not wear out overnight, and it would be obvious if they were not being well maintained.

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Some Financial, Economic, and Social Policy Issues Associated with Toll Finance

GARY L. GITTINGS

Financial pressures are forcing state departments of transportation to consider alternative funding strategies, including an expanded roll for toll financing as a supplemental source of revenue to complement current user charges. It is timely and appropriate, therefore, to examine some important financial, economic, and social policy issues associated with tolls. The discussion is primarily directed toward the use of tolls for major reconstruction on federal-aid highways. Among the findings are that, despite the relative inefficiency of toll finance as a highway revenue mechanism, there are circumstances in which tolls may be economically justified. One example is when there are insufficient revenues from traditional highway user imposts and toll financing is used to make needed highway improvements many years in advance of when they otherwise could be made. However, federal policy, which mandates full repayment of all prior federal aid used on a potential toll facility, severely limits the usefulness of the toll mechanism for purposes of resurfacing, restoring, rehabilitating, and reconstructing highways. This policy has no economic justification. From a social equity perspective, toll financing has a potential advantage over current user taxes and fees because of the ability to more closely align the user charge with the benefit received or with the direct use made of the highway facility. The choices made about toll collection system design have significant implications for the capital and operating costs of toll collection. However, toll collection design decisions cannot rest on cost criteria alone, for the design will have implications for user access, traffic route choice, toll revenue, safety, and highway financing equity that also must be recognized.

During the last decade numerous state departments of transportation have come under extreme financial pressure because of the magnitude of the funds required to maintain and rehabilitate the existing highway network at a satisfactory level of service. In addition, new highway investments, although perhaps not demanded to the same degree as in past eras, nonetheless remain an important and necessary part of most states' highway programs. The states have responded to the fiscal pressures with a variety of strategies including shifting priorities, adopting new management techniques, increasing the rates of current revenue sources, and searching for new revenue sources. New priorities have caused a shift away from the long-range network expansion programs prevalent in the 1960s to programs that emphasize system preservation through maintenance, rehabilitation, and improved management of existing resources. New management techniques have been adopted in such diverse areas as pavement maintenance, construction, quality assurance, and fiscal planning and programming. In a number of states, the means by which highway needs traditionally were defined have changed to reflect more accurately the benefits that are achievable through a given improvement. Overall, emphasis has been placed on improving the management and cost-effectiveness of highway programs.

The Surface Transportation Assistance Act (STAA) of 1982 increased and modified the structure of highway user taxes to provide for a 50 percent increase in funding for the federal-aid highway program. To match the federal aid, many states implemented user tax and fee increases of their own, but, because funding demand continues to exceed supply, states have also been looking to new sources of funding, including an expanded role for toll financing of highway improvements. Wisconsin, for example, initiated a study before passage of the STAA on toll financing for Interstate "4R" (resurfacing, restoration, rehabilitation, and reconstruction) needs *(1)*. Although the 4R

Pennsylvania Transportation Institute, Pennsylvania State University, University Park, Pa. 16802.

funding provided by the STAA reduced Wisconsin's immediate need for toll financing, other states continue to study toll financing for new construction as well as for major reconstruction. Pennsylvania sponsored two toll-financing feasibility studies for this purpose *(2, 3)*. Arizona, Colorado, Maryland, Michigan, and Virginia are all reported to have recently finished toll feasibility studies *(4)*.

The renewed interest in tolls has prompted recommendations for changes in current federal statutes that limit the use of toll financing. Proposals have been made by such diverse groups as the Heritage Foundation, the American Association of State Highway and Transportation Officials, and the Reagan administration, as well as by individual states *(5–7)*. Numerous bills related to toll financing have also been introduced in the Congress. In most cases, the interest in tolls is as a supplemental revenue source to complement, not replace, existing user charges.

Given the current interest in toll financing, it is appropriate and timely to examine some of the important financial, economic, and social policy issues associated with the toll pricing mechanism. Such is the purpose of this paper. The discussion is directed principally to the use of toll financing for 4R-type improvements to existing highway facilities, although most of the issues pertain to toll financing of new construction as well.

IMPLICATIONS OF FEDERAL-AID PAYBACK POLICY FOR TOLL FINANCING

It has long been recognized that toll financing is a relatively expensive means of raising revenue for highway improvements and imposes additional costs on the economy that are not incurred from the use of more conventional means, such as motor fuel taxes or vehicle registration fees. The most commonly recognized additional costs are

1. Direct costs of toll collection, including the capital costs to construct toll collection facilities and purchase collection equipment and the operating costs to collect tolls and maintain the toll facilities;
2. Direct costs on toll facility users from stops at toll collection plazas; these costs include higher vehicle operating costs, increased travel time, and potentially decreased highway safety;
3. Direct costs to users diverted to alternative routes who otherwise would have used the toll facility if it were toll free; and
4. Indirect costs, imposed by diverted traffic, to users of alternative routes.

These costs can be significant; they have an important bearing on the economic justification of toll financing. The most critical determinants of the financial viability of toll road projects are the magnitude of capital construction costs, the prevailing bond coupon rates and coverage ratios, the type of toll collection system, the toll rate structure, and the volume and vehicle mix of traffic. However, for financing the reconstruction of existing federal-aid highways or bridges, another factor, federal policy on the payback of federal aid previously expended on the facility, is in most instances the most important variable determining the magnitude of total costs and the ultimate financial viability of toll financing *(2)*.

Federal policy on payback of federal aid is founded on the doctrines of 20th-century, federal highway funding policy. Commencing with the passage of the Federal-Aid Road Act in 1916 and reinforced in the Federal-Aid Highway Act of 1921, U.S. government highway funding policy has encouraged funding sources supported by general user taxes and discouraged direct user charges or toll financing *(8, 9)*. Indeed, the early federal acts explicitly prohibited the use of federal aid to build toll roads. However, through the years modifications in federal policy have gradually relaxed the strict restrictions preventing the mix of federal aid and toll facilities, although a general policy favoring toll-free roads is still maintained. In most cases, a condition of these modifications has been that tolls be removed from the facility when the construction debt has been retired.

The exceptions permitting the mix of federal-aid and toll financing have arisen from recognition of the benefits of an integrated, well-maintained highway network whether or not it is completely toll free *(2)*. The first type of exception, granted in 1927, resulted from congressional awareness that its prohibition on tolls was leading to a fragmented highway network. State and local governments were building toll facilities but not connecting them with federal-aid roads. Congress modified its toll policy to permit federal funding of toll bridges and their approaches on the federal-aid highway system.

The second and third exceptions, contained in the Federal-Aid Highway Act of 1956, permitted the use of federal aid to construct approaches to toll roads on the Interstate system and incorporated approximately 2,500 mi of existing toll roads into the proposed 40,000-mi Interstate system. In the latter case, Congress acknowledged the impropriety and wastefulness that would result from building high-class free roads parallel to and in competition with existing turnpikes *(8)*.

The fourth exception also pertains to turnpikes on the Interstate system. Section 105 of the Surface Transportation Assistance Act of 1978 authorized the use of federal Interstate 4R funds on Interstate system toll roads. However, as with the first and second exception categories, pledges must be made to remove the tolls when the bonded debt is retired. Three states, Connecticut, Kansas, and New York, have signed Section 105 agreements *(10)*.

Instances of Federal-Aid Payback to Permit Tolls

In addition to these four exception classes, Congress has periodically allowed states to repay federal aid expended to build or partly build a highway so that tolls may be imposed. There have been at least five such cases, and in each instance the passage of the legislation necessary to permit the repayment of federal funds has not appeared to be politically difficult *(11)*. However, in each case the facility was less than 50 mi long; it is not clear that congressional approval would be as readily forthcoming for the conversion of a longer, federal-aid route or a portion of the Interstate system to toll road.

That, in each of the five cases, Congress required the full payback of all federal aid has significant implications for the

financial feasibility of converting any existing limited-access highway to toll collection. For example, Rao and Gittings determined that the full payback of $385.7 million of federal aid expended on Interstate 80 in Pennsylvania as of December 31, 1979, would account for approximately 42 percent of the required bond issue for capital costs to convert the road to toll collection *(2)* (Table 1). The expense of payback exceeded the estimated reconstruction cost of the highway at that time and was nearly 20 times the cost of constructing the toll collection barriers. Without the payback requirement, the required bond issue was estimated to be 53 percent lower, as the data in Table 1 indicate.

This increase in the bond issue occasioned by a full payback requirement also dramatically raised the toll rates needed to make I-80 a self-sufficient (including a satisfactory debt service coverage ratio) toll road. The estimated necessary toll rate for automobiles ranged from $1.68 to $3.22 at each of the five barriers along the route if full payback were mandated. The range results from alternative assumptions about the amount of traffic diverted by tolls *(2)*. Assuming no payback, the estimated necessary automobile toll rate dropped to a range of from $0.66 to $1.77. Assuming an automobile traveling the full 318-mi length of I-80 in Pennsylvania, the per mile toll rate would range from 2.7 to 5.2 cents with full payback and from 1.1 to 2.8 cents without payback. The latter is comparable to toll rates on existing, older, major nonurban toll roads in the United States.

The impact of federal payback policy on the financial feasibility of converting any given Interstate route to a toll road is even stronger today than it was just a few years ago because of the recent major federal expenditures for Interstate 4R. For example, from January 1979 to January 1986, approximately $210 million was spent on I-80 4R projects in Pennsylvania. A payback requirement including the 4R outlay would certainly preclude the feasibility of I-80 as a self-sufficient toll road and might even jeopardize a breakeven operation, in which annual revenues just cover annual expenses including debt service, at reasonable toll rates.

Similar findings were also estimated for toll financing of the rehabilitation of a short 46-mi stretch of I-90 through northwestern Pennsylvania just south of the city of Erie *(2)*. Full federal-aid payback consisted of $81.6 million, which amounted to 54 percent of the required bond issue to convert the route to a toll road. This percentage was higher than on I-80 because the 4R requirements were not proportionately high. The required bond issue was estimated to be three times lower without payback than with full payback. The impact of the payback requirement on the required toll rates was similar to that for I-80.

The findings from the I-80 and I-90 case studies in Pennsylvania led to the conclusion that the principal costs of converting most existing limited-access, federal-aid highways to toll roads would be the payback of prior federal-aid expenditures. There may be a few facilities for which existing reconstruction costs might exceed the cost of previous federal aid, but the number of such facilities is likely to be low given the recent federal emphasis on restoration *(2)*.

An additional conclusion from the case studies was that most limited-access highways of at least moderate traffic levels (probably 10,000 or more vehicles per day and an average traffic mix between trucks and automobiles) would generate sufficient revenues from tolls set at prevailing rates to cover all financial costs of toll collection, including amortized debt service on toll collection facilities plus annual roadway maintenance expense and the annual debt service on major reconstruction. However, few routes carry sufficient traffic volumes to cover the total costs of toll road conversion and operation if full federal-aid payback is required *(2)*. It is should be noted that Rao and Gittings did not explicitly consider the potential loss of Interstate 4R funds in their case study calculations.

Evaluation of and Recommendation on Payback Policy

Given the importance of a federal policy requiring full federal-aid payback to the financial viability of using toll financing to rehabilitate existing major routes, is there an economic rationale that would justify such a policy? When a highway facility has been constructed, the federal aid expended for construction is a historical or sunk coat. Unless the remaining physical resources in the highway facility have alternative uses, and the federal government can lay claim to these resources on

TABLE 1 CAPITAL COSTS OF CONVERTING INTERSTATE 80 TO A TOLL HIGHWAY IN PENNSYLVANIA

	Federal-Aid Payback		No Federal-Aid Payback	
Capital Cost Component	Cost ($ million)	Percentage	Cost ($ million)	Percentage
Construction of toll barriers, plazas, and buildings and purchase of collection equipment	20.2	2.2	20.2	4.7
Payback of federal aid	385.7	42.0		
Reconstruction (4R) of highway	315.4	34.3	315.4	73.8
Interest and bond issue costs	197.6	21.5	92.0	21.5
Total required bond issue	918.9	100.0	427.6	100.0

NOTE: Principal assumptions are that all figures are in 1980 dollars; there is a 30-year, 9 percent coupon bond issue; federal aid is used through December 31, 1979, for both original construction and improvement; there is an open, main-line barrier, toll collection system; and interest costs are for bondholder payments during construction.

the basis of its prior investment, requiring the payback of federal aid as a condition of toll financing has no economic justification. Because the value of the remaining physical resources in the case of deteriorated highways appears to be quite limited, if not nonexistent, a federal policy mandating full payback incorrectly imposes a financial cost on the state for physical resources that no longer have economic value. Such a policy distorts state decision making away from what potentially might be a prudent, economically justified course of action—toll financing.

A federal policy mandating full payback would also require the charging of higher tolls that would divert more traffic and misallocate more resources than otherwise is the case with toll financing. That is, because toll rates set high enough to cover full payback of federal aid include charges that are not occasioned by highway use, they result in a greater misallocation of traffic between the toll road and toll-free roads than would be the case if full payback were not mandated. This traffic misallocation also imposes additional economic costs on users of alternative toll-free roads.

Further, from an equity viewpoint, full payback is highly unjust. In effect, payback is forcing users of the new (reconstructed) facility to pay for the cost of the old (original) investment, even though they are not the principal beneficiaries of that investment. The majority of the benefit of the original investment accrued to its users, who presumably, through user taxes, have already paid for the cost of the original facility.

Nonetheless, the obligation of federal aid to the states is legally viewed as a contractual arrangement, stipulating that federally aided facilities shall be free of tolls. It may be politically difficult to pass legislation to break the provisions of the contract despite the economic and social equity rationale. Therefore, it is likely that federal payback will be required. However, if payback is required, it should be related to the remaining value of the highway facility and not the full cost of the original investment. Payback should not be required on that portion of the original value that has been consumed through use or natural deterioration. It follows that the logical way to measure the remaining value for payback is to depreciate the federal-aid portion of the original investment that has deteriorated, allowing for a suitable residual or salvage value of the highway elements not fully depreciated.

Depreciation is a complex issue, however. A highway facility contains many physical components with vastly different service lives. For example, pavements generally deteriorate in 10 to 20 years, depending on usage, whereas structures may last more than 50 years and rights-of-way may not deteriorate for thousands of years. Consequently, there are legitimate arguments for using different service lives for each highway component; this complicates the depreciation calculation. Additional complexities include estimating a market salvage value for each component and establishing the appropriate method of depreciation. Traditional private-sector depreciation methods, such as straight-line or various accelerated alternatives, may not be indicative of the rate at and manner in which highway components depreciate.

Regardless of the complexities that depreciation may introduce, they are not significant enough to invalidate the concept nor the practicality of relating federal-aid payback to the remaining value of the highway facility. For example, if the highway pavement, including subbase, is badly deteriorated, the federal share of the original pavement cost should be fully depreciated with no salvage value. None of the pavement cost should be included in the payback requirement. Because other highway elements, such as earthwork and structures, have longer service lives than pavements, they should be depreciated only partly, and the remaining value should be included in the federal payback. The full value of the federal share of the right-of-way and engineering costs should also be included in the payback. The straight-line method of depreciation is the simplest and most straightforward to use, and it probably provides a reasonably accurate estimate. Although further refinement of this suggested approach could be made, it probably would not add significantly to the accuracy of the estimate of the proper depreciated value for federal payback purposes.

The consequence of a federal payback policy with depreciation for the financial viability of using toll financing can again be demonstrated by the two Pennsylvania case studies. Table 2 gives the impact on the total required bond issue (A), annual debt service requirement (B), total annual costs (E), and annual revenue goal (F) from the variation in payback policy for both I-80 and I-90. In both instances, substantial savings result from a policy that allows depreciation. These savings improve the financial viability of both projects, moving them from a situation in which they fall short of breakeven to one in which they nearly meet the annual revenue goal (Figures 1 and 2).

CONSEQUENCES OF ALTERNATIVE TOLL COLLECTION SYSTEMS

Because toll financing occasions additional economic and financial costs not incurred with traditional user charges, it is important that these additional costs be minimized to mitigate the adverse impacts of tolls. One potential for significant cost savings lies in the design of the toll collection system. This design involves choices about the type of toll system, the number of collection points, the location of collection points, and the degree of automation in the system. The choice made about each of the items will have significant implications for the capital and operating costs of toll collection. However, toll collection design decisions cannot rest on cost criteria alone, for the design will have implications for user access, traffic route choice, toll revenue, safety, and highway financing equity that also must be recognized.

The complexity of the design decisions varies with the type of highway facility. For bridges, the design choices are relatively straightforward. The choices are primarily concerned with two questions: whether to collect tolls in one or both directions and at which end or ends of the bridge to locate toll barriers. The most favorable circumstances for collecting tolls in only one direction are situations in which a high percentage of the trips use the same route in both directions, such as work trips, where there is not a good alternative route. In these situations tolls can be doubled and collected in only one direction without arousing strong political objections. If tolls are to be collected in both directions, an additional choice must be made between using one or two barriers.

TABLE 2 IMPACT OF ALTERNATIVE PAYBACK POLICIES ON THE TOTAL FINANCIAL COSTS OF CONVERTING PENNSYLVANIA ROUTES TO TOLL ROADS ($ millions)

	I-80			I-90		
	Federal Payback Without Depreciation	Federal Payback With Depreciation	No Federal Payback	Federal Payback Without Depreciation	Federal Payback With Depreciation	No Federal Payback
Capital costs						
Construction of toll barriers and interchanges	20.2	20.2	20.2	9.8	9.8	9.8
Payback of earlier federal aid	385.7	159.4		81.6	32.7	
Construction or reconstruction of highway	315.4	315.4	315.4	27.2	27.2	27.2
Interest, bond issue costs	197.6	135.6	92.0	32.5	19.1	10.1
Total required bond issue (A)	918.9	630.6	427.6	151.1	88.8	47.1
Annual debt service requirement (B)	90.8	62.3	42.3	14.9	8.7	4.6
Debt coverage at 150 percent (B × 1.5) (C)	136.3	93.5	63.4	22.4	13.1	7.0
Total operation and maintenance expense (D)	25.4	25.4	25.4	6.4	6.4	6.4
Total annual costs (B + D) (E)	116.2	87.7	67.7	21.3	15.1	11.0
Annual revenue goal (C + D) (F)	161.7	118.9	88.8	28.8	19.5	13.4

NOTE: Principal assumptions are that all figures are in 1980 dollars; there is a 30-year, 9 percent coupon bond issue; federal aid is used through December 31, 1979, for both original construction and improvement; there is an open, main-line barrier, toll collection system; and interest costs are for bondholder payments during construction.

Policy Decisions on Highways

Determining the physical configuration of the toll collection system is more complex for highways than for bridges. Two major policy decisions must be made. One concerns the traffic that is to pay tolls—through traffic only, through and some local traffic, or all users. The second is a choice about the number of interchanges. Both policy decisions should be made interactively for they deal with the same broad issue of facility access and require an assessment of trade-offs on facility costs, traffic impacts, and community reactions.

The decision about the traffic that is to pay tolls dictates the type of toll collection system employed and thus is made with consideration of the accessibility and cost characteristics of alternative collection systems. There are three basic variations: closed (ticket) systems, open (main-line barrier) systems, and hybrid (barrier-ramp) systems. The closed toll collection system limits access to toll-paying motorists. Tollbooths are

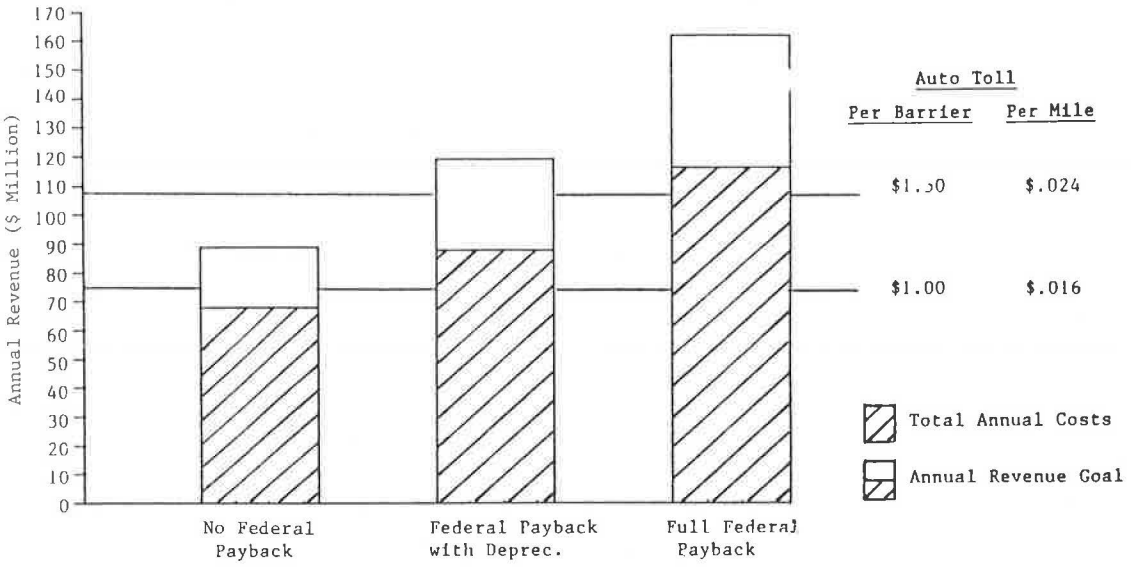

FIGURE 1 Implications of alternative federal payback policies, open main-line barrier system, I-80 in Pennsylvania.

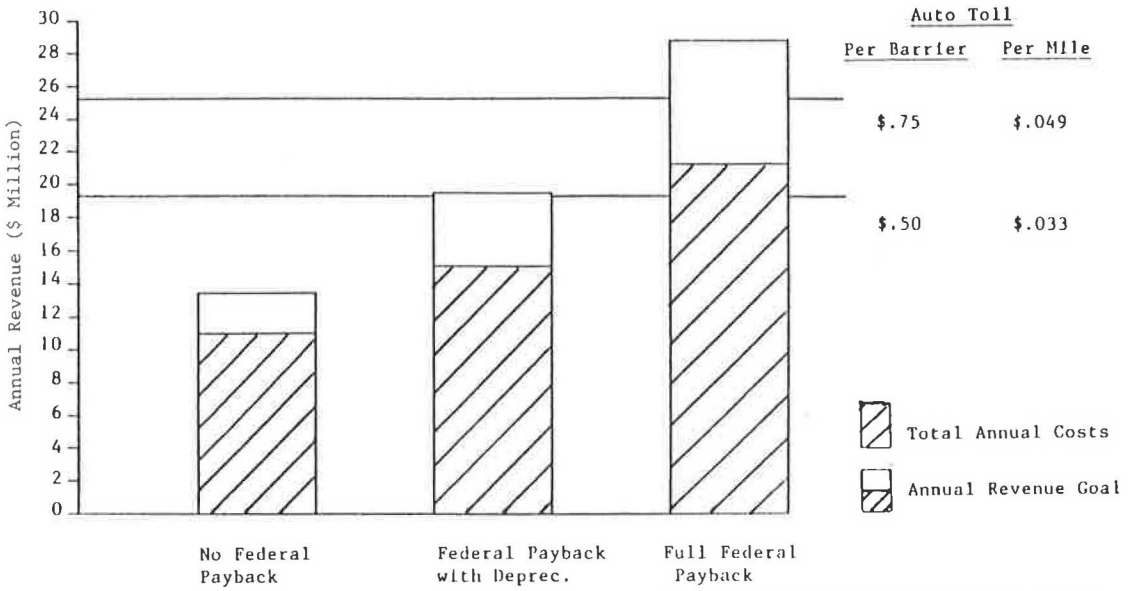

FIGURE 2 Implications of alternative federal payback policies, open main-line barrier system, I-90 in Pennsylvania.

located at each point of entry and exit, and main-line barriers span the roadway at each end of the toll route. Typical examples of closed, ticket system toll roads are the New Jersey, Ohio, and Pennsylvania turnpikes.

A second toll collection alternative, the barrier system, allows local, short-distance traffic to use the facility without paying tolls. Barriers are located intermittently along the main line of the road; no tollbooths are placed on the interchange ramps. All traffic must stop at the barriers to pay the toll; however, local traffic may avoid paying tolls if there is no barrier between entry and exit points. The percentage of trips allowed to move toll free depends on the number and location of the main-line barriers. The Connecticut Turnpike and the Bee Line Expressway in Florida are examples of barrier system toll roads.

A third alternative design, the barrier-ramp system, is a hybrid of the other two systems. It may be designed either as a closed or an open system and is often found on toll roads that pass through both urban and rural areas. If designed as a closed system, toll barriers are located at intervals along the main line. In addition, most interchange ramps also contain toll booths so that no segment of the road may be used without payment of a toll. A good example of the closed barrier-ramp system is the Illinois Tollway System.

Open barrier-ramp systems allow the flow of some toll-free traffic. They may be designed with main-line toll barriers and tollbooths on selected high-revenue interchange ramps and yet allow toll-free passage between certain contiguous interchanges. An example of this type of design is the Garden State Parkway in New Jersey, which has three toll-free sections near the towns of Elizabeth, Toms River, and Cape May.

The open hybrid system also may be designed to separate completely the open and closed portions of the toll road. The main line of the New York Thruway is a closed ticket system, although spurs of the thruway serving Buffalo and New York City are open and use main-line barriers for the collection of tolls.

Generalizing on the (financial) cost differential between barrier and closed toll collection systems requires assumptions about many variables. Most important for closed-system costs is the number of interchanges retained. The choice of number of interchanges involves a trade-off between total costs and user accessibility, both of which vary directly with the number of interchanges. Existing nontoll limited-access highways have a higher density of interchanges and are more accessible than typical, closed-system toll roads. For example, the 318-mi I-80 through Pennsylvania has 62 interchanges. In contrast, there are only 28 interchanges along the 358-mi, east-west main line of the Pennsylvania Turnpike. Similarly, on 225 mi of I-70 through Ohio there are approximately 70 interchanges, but on the 241-mi Ohio Turnpike there are only 19 interchanges, including the 2 end terminal tollgates. The high density of interchanges coupled with the need for collection facilities at each entry and exit point makes the cost of converting existing nontoll, limited-access highways to closed-system toll roads extremely expensive, both in terms of the capital costs to adapt each interchange to facilitate toll collection and in terms of operating and maintaining the many toll collection points. Costs can be decreased by closing some interchanges; however, this action may also reduce toll revenue and will decrease accessibility.

Even though the financial implications of closing an interchange can be assessed analytically given knowledge of motorists' behavior with respect to tolls, the decision on closing may be primarily political because of the complex social impacts involved. Closing an interchange can impose significant changes in travel patterns and social interactions. Objections are likely to arise from motorists who are frequent users of the interchange, from nearby business and commercial establishments, and from the community in general if there is a perception that the change in accessibility is a threat to community safety. On the other hand, homeowners in close proximity to the interchange may applaud its closing. However, for the most part, closing an interchange takes something away from tax-

payers without giving them much in return. Such actions by government are rare and are likely to be resisted in the political arena.

Barrier systems have the potential of maintaining accessibility while minimizing the cost of toll collection by concentrating the toll collection function in a few locations. By not collecting tolls on low-volume interchanges, barrier systems avoid points where collection expenses per revenue dollar are high. However, this cost advantage of barrier systems is offset to a degree by the need for more toll collection lanes per collection point due to the higher traffic volumes found on the main line. Furthermore, construction costs for each main-line barrier lane are higher than for closed-system collection lanes because of the need for longer and wider approaches to each collection point.

Because of the offsetting costs, barrier systems are not inherently less costly than closed toll collection systems even though, in practice, toll collection is less expensive on main-line barrier toll roads. Only by limiting toll collection to a few locations do barrier systems realize major cost savings over closed toll systems. It is the potential to reduce costs provided by the inherent flexibility in the number of collection points that is the principal advantage of barrier systems.

This advantage may be put to full use in minimizing the costs of converting existing limited-access highways to toll routes. For example, the capital costs for a closed toll collection system that maintains all present interchanges on I-80 in Pennsylvania were estimated to be $508 million in 1980 dollars *(2)*. These costs included construction of tollbooths, support buildings, and plaza areas; interchange area reconstruction; and purchase and installation of toll collection equipment. Nearly 50 percent of the total cost was for reconstructing interchanges to make them suitable for toll collection. In contrast, the total cost to construct a main-line barrier system consisting of five barriers over the 318 mi of I-80 was estimated at $20.2 million. The variation in operating expense was equally dramatic, with annual fare collection expenses estimated at $48.8 million for the closed system versus $6.7 million for the barrier system *(2)*.

Toll Collection System Safety

Although barrier toll collection systems have potential cost advantages, there are some disadvantages relative to closed systems. Barriers along the main line raise the potential for accidents because motorists approaching the barrier must come to a complete stop from high speeds while concurrently jockeying for the shortest queue and searching for the required toll. Closed ticket systems, where vehicle deceleration occurs primarily on the exit ramps before the toll collection area, may thus be safer than barrier systems.

User Reaction to Alternative Tollbooth and Barrier Configurations

Another item to consider when choosing a toll collection arrangement is user reaction to the arrangement and the resulting impact on the distribution of traffic between toll and alternative toll-free routes and on toll revenue. User reaction is likely to vary between toll collection systems primarily as a function of trip length. This is most apparent for trips on short segments of the potential toll route. Motorists who use short segments of a currently free road would not change their travel patterns if those segments remained open or free under a barrier or open barrier-ramp toll system. Should a closed system be implemented, however, some marginal short trips would not be made, or at least some of them would be diverted to alternative free routes. These marginal trips include nonessential trips, trip purposes for which travel time is not highly valued, trips for which the toll route offers only a small savings in time, or trips made by people with low incomes.

The impact of the toll collection configuration on longer trips is primarily a function of total toll charge and barrier density. There is nothing inherent in any of the configurations that would cause toll rates to be higher on one alternative than on another. Given equal total toll charges, barrier and open hybrid systems, however, may divert a proportionally higher number of long trips than closed systems because the higher number of barriers encountered on these systems increases travel time. An open system with three or more barriers becomes less attractive relative to closed systems. Although travel delays at toll barriers may be short relative to trip times, such irritating delays are perceived as being longer than they actually are. This perception may cause more longer trips to be diverted from barrier and open hybrid configurations than from closed systems.

Because user reaction varies with trip length, it is difficult to generalize about which toll collection system is likely to divert more traffic without knowledge of the trip length distribution. Of course, the more trips diverted by tolls from uncongested highway facilities, the higher the adverse impact of tolls from the misallocation of traffic between toll and nontoll routes. And, the more traffic diverted, the lower the toll revenue.

Variations in the Equity of the Toll Collection System

The basic theme in highway finance has been that the highway user should pay for the highway system. This theme is viewed by the general population and its political leaders as an equitable means of providing the nation with a good highway system. Two principles for charging users are most popular: The "benefit principle" is that users should pay for roads in proportion to the benefits received. The "incremental cost principle" is that users should pay according to the highway construction costs required for their type of vehicle *(12)*.

On the basis of the benefit principle, the closed system is the potentially more equitable toll collection design because each user must pay a toll for using the facility; if the benefit from making the trip were known, each user could be charged a toll equal to the benefit received in accordance with the tenets of the benefit principle. On open toll systems, some users are allowed to move toll free; hence they can never be charged for the benefits of making the trip. However, given that the benefits of trip making are most often not known, there is no sound basis for drawing conclusions about the equity of one toll collection system versus another, at least in terms of the benefit principle. It cannot be argued that either toll collection alterna-

tive more or less closely aligns the toll charge to the benefits received from trip making.

In terms of the incremental cost principle, closed systems are inherently more equitable because their charges are based on each increment of road service consumed. Open system charges are much more lumpy; some users pay high costs per unit of service while other users pay no toll.

ECONOMIC EFFICIENCY OF TOLL FINANCING

There is little argument that toll financing is a more expensive method of financing highway improvements than traditional user charge methods. Some of these additional expenses are direct economic costs, such as the capital and operating costs for toll collection and the costs incurred by toll facility users from additional stops to pay tolls. Some additional costs are indirect economic costs, such as the additional costs imposed on users of alternative toll-free routes by toll-diverted traffic. And, as previously discussed, expenses such as federal-aid payback are not economic but financial costs. To the extent that these financial costs make toll rates higher than costs occasioned by toll facility use and thus divert traffic that would use the toll facility if toll rates were lower, toll financing involves an economic misallocation of traffic between toll and nontoll highway facilities.

Capital Costs of Toll Collection

Probably the most visible and frequently discussed of the additional expenses associated with toll financing are the capital and operating costs for toll collection. The capital construction costs incurred to install toll collection facilities, including tollbooths, buildings, plaza areas, collection equipment, and, if necessary, interchange reconstruction, may be relatively minor, or they may be significant enough to dictate the financial feasibility of the toll conversion project. The most important factors determining the absolute magnitude of these capital costs are the type of toll system; the number of toll collection points; the level, composition, and peaking characteristics of the traffic stream; and the size and location of the toll conversion project. The impact that these factors have on the magnitude of capital costs and the design of the toll collection system was discussed in more detail earlier as well as in other sources *(2, 11)*. As a general rule, the capital costs for toll collection, although potentially significant, can be held to less than 10 percent of total capital costs, including federal-aid payback, assuming that a cost-efficient toll collection system is used.

Operating Costs of Toll Collection

Toll collection is an expensive way of raising highway revenues. As traditionally practiced in the United States, toll collection is labor intensive with labor costs accounting for as much as 80 percent of total collection expenses on closed ticket systems *(13)*. Technological improvements as well as better management techniques have sought to trim the labor intensity of collection. For example, the use of main-line toll barriers has reduced the need for manning each point of access and egress. The substitution of automatic machines for human toll collectors has further reduced the necessary manpower. So has the practice on the Garden State Parkway of using senior citizens as part-time employees to meet peak-period demands. Other innovations include collecting tolls in only one direction with a doubling of the toll rate and limiting the collection hours to avoid low-volume periods *(14)*.

Despite the improvements, toll collection costs remain relatively high, particularly on closed ticket systems. In 1985 Pennsylvania Turnpike toll collection costs as a percentage of toll collection revenue were 14.8 percent *(15)*. New York State Thruway and New Jersey Turnpike collection costs were 16 and 19 percent of total toll revenues, respectively, in 1985 *(16, 17)*. These percentages are a few points higher on all three toll facilities than they were in 1980. These percentages also do not include toll collection area maintenance expenses, costs that are not incurred with traditional, highway user imposts.

The collection costs for the traditional user imposts are lower than for tolls. The costs for motor vehicle registration and license fee collection as a percentage of fee receipts for all U.S. states ran approximately 13 percent in 1984. The collection costs for motor fuel taxes averaged less than 1 percent of tax receipts in 1984 *(18)*. Because motor fuel service companies serve as the collection agents, motor fuel taxes are a highly efficient means of raising highway revenue. Neither registration and license fee collection costs nor motor fuel tax collection costs as a percentage of receipts have changed significantly since 1980. It is apparent that toll collection, in comparison with traditional highway user taxes and fees, is an inefficient means of raising highway revenue.

RATIONALE FOR TOLLS DESPITE ADDITIONAL COSTS

Even though toll financing is generally an economically inefficient means of collecting highway user revenue, are there, nonetheless, special circumstances in which toll financing might be economically justified? One of the often cited advantages of tolls is that they provide a means of levying congestion prices on heavily traveled urban routes. The additional costs of such toll financing may be more than offset by the ability to price road users in accordance with the costs occasioned by use, including the high external or social costs imposed by road use during peak travel periods. Including these social costs in the toll internalizes the social costs in the road use pricing system, thereby encouraging road users to make more efficient route or mode choices. If congestion pricing sufficiently mitigates peak-hour demand, there may be an additional benefit from the postponement or avoidance of the need for additional road capacity. The rationale for congestion tolls has been developed extensively *(12, 19–21)*. Its use on U.S. toll facilities is, however, quite limited.

Toll financing might also be justified under special financial conditions. Rao and Gittings concluded that toll financing can be a useful and justified way of supplementing general highway user tax and fee revenue, particularly if the toll revenues are dedicated to building, maintaining, or improving facilities that, in the absence of toll financing, are not likely to be built,

maintained, or improved to first-class standards *(2)*. For example, in the case of an existing highway facility, if funds from traditional revenue sources are not available to make needed improvements in a timely fashion, the level of service deteriorates, and the cost of using the deteriorating facility correspondingly increases. On the other hand, if toll financing expedites the required improvements, users may benefit from lower vehicle operating, travel time, and accident costs despite the higher highway user charges associated with tolls. The primary question, then, is whether the increase in user benefits made possible by toll financing is sufficient to justify the additional costs associated with toll collection. If benefits exceed costs, then toll financing may be economically acceptable within the constraints imposed by society on other means of financing.

However, this primary question is difficult to answer because it involves speculation on the level of service if the needed improvements are not made. Hypothetically, in the worst case, the road is allowed to deteriorate and is closed for safety reasons. For the highway's users, the closing of the road means increases in travel times, accidents, and possibly operating costs as they divert to alternative routes with lower levels of service. In some cases fewer trips may be made. These additional user costs can be viewed as the maximum user benefits of toll financing for those travelers who would have used the road as a toll facility. If the deteriorated road is rehabilitated as a toll road, benefits accrue to users of alternative routes who would otherwise experience increased congestion and more rapidly deteriorating highway facilities occasioned by the diverted traffic.

A more likely scenario than the worst case is that the road is maintained at a lower level of service with a lower posted speed limit, and a minimum amount of surface maintenance is performed to maintain the integrity of the pavement. In this situation, the benefits to users of having a more immediate toll-financed reconstruction of the highway would be the difference in accident, travel time, and vehicle-operating costs between a higher level of service toll road and a lower level of service free road. These benefits must be measured over the period from when a reconstructed highway could be completed with toll financing to when it could be completed with conventional financing. The length of this period of time will, in most circumstances, be a governing factor in whether or not the benefits of toll financing exceed the additional economic costs.

Recent analysis by the Congressional Budget Office (CBO) estimated that toll-financing benefits may exceed the additional costs if a needed highway facility can be built 4 or more years sooner than under conventional pay-as-you-go tax financing *(10)*. However, if toll financing produces a facility only 2 or fewer years sooner, the use of toll financing is probably not worth the additional costs. The CBO indicates that the time advantage needed to make toll financing beneficial is sensitive to the overall level of benefits provided by the road, the prevailing bond interest rates, and the amount of traffic diversion caused by tolls.

Social Equity

Thus far the discussion has examined the economic implications of using toll financing to rehabilitate existing federal-aid routes. From an economic viewpoint, it is clearly inefficient to impose user charges via the toll mechanism. However, in addition to economic efficiency, there are a number of other commonly accepted goals of pricing or tax mechanisms designed to raise funds for public action. Toll financing also should be judged in light of these other goals.

The most politically popular of the other goals is an equitable distribution of the tax burden *(22)*. In highway finance, this equity goal has been translated into the policy that the highway user should pay for the full cost of the highway system *(12)*. This policy arose in part because it was viewed as the fairest and most proper way of paying for highways. However, although the basic policy is commonly accepted, there has not always been agreement about what constitutes an equitable distribution of the financial burden among highway users. One of the most often accepted guidelines today is the benefit principle, whereby users pay for roads in proportion to the benefits received *(12)*. In the early 1960s Mohring and Harwitz (*23*, p. 88) used the benefit principle, expressed in terms of equating either benefit tax ratios or net benefits for all population classes, to analyze the equity of alternative tax systems for raising highway revenues; their conclusion was that

> primary reliance on levies such as tolls or gasoline taxes that are directly related to highway use would provide a more nearly equitable allocation of the highway financing burden than would reliance on the general tax revenues of the federal government.

The governing criterion that led to this conclusion was the relative freedom of choice, afforded by each tax alternative, to consume highway services. This freedom was seen as critical to the potential of each tax system to equate benefit-to-tax ratios. The further the choice of paying for each highway service is removed from the actual consumption of each service, the greater the likelihood that an inequitable burden is placed on the individual consumer. By imposing a charge only for each use of highway service, the highway authority is giving the consumer the freedom to choose whether the direct benefits received from a given trip exceed the direct costs, including the use charge. The greater the freedom of choice, the authors argued, the higher the potential to equate benefit-to-tax ratios for all population classes.

Mohring and Harwitz did not express an opinion on whether tolls or gasoline taxes were more equitable on the basis of the benefit principle. However, using their freedom of choice criterion, it would appear that tolls levied for the rehabilitation of a given facility are more equitable than a general gasoline tax increase for the same purpose, because the tolls more closely align payments to the use of the facility. With the gasoline tax increase, payments are made by highway users whether or not they travel on the rehabilitated facility. Consequently, these users do not have the option of making payments only if they use the facility; they pay whether or not they receive any benefits from the facility. On the other hand, with tolls, only those who benefit from use of the toll road pay the toll. Therefore, it would appear that tolls offer a more complete freedom of choice and thus a greater potential for equating benefit-to-tax ratios or net benefits.

CONCLUSION

For many decades, the U.S. highway road user charge policy has steered a path clear of toll financing and generally discouraged the use of tolls as a highway revenue mechanism. Yet the present financial status of the U.S. highway program, relative to the financial needs of that program, may no longer ignore toll financing, particularly in light of the existing political climate that favors governmental fiscal austerity and balanced budgets. In this climate, toll financing can be a viable supplemental source of important revenues for needed highway improvements that otherwise would be postponed or forgone. Toll financing should be viewed as one more component of a package of financing mechanisms to be judiciously employed in funding the level of highway service desired.

In this paper some of the financial, economic, and social policy issues associated with imposing user charges via the toll mechanism have been examined. Particular attention has been given to the use of tolls to rehabilitate existing federal-aid routes. From an economic viewpoint, toll financing is a relatively inefficient means of raising highway user revenue. Toll financing incurs additional economic costs over and above those costs incurred by other funding mechanisms. These additional costs include higher costs of collection and capital costs for the construction of toll collection facilities. Furthermore, highway users incur increased travel time, vehicle-operating, and possibly accident costs because of the necessity of stopping at toll collection facilities.

Nevertheless, there are circumstances in which toll financing may result in a more efficient use of highway facilities or may permit additional user benefits that exceed the economic cost disadvantage of tolls; in such situations, tolls can be economically justified. One example is when tolls are appropriately levied to reflect congestion costs. Another example is when there are insufficient revenues from traditional highway user imposts and toll financing is used to make needed highway improvements many years before they could otherwise be made.

However, one of the barriers to the use of toll financing in the latter instance is federal policy that mandates the full repayment of all prior federal aid used on a given highway facility before toll financing may be used to rehabilitate that facility. This policy severely limits the number of highway facilities that would be self-supporting or even break-even toll facilities at reasonable toll rates, thus reducing the usefulness of the toll mechanism for highway 4R purposes.

A major policy recommendation made in this paper is that full federal-aid payback not be required to convert an existing federal-aid facility to tolls. There is no economic justification for requiring any payback, and from an equity viewpoint full payback is highly unjust. However, it is also recognized that the obligation of federal aid to the states is legally viewed as a contractual arrangement, stipulating that federally aided facilities shall be free of tolls. It may be politically difficult to pass legislation to break the provisions of the contract despite the economic and social equity rationale. Therefore, it is likely that some payback will be required. In light of these circumstances, it is recommended that payback be related to the depreciated value of the federal-aid portion of the original investment and not the full cost. This policy is based on sound business principles and may satisfy the political concerns.

From a social equity perspective, toll financing has a potential advantage over current user taxes and fees. This potential advantage stems from the ability to align more closely the user charge with the benefit received or with the direct use made of the highway facility.

Decisions on toll collection system design also have economic and social consequences. The design decisions involve choices about the degree of user access and about the traffic that is to pay tolls. If a relatively high level of access is desired, the inherent flexibility of the main-line barrier system design provides important capital and operating cost savings and allows some toll-free local traffic movement on the toll facility.

However, allowing some traffic to move toll free may raise some objections on equity grounds and will reduce gross toll receipts. If a policy limiting toll road use only to toll-paying motorists is desired, then a closed-system design must be constructed. This type of design, however, may be prohibitively expensive for converting existing, limited-access highways to toll roads because of existing high interchange density. Some low-volume interchanges could be closed; however, this may be politically impractical.

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Financing, Private-Sector Involvement, and Market Processes in the Provision of National Roads in South Africa

M. F. MITCHELL AND J. L. BOTHA

In this paper is described the changing basis of the provision of rural roads in South Africa that led to the introduction of toll roads and, in the process, to an increasing degree of privatization in the provision of roads. The background financial and administrative arrangements for the provision of rural roads is discussed and national policy that influences the financing of roads is described. With the increasing shortage of funds for roads during the past decade, the need for better economic justification of specific road projects and the search for new sources of funds combined with the policy of user charging and of supporting the free market system has had a significant effect on the development of the rural road system. Before 1980 the private sector was involved in road provision to a varying extent through contracting, construction work, and consulting services. Following a decision in 1982 to implement toll roads on a limited basis on the national road system, private-sector involvement expanded to include financing and management of revenue collection activities. Greater attention was paid to the economic and financial justification of road projects. After the policy of toll financing of roads was established, the Department of Transport was approached by private-sector companies requesting the grant of concessions to finance, design, construct, maintain, and operate certain national roads and to collect tolls to defray the costs. These proposals, which would constitute further privatization in the road sector in South Africa, are currently under consideration.

M. F. Mitchell, Department of Transport, P.O. Box 415, Pretoria 0001, Republic of South Africa. J. L. Botha, Civil Engineering Department, University of Alaska, Fairbanks, Alaska 99775.

South Africa covers an area roughly equal to 12 percent of the United States or 3.7 percent of the area of the whole of Africa. Its road system at present consists of approximately 3000 km of freeways, 50 000 km of rural two-lane blacktop roads, and 135 000 km of gravel roads. There are a total of more than 230 000 km of roads and streets.

The purpose of this paper is to describe the changing basis of the provision of rural roads in South Africa that led to the introduction of toll roads and, in the process, to an increasing degree of privatization of road provision. The limited introduction of certain market forces into the provision of roads in South Africa is described as is the increasing involvement of the private sector.

Until the end of the 1970s planning of the national road system in South Africa was based on the concept that the major cities of South Africa should be connected by a system of freeways. The road standards used were basically similar to U.S. standards modified to take into account the South Arican rule of the road (i.e., drive on the left) and climatological conditions. However, funds available for roads decreased dramatically in the mid-1970s, and it soon became apparent that expenditures on roads had to be better justified than previously and that new sources of revenue had to be explored. At about the same time, the government gave impetus to its policies of promoting the free market system and charging the user for services provided by government.

The need for better economic justification of roads and the search for new sources of funds for roads, combined with the