ORGANIZATION, MANAGEMENT AND FINANCING IN A ROAD AGENCY

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ABSTRACT

This paper focuses on issues and concepts involved in the road administration organization, management, and financing. Road Administration organization is analyzed using a cost function which supported a decentralized "fractal organization" for a road agency. Road management systems are then discussed. It is argued that for the management systems to be useful must be compatible with the agency organization. Finally, the Road Fund and road user charges are discussed and their importance to road administration management elaborated.
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Introduction

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 a constellation of political, technical, environmental, managerial and historical forces. Because of its 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", "environment", and the "value of the employees" are increasingly recognized and add to the managerial dimension of a road administration's mission.

The operational objectives to which road administrations' professional staffs attach importance are among the following: traffic safety, capacity increases to sustain or enhance current operating speeds as well as respond to changing traffic demand, rehabilitation of existing roadways, and environmental amelioration. In some countries and States improved farm to market accessibility, congestion management, and promotion of carpooling and public transit are also important objectives.

The issues and problems surrounding accomplishing these objectives constitute a familiar, well trodden ground for road professionals in every country, and most transport managers anticipate them in the normal course of their work. However, what makes dealing with them technically difficult is their intricate relationship with a full range of socio-economic parameters and nearly every facet of life, and the complications they introduce to decision-making in road management.
It might appear on the surface to be a contradiction, but in fact the "big picture", the 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 concepts involved in the road administration organization, management, and financing.

**Organization and Administration, a Brief International Review**

Structures for organization and administration vary from country to country. They seem to be dependent on the size, population, and historical heritage. Organizational development is not an accurate science, it simply is a certain arrangement of human cooperation. The organizational structure alone does not determine the effectiveness or success of the administration. There are "soft" factors involved; motivation, leadership, culture, etc. There are basic differences between federal and integral states. The management, ways of doing road works and responsibility areas of roads, influence the ways of organizing road administrations. The historical and political administration of a country also form the framework of organizing road administrations.

A recent survey of resource allocation practices in the OECD countries (1) showed a remarkable communality in these practices and managerial approaches in spite of the 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 is relevant in Germany, Italy, Spain, Switzerland and the United States. Canada also has a
Federal governmental level but this level is not involved in allocating road budgets. In other countries the Federal-State hierarchy is missing or replaced by another administrative organization or procedure. Interestingly, even when the governmental levels and the road administrative bodies are similar, they do not have similar responsibilities. Second, and one which seems to generate keen interest in many countries, is that pervasive traffic or financing problems are a motivation for creating totally new kinds of institutions. A good example are the motorway concession companies in France. Third, two main types of organization structures can be detected: the functional line organization and the fractal organization (to be discussed later). In the former responsibilities are divided functionally - construction, maintenance, planning and design, administration. This is the most common type of organization. In the fractal organization model, there is a comprehensive delegation of responsibility. These types of organizations are found in Sweden and Finland.

Managerial approaches showed great similarity and encompassed the planning and execution involved in the development, maintenance, and operations of the road system. 'Development' consists of construction of new roads, increases to capacity by means of adding lanes, and substantial realignment of a road which may or may not increase capacity; 'maintenance' denotes periodic resurfacing or strengthening of structural capacity; and, 'operations' includes snow and ice removal (in certain countries), care of roadside and service areas, guardrails, traffic signs and markings, and other minor repairs - potholes, shoulders - to keep pavements smooth and safe to the motorists. Within this three part division are embedded also traffic safety, environment, congestion management, and ends other than those directly impacting transport. These three main activities are shown as columns in Figure 1. The three-part division corresponds to the policy and budget making practices of most public infrastructure agencies and to the time horizon of decisions: development for long range, maintenance for intermediate range, and operations for the short range and emergency interventions. This division, observed in most countries, is a useful management aid; a somewhat similar management tool as functional classification of roads.
There also are three administrative decision making levels in each road program area. They are shown as rows in Figure 1 and illustrates in compact form the domains of management and resource allocation in a road administration. The first level - the network level - deals with policy and is usually exercised by the central management in the Administration or the Ministry. The second - the project level - is normally performed by the regional office's engineers charged with execution of the policies and deals with design. The third level - the program level - lies between the network and project levels; its function is to program the actions over years to implement the policies set at the network level, the multi-year road program.

**Management, Performance, and Organization of a Road Agency**

*Literature Review*

There is a shortage of literature on State or country road administration organization or their performance, or comparisons of road agencies in different countries or in different regions of a country. Larson and Rao's (2) seminal study of the U.S. State Highway Agencies' capital program management practices illustrates the complexity of these practices and the variance that exists in them between the 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, but his proposal has wider applicability). According to Heggie, the key managerial challenge includes the fundamental reforms regarding organization, management, and financing; the process for these reforms, and the strategy to be followed. Hartgen (5) uses a number of indices to compare the productivity and effectiveness of State highway agencies over time in the U.S. Finally, Humphrey et al (6) report on the methods used to assess the State DOT performance in response to David Hartgen's bold attempt to rank the performance of the State DOT's in the U.S.
Agency Performance and the Management Effect

The remainder of this section reports on a Finnish study (7) whose original aim was to study the agency's productivity and the effect of management on it; surprisingly the study was important from the point of view of the administrations organization.

Method. A review of literature (8,9) showed that the cost function was a versatile means to address questions relating to productivity and efficiency. Specifically for 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 new thing was to introduce management variables to the cost function to gauge their importance.

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

\[ C = g(W_i, Q_j, M_k, T, D_i) \]  

(1)

where \( C \) is the total cost of production, \( W_i \) a vector of input prices, \( Q_j \) a vector of outputs, \( M_k \) a vector of management variables, \( T \) the binary time variable or a proxy for technology, and \( D_i \) a 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 \( \text{m}^3 \), 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.
The input prices include wages, capital service, haulage, and material. There are three management variables over which the road agency, or management of a project, is considered to have control. The effects on costs of speed of construction, and of the percentage of contract work both give valuable information of past decisions and to 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.

**The maintained hypothesis.** Rigorous statistical tests (3) showed 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 differences; 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 form:

\[ \ln C = f(\ln W_i) + g(\ln Q_j, \ln M_k) \]  

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

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. The elasticity of cost with respect to per cent of contract work was against intuition: positive. The reason for this might be that the fast increase in the share of contract work had not been followed by a similar decrease in regions' own fixed
manpower, and had a negative impact on cost. [Because the 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% in the fixed labor force raises total costs 0.88% on the average, whereas the share of labor is only about 35% of the costs. A change in costs with respect to the amount of direct labor is thus elastic.

*Measuring Performance*

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

\[
Total \text{ factor productivity} = \frac{\text{change in outputs}}{\text{change in inputs}} \quad (3)
\]

\[
\text{inputs} = \frac{\text{total costs}}{\text{weighted input price}}
\]

\[
Total \text{ factor productivity} = \text{management effect} + \text{time trend} \quad (4)
\]

\[
\text{Change in unit costs} = \text{Change in input prices} - \text{Productivity} \quad (5)
\]

The Total Factor Productivity (TFP) measure differs from the traditionally used time effect by the management variables' effect. This is an important difference: management does have an effect on agency performance.

The above equations enable analyses of the changes in TFP from two different angles: the production process, which compares input and output quantity levels and their changes \[eq(3)\]; and the differences in the management factors and the rate of technical change \[eq(4)\]. A third interpretation is possible: the background variables can be seen as the sources of variations in the production process, e.g. changes in the level of input factors can be motivated by a technological innovation, a change in the speed of construction can affect both input usage and output levels and thus the productivity development of road construction and
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 other there are economies of scope and the costs of overlaying are affected by other outputs of the road agency. The labor force in a modern road agency is trained to have multiple skills and the question of economies of scope cannot be ignored (see (3) for a discussion). The cost function can also be used for inter-country comparisons (8). The fact that some measures have been found efficient in one context does not mean that they would be so elsewhere. For example, cost reductions achieved by contracting out maintenance may simply be a sign of the inefficiency in that particular country which may not be present in another country.

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

The traditional price orientation of productivity studies need to be shifted to transaction costs: what is the management environment, why is one organization better than another, what is the role of the management philosophy, what of technology, what of the managers themselves?

Suffice it to conclude this section that the cost function together with the road management system and periodic audits of road condition provide the information necessary for performance assessment of a road agency. It must be added, that in all phases the people responsible for the work must be involved because they can supplement and explain the things that a model cannot.
Organization and Performance

Good organization structure is a necessary umbrella for effective road management. Organization is a means for good results in production and for meeting the customers needs.

Current Situation. Typically the Country (State) Road Administration has a centralized decision-making and functional line organization. The regional offices 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 organization structure is based on the technocratic idea that each line has its own separable product, and that within the line output (e.g. 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; organizational needs may exceed "optimal" needs, and there may be a loss of information due to top down micromanagement, etc.

An Approach for Restructuring. There are several approaches to resolving resistances in public organizations to provide 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; non-separability of management and output; multiproduct nature of the "firm"; economies of scale; irrelevance of the region specific characteristics; and the importance of scheduling (programming) of projects and their optimal timing on costs (10).
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. In what scale should the decentralization be done? According to the model, optimally FINNRA should be divided into 4-5 regions instead of the then existing thirteen. 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 are taking effect gradually, the first ones beginning 1991. A duration from idea to implementation of 3 years!

When these findings are translated to practical terms they mean that, given its budget, the executing regional office must have a comprehensive responsibility regardless of the size of the region to creatively manage all its outputs. That is, the regional director should be accountable for design, construction, rehabilitation and maintenance once policy and the overall program goals have been established. The regional director could, for example, be accountable to the Director General and the Board of the Road Administration.

What then is the role and composition of the Central Administration (CA)? Following the results and reasoning above, the CA must have a comprehensive responsibility (of recommending to the Board or the Ministry) for the policies to be followed and the distribution of monies within the country, and be accountable of the Road Agency's performance. Many advantages can be gained if the Directorate of the Agency is composed of the Director General and the Region Directors and forms a general purpose management team. These advantages include: formulation of goals in a manner which is equivalent to every region; commitment to distribution of allocated monies; possibility to monitor performance in a consistent manner; cohesion within the agency; etc. The If the country is divided into numerous regions the size of the
Directorate can become too big and make it unmanageable. It, therefore, 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 where the area chief is responsible and accountable for the roads in his area, planning, design, safety, construction, maintenance, environment, everything. He may employ experts, but the manager has general purpose responsibility.

The organizational structure sketched above, and shown 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. Words general purpose apply only to management; activities which are best performed at the region level, e.g. programming and executing road condition surveys need not be delegated. Centralization, decentralization and delegation depends on technology and available expertise; not only on organization structure.

It is important to note that concurrently others arrived at the above 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 U.S. echoed similar themes. Larson and Rao (2) in their study propose that "in a more competitive environment for resources, highway capital programs will likely require a new focus and broader ranging goals", but 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 the ideas commonly held in Finland and Sweden at
the time (both countries were undertaking reorganization at the time of the publication of the Larson and Rao's study). Thus, the model results were also reflected in current thinking in the profession.

In concluding this section it is hoped that studies are undertaken to determine how many regions a country should have. A hypothesis can be made 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 employment of more advanced technologies and information systems. It is also speculated that the functional and fractal organizations need be employed 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 and may well be the best organizational model in most developing countries for some time to come. The organization structure is important for the fulfillment its mission. It is also important that organizational restructuring keeps 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 also a political process. More research and experimentation is needed on these matters.

**Implications to the Management Systems**

Management systems are a necessary element of good management. It is less often thought that organization structure and decision-making style are important factors in the design of the management systems. The design of FINNRAs (11,12,13) road management system was critically affected by the organizational considerations and by the weaknesses of the then practiced budgeting and output formulation processes which, among other things, permitted serious leakage of funds and apparently non-optimal choices of projects.
The road management system (RMS) must be consistent with the management structure implied by Figure 1: the program areas of development, maintenance, and operations of roads and bridges; and the administrative decision making levels network, program and project levels. It is recalled that the network level, exercised by the Central Administration, deals with policy and resource allocation; the project level, performed by the regional offices, deals with design and work planning. The program level to implement the policies over many years is a joint responsibility of the Central Administration and the regional offices. Often this kind of system is called a "top-down" method as opposed to "bottom-up" method which builds the multiyear program from individual projects. The following explains that the system developed and adopted by FINNRA is both.

The key ideas in the "top-down" (reading Fig. 1 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 can make an action recommendation;
* Central Management has many other considerations, constraints, etc. which it needs to value when distributing the budget;
* the budget and other constraints are explicitly considered and their importance assessed and communicated in terms of trade-offs between competing programs;
* Central Management operates in a ‘virtual’ reality.

These thoughts are consistent with contemporary practice and thinking in road management which emphasizes the role of the CAO and the "top-down" position of the Central Management. It accepts that transportation is perceived and used by policy makers as "means to ends other than those directly impacting transportation" and is compatible with Larson and Rao's thoughts about "competitive environment for
resources”, "new focus and broader ranging goals”, and ". the need for direction and control on the one hand and freedom and flexibility on the other.”.

The key ideas of the "bottom-up" (reading Fig. 1 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 which affect the final design and the final program; these variables include "historical memory" of the agency;
* the design engineer must have both "direction" (budget constraint, recommended action, etc.) and "control" (audit of the road conditions) but also freedom to exercise his creativity to make the engineering design;
* the design engineer operates in a "concrete" reality

This "bottom-up" approach insures 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, which yield clear monetary benefits to road agency and users alike are taken advantage of. In a companion study (10) these benefits were calculated to range from 11 to 25 per cent of project costs, depending on the demand volume on the road.

This section is concluded by emphasizing the importance of compatibility between the management systems. For example, had a "bottom-up" RMS adopted all the way, the Central Management would not have been able to exercise "direction and control", "consider broader ranging goals" and manage successfully in "competitive environment for resources". Similarly, if the "top-down" model was used all the way, the "freedom and flexibility" and "creative approaches" would have been compromised.
Funding and Road User Charges

In many countries allocation of the road budget is done from the country's general budget. Increasingly there are examples of system wide earmarking (Switzerland, the U.S. Federal-aid system, many U.S. States, and some African countries), and of toll roads (Austria, France, Italy, Norway, Spain, the U.S. Mexico).

Financing of 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) rightly points out. At the same time it is heavily contested by the macro-economists who, on theoretical grounds, see no relation between cost recovery and user charges, and see autonomous road agencies limited the maneuvering room of the Ministry of Finance.

This paper will not attempt to solve this hotly debated dispute. It merely seeks to lay out the issues of importance and not ignore the fact that there can be no accountability in management and no customer oriented service delivery without 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) - minimization of total transportation costs - determines the "optimum" size of the network and the "optimal" condition standards of roads, Figure 3. Today, few countries use 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 bestow 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 that taxing road users is not necessarily the best way to fill the shortage. Even if it is debatable whether the road users pay too much; road transport causes external costs on environment, noise, and congestion for which there is no market at present, taxing behavior which causes these externalities may not be a good policy. There also is considerable evidence of cross-subsidization from cars to trucks, especially to the heavier trucks.

The road users claiming to pay too much and the government allocating too little monies to roads, point to the need for having an appropriate road management system and analytical procedures for recommending road budgets and standards, and to pay for the costs of roads to have well reasoned user charges - a road tariff and a road fund.

**Pros and Cons of the Road Fund**

Road Fund is collected as road user charges an dedicated to roads. The most common cited advantages of the Road Fund are:

i. it provides for a stable road budget and avoids "political" diversion of road user charges;

ii. it stable promotes efficient programming and contributes toward lower contracting costs;

iii. it makes higher user charges more acceptable because their usage can be identified and monitored;

iv. it facilitates cost recovery and equity; beneficiaries and those who pay can be matched;

v. a link between payments and benefits promotes more efficient management of funds and increase sense of accountability because the programs can be easily monitored and a clear system of performance indicators can be developed;

vi. it is essential for commercializing the road agency.
The most common disadvantages are:

i. it is said to entail a cost in terms of loss of budgetary freedom, especially in unforeseen fiscal difficulties;

ii. it could lead to distortions between different sectors of the economy and overspending in the road sector;

iii. 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 identified "cons", propose that the following factors are important if a dedicated road fund is contemplated:

i. the planning process and the types of expenditures and functional classes for which road fund can be used must be clearly specified;

ii. 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;

iii. proper political control of road management, in addition to auditing and accounting safeguards, which covers both the money usage and the performance of the road administration;

iv. the road fund authorization should be periodic, e.g. four years at a time to maintain efficiency and avoid monopoly pricing.

It would appear 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.
A 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 the road user charges. Below is a compromise proposal to achieve these conflicting objectives, and yet provide a transparent system which allows a rather straightforward political oversight of agency performance.

i. Variable charges - fuel charges and axle load charges - to pay for maintenance and operations. Both are related to usage and inexpensive to collect. The fuel charges relate both to road wear and to many externalities; heavy vehicle charges, based on the axle loads and distance driven, relate to the road damage and for 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 and other measures in the future.

ii. Fixed annual charges - vehicle charges - to influence the movement toward less polluting and damaging vehicle fleet, and, most importantly, to pay for the expansion (or contraction) of the network and the interest on the capital invested on highways.

iii. Congestion tolls, made feasible by recent high-tech advances and restricted to congested facilities, for demand management and for paying for capacity expansion or other acts on any mode to alleviate congestion. (If fuel charge on vehicles using alternative fuels becomes difficult to collect, they also can be collected as a toll).

Any or all the above user tariff components may contain a component to ameliorate environmental harm, provided the harm is, in fact, compensated. There may also be sales taxes or VAT on fuel and vehicles which
would accrue to the State's general tax fund.

**Conclusions**

Each of the sections already end with conclusions and there is no need to repeat them. If there is one matter that needs emphasizing it is the importance of road agency organization, management and funding to its accountability and performance. To this end the authors have sought to make a contribution.
References


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FIGURE CAPTIONS

FIGURE 1: ROAD MANAGEMENT SYSTEM

FIGURE 2: FRACTAL ORGANIZATION

FIGURE 3: OPTIMAL ROAD CONDITION AND BUDGET