviation taxes could also make the air traffic control system self-financed. Neither of these options is as efficient as charging aviation users the marginal costs they impose on the air traffic control system.