

Organization, Management, and Financing in a Road Agency

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Issues and concepts involved in the organization, management, and financing of road administration are discussed. Road agency organization is analyzed using a cost function that supports a decentralized "fractal organization." Several road management systems are discussed and it is argued that for a management system to be useful it must be compatible with the agency's organizational structure. Finally, road funds and road user charges are discussed, and their importance to road administration management is elaborated.

A country's transport system is an enormous national asset. As the circulation system of the body politic, it facilitates commerce, communication, and economic and social growth. Management of the system is a highly sensitive and complex task, entrusted to a country's road administration and shaped by political, technical, environmental, managerial, and historical forces. Because of a transport system's complexity, the mission of a country's road administration is typically stated in broad terms (e.g., effectively manage the transport system that serves the country). In addition, serving clients, delivering quality products, protecting the environment, and valuing employees are increasingly recognized concerns, and they add to the managerial dimension of a road administration's mission.

Operational objectives to which a road administration's professional staff attaches importance include the following: traffic safety, increasing capacity to sustain or enhance current operating speeds as well as to respond to changing traffic demand, rehabilitation of existing roadways, and environmental amelioration. In some countries and regions, improved farm-to-market accessibility, congestion management, and promotion of carpooling and public transit are also important objectives.

Issues and problems surrounding these objectives constitute a familiar, well-trodden ground for transportation professionals in every country, and most transport managers anticipate them in the course of their work. However, what makes accomplishing the objectives technically difficult is their intricate relationship with a full range of socioeconomic parameters and nearly every facet of life, and the complications they may introduce into road management.

What might appear to be a contradiction is not; the "big picture" or vision of a country's road system can only be implemented by attending to a multitude of small details, both technical and social, and accomplished by various means, including good administrative management, optimal resource allocation, technical improvements, personnel training, and well-designed financing and attendant user charges. This paper focuses on issues and con-

cepts involved in a road administration's organization, management, and financing.

ORGANIZATION AND ADMINISTRATION: A BRIEF INTERNATIONAL REVIEW

Organizational development is not an exact science; it simply is a certain arrangement for human cooperation. Organizational structure alone does not determine the effectiveness or success of an administration. There are "soft" factors involved: motivation, leadership, and culture. The management of a highway system, including ways of doing road work and overseeing roads, influences the ways road administrations are organized. The historical and political organization of a country also forms the framework for organizing countries' road administrations.

A recent survey of resource allocation practices in the Organization for Economic Cooperation and Development countries (*1*) showed a remarkable communality in these practices and managerial approaches despite substantial differences in organizational structures. Three observations are relevant here. First, organizations reflect the governmental structures prevailing in each country. Thus a federal as well as a state level for road administration is relevant in Germany, Italy, Spain, Switzerland, and in the United States. Canada's federal government is not involved in allocating road budgets. In other countries, the federal/state hierarchy is either missing or has been replaced by another administrative organization or procedure. Interestingly, even when countries' governmental levels and the road administrative bodies are similar, they do not have similar responsibilities. Second, extensive traffic or financing problems are motivations for creating totally new kinds of institutions. Motorway concession companies in France are a good example. Third, two main types of organizational structures can be detected: the functional line organization and the fractal organization (to be discussed later). In the former, responsibilities are divided functionally, among construction, maintenance, planning and design, and administration. This is the most common type of organization. In the fractal organizational model, there is a comprehensive delegation of responsibility such as is found in the organizations in Sweden and Finland.

Managerial approaches to road administration among countries show great similarity and encompass the planning and execution involved in the development, maintenance, and operations of a road system. Development consists of construction of new roads, increases in road capacity by adding lanes, and substantial realignment of a road that may or may not increase capacity. Maintenance involves periodic resurfacing or strengthening of roads' structural capacity. Operations involves snow and ice removal (in certain countries); care of roadside and service areas, guardrails,

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and traffic signs and markings; and other minor repairs that keep pavements and shoulders smooth and safe for motorists. Traffic safety, environmental protection, congestion management, and other ends that do not directly affect transport may affect these three main activities (Figure 1). The three-part division of development, maintenance, and operations corresponds to the policy and budget-making practices of most public agencies. The divisions relate to the time horizon of decisions: development decisions are long range, maintenance decisions are made for the intermediate range, and operations makes short-range decisions and emergency interventions. The threefold division, observed in most countries, is a useful management aid; as a management tool it is likened to the functional classification of roads.

Similarly, there are three administrative decision-making levels: the network, program, and project levels. They are shown as rows in Figure 1, which illustrates, in compact form, the domains of management and resource allocation for road administration. The network level, which is first, deals with policy and usually involves actions by central management in the agency or ministry. The lowest or project level normally is performed by the regional office's engineers, who are charged with execution of the policies and design. In between is the program level; this level's function is to program the actions and implement the policies set at the network level, for example, a multi-year road program.

MANAGEMENT, PERFORMANCE, AND ORGANIZATION OF A ROAD AGENCY

Literature Review

There is a shortage of literature on state or federal road administration organizations and their performance as well as comparisons of different countries' or regions' road agencies. Larson and Rao's (2) seminal study of U.S. state highway agencies illustrates the complexity of management and financial practices and the variance that exists in them among states. Talvitie and Sikow (3) have studied productivity growth in Finland's road administration (FINNRA); Heggie (4) presents a comprehensive proposal for improving management and financing of roads (in sub-Saharan Africa, although the proposal has wider applicability). According to Heggie, the key managerial challenge includes fundamental reforms for organization, management, and financing; the process of these reforms; and the strategy to be followed in accomplishing them. Hartgen (5) uses a number of indices to compare the productivity and effectiveness of state highway agencies in the United States over time. Finally, Humphrey et al. (6) report on the methods used to assess U.S. state DOTs' performances in response to Hartgen's bold attempt to rank them in terms of performance.

Agency Performance and the Management Effect

The remainder of this section reports on a Finnish study (7) whose original aim was to study an agency's productivity and management. The study proved important from the point of view of the administration's organization.

Method

A review of literature (8,9) indicates that the cost function is a versatile way of addressing questions related to productivity and

efficiency. To assess efficiency, the method involves calculating average cost differences, through time or between regions, and decomposing them, in the present case, into input, output, and management effects and productivity or trend effects. The innovation was to introduce management variables to the cost function and to gauge their importance.

It was assumed that road production can be described indirectly as a cost function of the following form:

$$C = g(W_i, Q_j, M_k, T, D_i) \quad (1)$$

where

- C = total cost of production,
- W_i = vector of input prices,
- Q_j = vector of outputs,
- M_k = vector of management variables,
- T = binary time variable or a proxy for technology, and
- D_i = vector of dummy variables to specify the 13 different highway regions in Finland.

Data

Road construction and maintenance can be viewed as acquiring, moving, disposing, and treating materials. The volume of this work, measured in m^3 , is defined as output. In order to test for a multiproduct production process, four classes of roads were specified to allow for the possibility of different production technologies.

Input prices include wages, capital service, haulage, and material. There are three management variables that the road agency, or management of a project, controls. The effects on costs of speed of construction and percentage of contract work both give valuable information about past decisions that aids future planning. The amount of "own fixed manpower" is defined as the third management variable, which, in the short run, is often beyond the management's control. Several other variables were tried.

Maintained Hypothesis

Rigorous statistical tests (3) indicate that input prices are separable from outputs and management variables, but outputs are not separable from management. The road agency is a multiproduct agency whose output cannot be aggregated into a consistent scalar number. There appears to be no specific regional difference; however, if a single output is used to characterize the works, then regional differences in this single output are wrongly ascribed to region-specific variables. The cost function was reduced to the following form:

$$\ln C = f(\ln W_i) + g(\ln Q_j, \ln M_k) \quad (2)$$

The result is fortuitous: the management and output levels are separable from prices. At least, the result did not contradict the assumption of functioning factor markets. Inseparable management and outputs suggest, even require, that managers of the output (vector) also formulate it. This has clear implications for organizational structure.

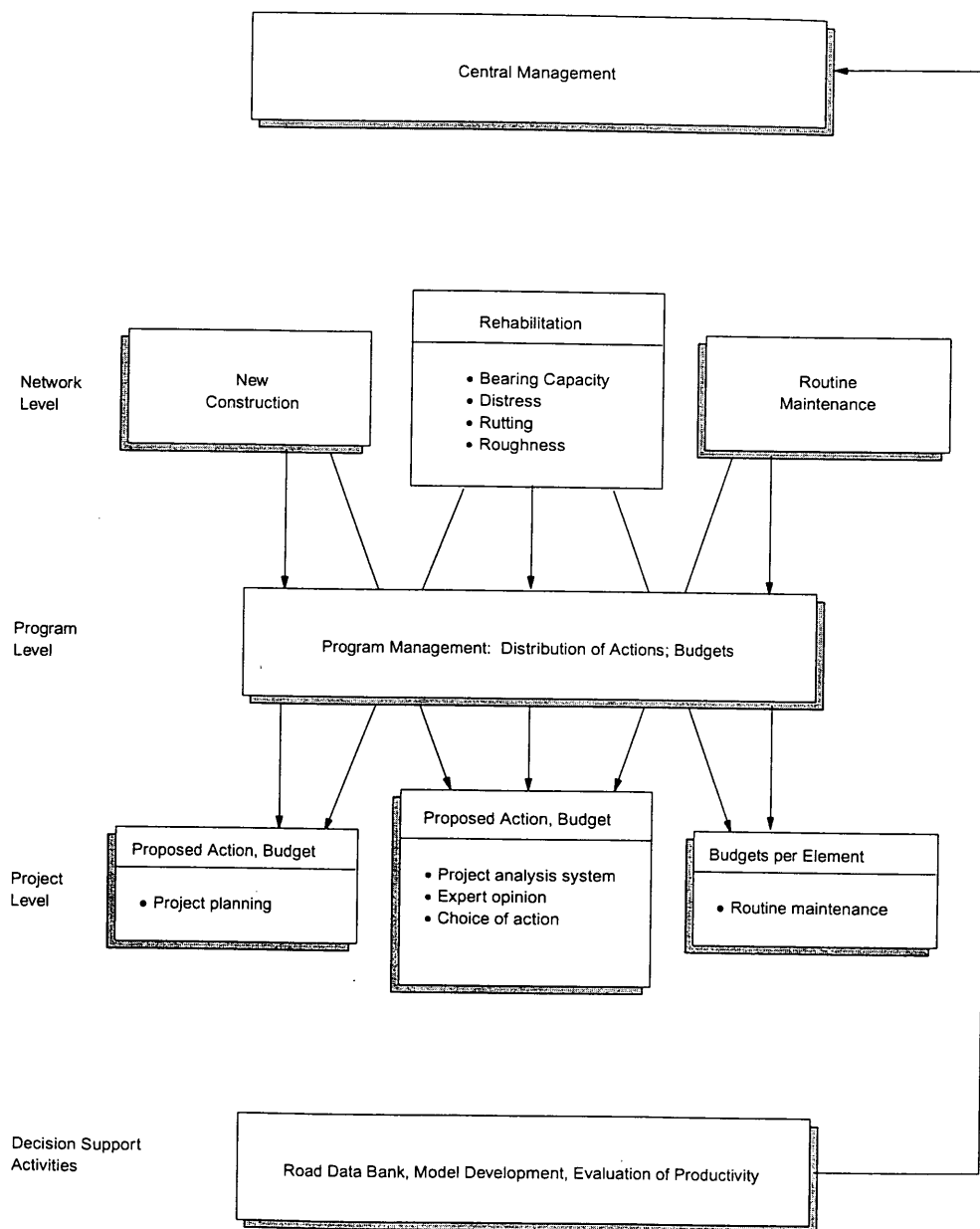


FIGURE 1 Road management system.

There were economies of scale. Also, management had an important bearing on costs. An increase in the speed of construction would have reduced costs in every highway region. Elasticity of cost with respect to percent of contract work was positive. The reason might be that the fast increase in the share of contract work had not been followed by a similar decrease in regions' own fixed labor, thus, it had a negative impact on cost. Because direct labor was also required to make a bid, it was easy to establish whether the mandated competition had reduced costs. It had. It was also evident that contracting increased productivity and reduced costs. An increase of 1 percent in the fixed labor force raises total costs 0.88 percent on the average, whereas the share of labor is only about 35 percent of the costs. A change in costs with respect to the amount of direct labor is therefore elastic.

Measuring Performance

After manipulation, the cost function can be used to obtain the following basic formulas:

$$\begin{aligned} \text{Total factor productivity} \\ &= \text{change in outputs/change in inputs} \quad (3) \end{aligned}$$

$$\begin{aligned} \text{Total factor productivity} \\ &= \text{management effect} + \text{time trend} \quad (4) \end{aligned}$$

$$\begin{aligned} \text{Change in unit costs} \\ &= \text{change in input prices} - \text{productivity} \quad (5) \end{aligned}$$

(In Equation 3, inputs = total costs/weighted input price.) The total factor productivity measure differs from the traditionally used time effect by the management variables' effect. This is an important difference: management affects agency performance. The above equations enable analysis of the changes in TFP from two different angles: from the production process, which compares input and output quantity levels and their changes (Equation 3); and from the differences in the management factors and the rate of technical change (Equation 4). A third interpretation is possible: the background variables can be seen as the sources of variations in the production process. For example, changes in the level of input factors can be motivated by a technological innovation, and a change in the speed of construction can affect both input usage and output levels and thus the productivity development of road construction and maintenance (3,10).

The cost function begs the question What is the output? The properties of this output are important to efficiency and productivity. For example, the efficiency of contract maintenance should not, cannot, be analyzed simply by taking one output, say overlaying, and examining its costs if there are economies of scope and the costs of overlaying are affected by other outputs of the road agency. The labor force of a modern road agency is trained to have multiple skills, and the question of economies of scope cannot be ignored (3). The cost function also can be used for intercountry comparisons (8). The fact that some measures have been found efficient in one context does not mean that they will be so elsewhere. For example, cost reductions achieved by contracting out maintenance may simply be a sign of inefficiency in that particular country, which may not be present in another country.

Cost function is a good method for assessing a road administration's productivity and efficiency trends. It is a particularly useful tool for the management. For instance, it soon became apparent that FINNRA's excess manpower and slow speed of construction with many ongoing projects were detrimental to efficiency. Remedies were taken to correct these problems after studies from different starting points confirmed the cost function results.

Traditional price orientation of productivity studies need to be shifted to transaction costs to consider What is the management environment? Why is one organization better than another? What is the role of a management philosophy, of technology, and of the managers themselves?

In sum, the cost function, together with a road management system and periodic audits of road condition, provide the necessary information for performance assessment of a road agency. In all phases the people responsible for the project must be involved in this analysis because they can supplement and explain the things that a model cannot.

Organization and Performance

Good organizational structure is necessary for effective road management including good results in production and meeting customers' needs.

Current Situation

Typically, a country's road administration has a centralized decision-making and functional line organization. Its regional of-

fices are also organized along functional lines. Decision making that takes place at the regional level deals with straightforward work planning and not with program planning. This organizational structure is based on the technocratic idea that each line has its own separate product and that within the line output (e.g., a rehabilitated road), inputs (e.g., factor prices), and management (e.g., the number of projects) are separable from each other.

However, this may not be the most efficient organization. There are several problems: unclear and mixed functions and objectives, excess of organizational needs over "optimal" needs, a loss of information due to top-down micromanagement, and so forth.

Approach for Restructuring

There are several approaches to resolving resistances in public organizations and providing for the conflicting objectives of accountability, direction, control, flexibility, freedom, and creativity. One of these is organizational restructuring to enable management to manage efficiently. From the point of view of organization structure, the key results of FINNRA's cost function analysis were separability of prices from output and management, nonseparability of management and output, multiproduct nature of the firm, economies of scale, irrelevance of region-specific characteristics, and the importance of scheduling (programming) of projects and the effect of their optimal timing on costs (11).

Without proving the matter here, separability is a necessary condition for decentralization and delegation of decision making. Accordingly, FINNRA's output should not be defined by the central administration to be managed by the regional administration. Decentralization was a must. On what scale should the decentralization be done? According to the model, optimally FINNRA should be divided into 4 to 5 regions instead of the previous 13. Because there were no unique regional differences beyond the output, they could not be cited as evidence against restructuring. Still, restructuring of the regions proved to be enormously difficult both professionally and politically. Although decisions were made after a process of about 2 years, they have taken effect gradually, the first ones in 1991. From idea to implementation restructuring took 3 years.

When these findings are translated into practical terms they mean that, given its budget, the executing regional office must have comprehensive responsibility regardless of the size of the region to creatively manage all its outputs. That is, the regional director should be accountable for the design, construction, rehabilitation, and maintenance of the region's roads, once policy and the overall program goals have been established. For example, a regional director could be accountable to a director general and the board of the road administration.

What then is the role and composition of the central administration? Following the results and reasoning above, the central administration must have comprehensive responsibility of recommending to the board or Ministry policies to be followed, and the distribution of monies within the country. It must be accountable for the road agency's performance. Many advantages can be gained if the directorate of the agency is composed of the director general and the regional directors and forms a general purpose management team. Advantages include formulation of goals in a manner that is uniform for all regions, commitment to distribution of allocated monies, possibility of monitoring performance in a consistent manner, and cohesion within the agency. If the country

is divided into numerous regions, the size of the directorate could become too big and unmanageable. It is important that the number of regions is optimally small.

At the regional level, the same reasoning and rules apply. Instead of line organization, the regional director should have an area organization under which the area chief is responsible and accountable for the roads in the area as well as planning, design, safety, construction, maintenance, and environmental safety. He or she may employ experts, but the manager has general responsibility.

The organizational structure outlined above, represented in Figure 2, can be called a fractal organization, because each lower level is a replica of the higher level. This organizational structure does not mean that everything is delegated. Activities that are best performed at the regional level (e.g., programming and executing road condition surveys) need not be delegated. Centralization, decentralization, and delegation depend on technology and available expertise, not solely on organization structure.

Concurrently, other administrators arrived at these conclusions by means other than an econometric study. At least two FINNRA regional directors expressed similar thoughts about the organization and, in particular, how to organize the regional road agency. Comprehensive managerial responsibility and delegation of authority were timely concepts. Studies in the United States echoed similar themes. Larson and Rao (2) propose that "in a more competitive environment for resources, highway capital programs will likely require a new focus and broader ranging goals," but they maintained that there was no "right way" to manage the highway capital program and argued for "directed autonomy" to allow creative approaches to be developed by individual states. Larson and Rao suggested that the best results are achieved when there is a "balance between the need for direction and control on the one hand and freedom and flexibility on the other, depending on the political, cultural, and demographic circumstances" of each state (country). These ideas are certainly not contradicted by ideas that were commonly held in Finland and Sweden at the time (both

countries were undertaking reorganization as Larson and Rao's study was published). Thus, model results were reflected in the current thinking of professionals in transportation.

It is hoped that studies will be undertaken to determine how many regions a country should have for purposes of transport administration. One hypothesis is that a functionally organized line organization is more efficient with low-level technology and insufficient information systems. A fractal organization only becomes possible with the use of more advanced technologies and information systems. Some speculate that the functional and fractal organizations need to be used in a cyclical manner: the functional line organization to push forward specialization and advanced technology, the fractal organization to consolidate the technological gains made in the organization. That the line organization has been in effect up to recent times in most countries shows its viability; it may well be the best organizational model for most developing countries for some time to come. An organization's structure is important to the fulfillment of its mission. It is also important that organizational restructuring keep pace with technological development. Needless to say, the issue of organizational structure and the number of subdivisions has political importance; an organizational restructuring is always a political process. More research and experimentation is needed on these matters.

IMPLICATIONS FOR MANAGEMENT SYSTEMS

Management systems are a necessary element of good management. Not everyone appreciates that organizational structure and decision making style are important factors in the design of the management systems. The design of FINNRA's road management system (10,12,13) was critically affected by organizational considerations and by the weakness of the then practiced budgeting and output formulation processes, which, among other things, permitted serious leakage of funds and nonoptimal choices of projects.

The road management system (RMS) must be consistent with the management structure reflected in Figure 1. Network level decisions, exercised by the central administration, deal with policy and resource allocation. Project level decisions, performed by the regional offices, deal with design and work planning. Program level decisions to implement policies for many years are the joint responsibility of the central administration and the regional offices. This organizational system is called a "top-down" method, as opposed to a "bottom-up" method, which builds the multiyear program from individual projects. The system developed and adopted by FINNRA is both.

Key ideas in the top-down method's (Figure 1 as read top down) network-level RMS are the following:

- All investment, maintenance, and operations monies are accounted for.
- Central management distributes monies to regions, normally by functional classification (or volume class), and may recommend an action.
- Central management has many other considerations and constraints that it needs to value when distributing the budget.
- Budget and other constraints are considered explicitly and their importance assessed and communicated in terms of trade-offs between competing programs.
- Central management operates in a "virtual" reality.

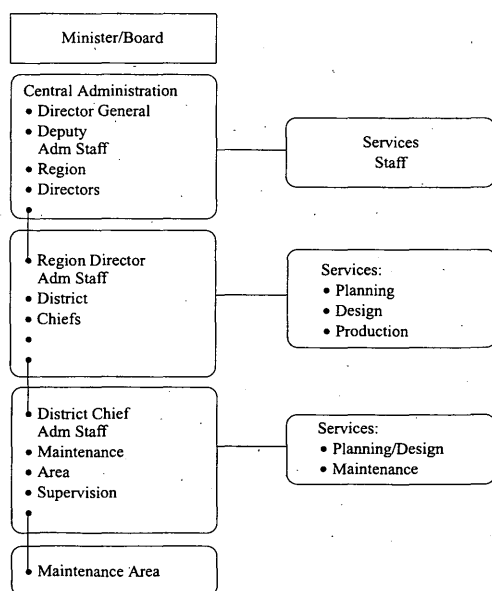


FIGURE 2 Fractal organization.

These thoughts are consistent with contemporary practice and thinking in road management, which emphasizes the role of the chief administrative officer and the top-down authority of the central management. In that context, transportation is perceived and used by policymakers as a means to ends other than affecting transportation; the approach is compatible with Larson and Rao's (2) thoughts on a "competitive environment for resources," or "new focus and broader ranging goals," or "the need for direction and control on the one hand and freedom and flexibility on the other."

Key ideas of the bottom-up method (Figure 1 as read from bottom up) project-level design system are the following:

- Even a single project consists of many tasks.
- There are many centrally unavailable but locally available variables that affect the final design and the final program, such as "historical memory."
- A design engineer must have both direction (budget constraint, a recommended action) and control (e.g., conduct an audit of the road conditions). But he or she must also have the freedom to exercise creativity in designing the project.
- A design engineer operates in a "concrete" reality.

The bottom-up approach ensures that regional management conceives the output vector it is responsible for managing for cost and level-of-service. In doing so, project-level scale and other effects, involving project size, construction time, and scheduling—all of which yield clear monetary benefits to road agency and users alike—are used to advantage. In a companion study (11), these benefits are calculated to range from 11 to 25 percent of project costs, depending on the demand volume on the road.

In conclusion, compatibility between the management systems is important. For example, had a bottom-up RMS been adopted all the way, the central management would not have been able to exercise direction and control or consider broader ranging goals and manage successfully in a competitive environment for resources. Similarly, if the top-down model was used exclusively, freedom and flexibility and creative approaches would have been compromised.

FUNDING AND ROAD USER CHARGES

In many countries, the national road budget is allocated from the country's general budget. Increasingly, there are examples of systemwide earmarking (as in Switzerland, the United States, and some African countries) and of toll roads (Austria, France, Italy, Norway, Spain, Mexico, and the United States).

Financing road administration from general budget revenues coincides with the old road agency model: centralized administration and heavy producer organizations. More autonomous road organizations, even with general budget financing, tend to be more flexible and business oriented, leaning heavily toward contracting out and willing to develop user charges, a road fund based on user tariff. Road funding, be it earmarking a user tariff or developing toll roads or a combination of the two, is an integral element of road agency reform, as Heggie (4) points out. At the same time macroeconomists contest this point; they see no relation between cost recovery and user charges on theoretical grounds. They see autonomous road agencies limiting the maneuvering room of the country's Ministry of Finance.

This paper will not attempt to resolve this dispute. It merely seeks to lay out the issues of importance and not to ignore the fact that there can be no accountability in management and no customer-oriented service delivery without a degree of control of income and without appropriate user charges.

Basis of Road User Contributions

The framework used for deciding road budget allocation and distribution (between regions and road classes) to minimize total transportation costs determines the optimum size of the network and the optimal condition standards of roads (Figure 3). Today, few countries employ user costs to help determine the road condition standard. Instead, the road condition standards are determined by engineering and other considerations.

The issue is not, as road users maintain, that they already contribute more to government revenues than is spent on roads. The issue is that governments do not have surpluses; instead they experience shortages of tax revenues. But taxing road users is not

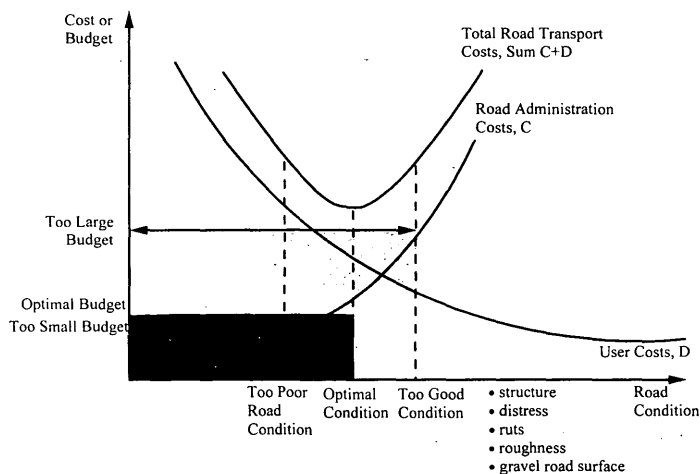


FIGURE 3 Optimal road condition and budget.

necessarily the best way to make up the shortage. Even if it is debatable whether road users pay too much, road transport incurs external costs in terms of pollution, noise, and congestion for which there is no market value at present; taxing behavior that incurs these external costs may not be good policy. There is also considerable evidence of cross-subsidization from cars to trucks, especially to heavier trucks.

Road users claiming they pay too much and the government allocating too little monies to roads point to the need for an appropriate road management system and analytical procedures for recommending road budgets and standards. There is also the need to pay for the costs of roads, which means well-reasoned user charges, such as a road tariff, and a road fund.

Pros and Cons of the Road Fund

A road fund is created by collecting road user charges. The fund is dedicated to roads. The advantages of a road fund most often cited are the following:

- It provides for a stable road budget and avoids political diversion of road user charges.
- It promotes efficient programming and contributes toward lower contracting costs.
- It makes higher user charges more acceptable because their use can be identified and monitored.
- It facilitates cost recovery and equity, because beneficiaries and those who pay can be matched.
- It constitutes a link between payments and benefits, which promotes more efficient management of funds and increases the sense of accountability, because the programs can be easily monitored and a clear system of performance indicators can be developed.
- It is essential for commercializing the road agency.

The most commonly cited disadvantages of a road fund are the following:

- It is said to entail a cost in terms of loss of budgetary freedom, especially if unforeseen fiscal difficulties arise.
- It could lead to distortions between different sectors of the economy and overspending in the road sector.
- It has not been successful in ensuring adequate monies for maintenance; there has been a tendency to use road fund monies for new construction.

Lessons from earmarked road fund experiments, and the "cons" identified, suggest that the following factors are important if a dedicated road fund is being contemplated:

- The planning process and the types of expenditures and functional classes for which a road fund can be used must be clearly specified.
- The yearly level of expenditure, the road sector allocation and its distribution between the major activities—new construction, maintenance, and operations—should be determined by reliable, periodically updated data and appropriate analytical procedures.
- The road management, in addition to auditing and accounting safeguards, which cover both the money usage and the perfor-

mance of the road administration, should be under proper political control.

- The road fund authorization should be periodic (e.g., set 4 years at a time, to maintain efficiency and avoid monopoly pricing).

It appears that the pros of road funds outweigh the cons, if appropriate safeguards are observed. The matter of funding is an important part of road agency management, and research should be undertaken to clarify the issues surrounding road funds.

Proposal for Road Fund Based on Road User Charges

Customarily, public finance principles of economic efficiency, administrative cost, and equity, in addition to cost recovery, are applied in developing road user charges. The following compromise proposal is designed to achieve these conflicting objectives and yet provide a transparent system that allows straightforward political oversight of agency performance.

- Variable charges, such as fuel charges and axle load charges, are levied to pay for maintenance and operations. Both charges are related to usage and inexpensive to collect. Fuel charges relate to both road wear and to many externalities. Heavy-vehicle charges, those based on the axle loads and distance driven, relate to road damage and a road's structural capacity. Electric cars and bad driving habits, as reflected in the drive cycle, are not covered and may require substituting tolls for fuel charges or other measures in the future.
- Fixed annual charges, vehicle charges, may influence the movement toward a less polluting and damaging vehicle fleet and, most importantly, may be applied to pay for the expansion (or contraction) of the network and pay interest on the capital invested in highways.
- Congestion tolls, made feasible by recent technological advances and restricted to congested facilities, are considered for demand management and for paying for capacity expansion or other acts on any transport mode to alleviate congestion. (If fuel charges on vehicles using alternative fuels become difficult to collect, such charges also can be collected as a toll.)

Any or all the above charges may contain a component to ameliorate environmental harm, provided the harm is, in fact, compensated. There may also be sales taxes or value-added taxes on fuel and vehicles that would accrue to the general tax fund.

CONCLUSION

Each of the sections offer conclusions; however, if there is one matter the authors want to emphasize it is the importance of a road agency's organization, management, and funding to its accountability and performance.

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Publication of this paper sponsored by Committee on Management and Productivity.