CHAPTER III

ALLOCATION AND DISTRIBUTION OF FUNDS BETWEEN ROAD CLASSES AND ROAD IMPROVEMENTS

III.1. INTRODUCTION

As outlined in the two preceding Chapters, the purpose of resource allocation is to determine the appropriate total level of capital and maintenance investment that is to be made available for road repair and rehabilitation, bridge reconstruction and rehabilitation, and new construction, usually on an annual basis. Distribution is the manner in which total funds allocated for highway and bridge repair are made available to subnational jurisdictions, road systems, and types of improvement.

This Chapter considers both the allocation and the distribution of the overall budget established for national road maintenance and rehabilitation. It describes the methods commonly used for **(1) the determination of total funds to be allocated; and (2) distribution of those funds (a) by roadway system; (b) by governmental unit; and (c) by highway and bridge improvement type.**

This Chapter also summarises the systems currently in use by the countries participating in the preparation of this report, describes the common elements and suggests potential improvements to facilitate more cost-effective and efficient distribution of scarce resources for highway and bridge rehabilitation and maintenance through the development of a systemic data and analytical structure. Specific recommendations for data and analytical development are included in the report conclusions.

Observations, comments and conclusions in this Chapter are based on the survey data presented in Chapter II and the Expert Group's Discussions.

III.2. RESOURCE ALLOCATION PROCEDURES

III.2.1. Basic patterns

Among the participating countries, four identifiable patterns of resource allocation can be identified. The defining characteristic of these four patterns is the degree of shared responsibility between the Ministries of Finance and Transport (or their equivalents) in the allocation process.

In the first pattern, the responsibility for allocation, especially for the national road system, is retained in governmental hands. For example, the Ministry of Transport in Canada is totally responsible for resource allocation on the national road network. In Great Britain, the Department of Transport has the responsibility on a central as well as on a regional level. In Turkey, the allocation/distribution procedure is maintained on a governmental level through the General Directorate of Highways (KGM) of the Ministry of Public Work and Settlement. The procedure for resource allocation in the United States is very much reflected by the interaction of responsibilities between the Federal and State levels.

In the second pattern governmental jurisdictions are still in charge of allocation, while the distribution procedures are transferred to national, regional, and local road administrations. Germany, Japan, Norway, Portugal, Spain, and Switzerland belong to this allocation/distribution category.

In the third pattern, autonomous bodies are involved. This describes the allocation/distribution process in Italy, with the Autonomous State Roads Administration (ANAS).

Finland and Sweden represent the fourth discrete pattern. Although the financial responsibility remains in the hands of the government, the Road Administrations have a strong impact. This is consistent with the "management by objectives" philosophy that these countries have adopted.

Typically, the Central Government generally defines the total annual roadway rehabilitation and maintenance budget. In addition to the initial budget allocation, the central government may also determine the distribution of those funds by governmental jurisdiction, road system and, in some cases, by major category of road improvement type, although the involvement of the central road authority varies by country.

Decisions are made using a combination of technical analysis to achieve efficiency in fund allocation, and political, social, technical and economic considerations to achieve funding equity and balance among competing interests and political jurisdictions. This combination of technical and political considerations appears to exist in some fashion in all of the countries participating in this study. As was true with the degree of central government involvement in the allocation process, however, the variations among countries in the relative mix of technical and political considerations are broad.

Under the political level(s) the managing responsibilities of road administrations differ between countries. Some countries use "management by objectives", "directed autonomy", or "zero based budgeting" philosophies in carrying out their responsibilities; other countries are more directly tied to the Ministry of Transport which permits only "limited autonomy" to their road administrations.

There also exists variations to these two main types -- directed vs. limited autonomy -- of administrative styles. In Italy, for instance, there is an autonomous body (ANAS) that has the responsibility for managing national roads and motorway networks (toll roads as well as freeways), and deciding how to use resources allocated to it annually, but the agencies managing the other networks are not autonomous and have much less freedom than ANAS in deciding about their use of resources.

The road funding allocation decisions, which are expressed as multi-year plans, are often based and developed using benefit-cost analyses as an important planning tool. This is a good omen; the analytical procedures to be proposed later on this report are based on the same principles as the benefit-cost analysis. The difference lies in the more comprehensive approach to road resource allocation and in the clear acknowledgement of the importance of the budget constraint and other relevant criteria.

Within some of the participating countries, resource allocation decisions are made unilaterally by the Ministry of Finance. In many cases, however, allocations are made in consultation with the Ministry of Transport. The consultation process can assist the Ministry of Finance in determining the appropriate total level of funding to be made available for road and bridge improvements. This determination must consider total maintenance and rehabilitation requirements to support the desired level of overall system condition and performance for the country's road and bridge systems. Involvement of the Ministry of Transport provides the technical advantage of providing continuous information to the Ministry of Finance regarding the national and regional economic development and performance implications of transport investments and its importance to other national objectives.

III.2.2. Country by country review

In this section the road budget allocation/distribution practices are briefly reviewed country by country. The reader is reminded of the fact that the administrative structures in the participating countries are different, and, therefore, the observed practices reflect different contexts of decision-making. Despite general similarities, each of the countries has its own, particular scheme for resource allocation/distribution for its transport system.

In **Canada**, the responsibility for national roads is solely entrusted to the Provincial Ministries of Transportation. Responsibilities for road networks on lower levels is entrusted to the road departments on county, township, and city/town levels. Provincial subsidies is an important source for road funding on these lower administrative levels. Each level of government is responsible for determining its own budget; however, this must be done in accordance with needs studies updated through a uniform system of inventorying.

In **Finland**, the basis of road allocation for the Finnish Road Administration (FinnRA) is Management by Objectives (MBO). This requires a series of objective negotiations between the central administration (directors) and the regional units (road districts). The objectives are agreed between FinnRA and the Ministry of Transport. The road budget is allocated to basic maintenance and investments through negotiations between FinnRA and the Ministry of Transport. Criteria for allocation come from the agreed objectives and the list of investment projects. The road budget for new construction or other improvement investments is agreed by the Ministry of Transport on the basis of the detailed project list submitted by the FinnRA. There are no detailed criteria for this decision making, but emphasis is given to four general criteria:

(1) Highway capacity on major routes between the most important economic production centres in the country;
(2) Highway capacity of the regional transport system;
(3) Urban capacity and safety problems, particularly on major highways; and
(4) Cost/benefit analysis and first year rates of return on investment.

The Central Administration of FinnRA distributes the road maintenance budget through product-based performance contract negociations with the districts. All fund distributions are done by the road districts.

In **France**, the yearly budget for road maintenance and toll motorways is fixed by the Prime Minister, after consultation with the Minister of Finance and the Minister of Transports. This budget is managed by the "Directeur des Routes" (and partly by the "Directeur de la Sécurité et de la Circulation Routière"). The main part is distributed to the "Directeurs Départementaux de l'Equipement" (DDE, about 100 in number) on the basis of formulae depending on length, heavy traffic and climate. The DDE are given objectives and are then free to use the funds.

The French motorway network is primarily funded through tolls and managed by seven semi-public companies. The State wide budget for (i) new construction, (ii) improvements to the existing network (e.g. adding lanes), and (iii) rehabilitation and periodic maintenance is determined in negotiations between the Ministries of Finance and Transport. Thereafter the Ministry of Transport decides the distribution of the total budget between the Motorway Companies on the basis of technical criteria. The government also decides the priorities for new construction and major improvements to the existing network.

Rehabilitation and periodic maintenance - and operations, of course - are the responsibility of the Motorway Companies, given the budget. The companies generally use "pavement management systems" and base the choice of actions on pavement condition, existing and forecast, to guide efficient use of budgeted monies.

The local authorities, about 100 "departments" and 36000 communities, are free to set their own road budget and manage it.

Administratively there are also "regions" (23) in France. They have no road assets of their own, but they use a part of their budget to help either the State or local authorities to implement projects -- modernisation rather than maintenance -- in accordance with the region's preferences.

In **Germany**, the federal, state, county, and city road departments have their own budgets and priorities. Priorities can be reestablished and funds reallocated accordingly. The Federal budget is distributed among the Federal states (Laender) by formula, considering the length of the Federal road network in each state. Percentages are recalculated every five years. The overall goal is a uniform level of road condition and performance.

In **Great Britain**, the Department of Transport obtains funds from Her Majesty's Treasury for all expenditures on National roads and through grants for 50 per cent of expenditures on local roads. The other 50 per cent of expenditures on local roads comes from locally allocated revenues. The Department of Transport divides the road budget between its nine regional offices for National roads. This division is influenced by the status of plan preparations and priority of particular programmes. The Department also divides the grants available to local highway authorities on the basis of formulae and programme priority.

In **Italy**, road budget allocation is made by an annual financial law. The road budget is divided using different methodologies by the Autonomous State Road Administration (ANAS). Consideration is given to:

-- Traffic demand;
-- Pavement condition;
-- Per cent of highways with four or more lanes;
-- Elevation above sea level and snow incidence;
-- Number of freezing days per year; and
-- Geological factors.

In **Japan**, road works are classified into three categories: Government General, Toll Road System, and Regional. The Ministry of Construction decides the allocation and distribution of funds for national expenditure between national roads, toll roads, prefectural roads, and municipal roads. Priorities reflect compromises driven both by technical criteria (demand and condition) and by local governments' desires. Regional road works are independent; the budget allocation and distribution as well as priorities are determined by local governments.

In the **Netherlands**, an Infrastructure Fund has been set up for the allocation of funds for the construction and maintenance of the main road network, main waterway network and rail network. The fund is replenished from an additional charge levied on motor vehicles; at least ten per cent of the proceeds of the petrol tax and contributions from other taxes at the State level.

The provinces, municipalities and polder boards are responsible for their own road planning and for the distribution of the contributions from the central government plus own tax income to road construction and maintenance.

In **Norway**, the Parliament allocates funds to the national roads as well as special programmes to improve bearing capacity and safety on county roads. For special programmes, counties are required to participate in the funding. County, city, and local councils appropriate funding to meet match requirements or other programme needs. The Parliament also allocates funds on a project basis for national roads.

Norway uses the following criteria in allocation for national roads. For operation and maintenance funds, the cost to maintain an optimum standard is used. For new investment allocations, project ranking using benefit-cost analysis is applied. In addition, funds are appropriated for certain special programmes to address needs by geographic area of the country. Toll-road collections offer an additional source of funds, but decisions about new toll facilities is also decided by the Parliament.

In **Portugal**, the national government is vested with all road construction and maintenance as a public utility function. The general government budget has, therefore, been the source of finance. The Public Works Ministry oversees the allocation process. The process considers equity of funding and new works planned within the next year resulting from a multi-year strategy.

Portuguese toll roads are entrusted to a concessionaire -- BRISA -- which is a limited liability company in which the Government holds a majority interest. Since the Government provides bond guarantees, it also determines budget allocation.

Some local roads combine local and central funding; the central funds come also from the general budget. The final distribution decisions used by the government include:

-- Physical characteristics of each administrative region's road network;
-- Pavement condition;
-- Traffic volumes; and
-- Priority of new network construction, as contained in the multi-year plan.

In **Spain**, allocations for national roads are made in the national budget by the Finance Ministry after consultations with the Public Works and Transport Ministry. The Parliament will approve the budget every year.

The national roads budget is divided into two main programmes: the new roads programme and the maintenance and operation programme. The allocation between the two is made following the planning of new infrastructure included in the multiyear road plan and the needs for maintenance (both routine maintenance and rehabilitation) and road safety (both included in the same programme) in accordance with technical criteria.

Technical criteria for allocation of maintenance funds are based on: extent of all types of road, km of motorway, km of highway, dual or single carriageways...), type of pavement, traffic, number of bridges, condition of pavements, climatic area and other factors.

In **Sweden**, the central government and Parliament decide the funds for construction of national roads, regional transport systems, and for maintenance and operation. The Road Management Division then distributes the money on the basis of project profitability analysis and maintenance requirements. The construction programmes are prepared every third year for national and regional transport systems. The Road Management Division is responsible for the preparation of these programmes. The programmes are based on projects proposed by the Regional Administrative Boards and the Municipal and Public Authorities. After 1994, these programmes will also include maintenance and operation.

The Road Management Division distributes construction funds to the seven regions and 24 counties. Sixty per cent of the funds are allocated based on "efficiency"; the remaining 40 per cent are allocated on the basis of "equity". Maintenance funds are suballocated with consideration given to the relative physical condition of roads throughout the country.

In **Switzerland**, federal roads are supported by the Swiss Federal Highway Office (SFHO), using funds dedicated from the fuel tax for roads and traffic. Federal grants are matched at 85/15 by State governments. Distribution is based on considerations of multi-year programming, budget, predicted fuel tax allocation, financial situation of the Confederation, state of the project and construction plants. Maintenance allocations include estimates of yearly costs and the maintenance cycle of the different parts of the roads and bridges. Urban and rural roads belong to municipalities and cities. Their funds are derived from personal taxes.

In **Turkey**, the Planning Department of the General Directorate of Highways (KGM) is responsible for identifying and proposing capital investments and preparing budget estimates. This department provides technical and economic studies for investment projects and also divides the budget between motorways, state roads, and provincial roads.

In the **United States**, each unit of government has its own budget and makes decisions about allocating funds to projects. Criteria vary, but include some blend of technical consideration and political desire. The Federal Government requires each recipient to follow prescribed processes for planning, financial management, environmental assessment, and other considerations. Out of these processes, statewide improvement programmes are developed and ranked by importance at the State.

Federal funds are authorised by the U.S. Congress and provided mostly by legislated formula to the States. Funds can usually be transferred among funded programmes. States have the authority to suballocate Federal funds, but are not required to do so. "Loan" programmes may be established among States or subjurisdictions within States, where Federal or State funds can be transferred and applied to maximise their effectiveness.

III.3. FUND DISTRIBUTION METHODS

III.3.1. Principal approaches

Once national budget allocations are made, the specific allocation for a nation's road transport system must be implemented through a fund distribution method. The programme and budget methods by which funds are allocated and distributed vary by country. In some of the participating countries, resources are allocated as a single budgetary item, with distribution by jurisdiction, road system, or improvement type delegated to regional or local road administrations. In other countries, road funds are distributed or suballocated by the central authority as two or more independent budget items. These independent budget items typically include, as a minimum, a component for road maintenance/ rehabilitation and a separate component for new construction.

Other distributions may be made in order to achieve specific national or regional objectives, including such elements as environmental enhancement, historic preservation, and safety. In some cases, particularly for transport enhancements to minimise social or environmental disruption, these objectives are only indirectly transport related. The share of total road and bridge maintenance and rehabilitation funds that are attributable to environmental and non transport functions is increasing in most western European countries and in the United States. The share attributable to network development and expansion is generally declining in more developed countries.

Further distributions or suballocations may be made for local roads to achieve geographic and political equity in funding distribution. Distribution in two or more directed programme categories appears to be prevalent throughout many European countries and the United States to achieve regional balance.

The initial overall determination of budgetary allocation performed by the Ministry of Finance may be considered systemic in nature. It requires objective and subjective evaluation of alternate investment strategies against a prescribed set of national or regional goals. In some cases, initial distribution of funds by highway system and jurisdiction to achieve equity also involves measurement against these same or similar objectives. In a few cases, little rigorous evaluation appears to be required.

Systematic measurement and evaluation requires the development of standardised data and analytical procedures to ensure that comparisons are accurately made throughout the nation's regions or provinces. The types of data required for this initial allocation are general in nature. They consist of measures of system usage and extent, land area, population, and other objective measures of areal dimension, as well as standard network measures that can be applied nationwide. These latter kind of road system data and their collection are discussed in Chapter VI.

In most western European countries, the Minister of Finance assumes a major role in the decision-making, either in terms of direct determination of funding and distribution methods or else in an advisory capacity to the Parliament or other elected officials. In most countries, the overall budget determination is based on a systematic approach that relies extensively on engineering and economic assessments to determine budgetary requirements. These requirements are defined within a strategic planning matrix arrived at through professional judgment, active consultation with districts within the country, or a combination of the two methods. This approach may be based on one of several types of financial and programme management conceptual designs, such as:

-- Management by objectives (MBO);

- -- Zero based budgeting (ZBB);
- -- Programme, planning, and budgeting systems (PPBS);

or some other programme management technique of arriving at funding allocations and distributions within a structured framework. These programme management styles, developed by public administration and business administration graduate study programmes, are widely applied internationally as a means of allocating limited funds for a variety of public programmes. They all require some degree of technical assessment and comparison against a set of prescribed objectives. The essential difference between these comprehensive resource allocation strategies and the strategies typically used today is that standard resource allocation is a marginal process. Past year allocations are used as a baseline for comparison against possible budget options and evaluations are made on the basis of marginal changes in allocation and distribution. Under the more comprehensive method, budgets are "built up" on the basis of how well an allocation level or means of distribution achieves a prescribed goal or objective.

As a general conclusion to this section, it may be observed that annual road and bridge funding in many developed countries has stabilised in recent years, and actually declined in some instances. The response to this scarcity in funding has been mixed. In some cases, fund efficiency has become a higher priority, with rigorous benefit-cost analyses taking a greater role in fund distribution. In other cases, fund equity has become a greater consideration, as political subjurisdictions seek to maximise their share of available funds at the expense of competing jurisdictions. Therefore, the Expert Group's broad analytical approach to the task of resource allocation and distribution is a timely response to the needs of the policy makers and managers.

III.3.2. <u>Methods of fund distribution by governmental unit</u>

There appears to be a correlation between method of distribution and country size and homogeneity. In smaller countries, where regional variations are negligible, fund distribution is usually accomplished on a "needs" basis, using nationally established criteria for determining needs and distribution formulae. These evaluations are typically made by the central road authority. In these cases, efficiency and effectiveness of resource allocation/distribution appear to be the most significant considerations (See Box IV.3, reading of this Box is preferably done in conjunction with Chapter IV).

In larger countries with varied geography, topography, and economic dissimilarities, efficiency is put forth as the primary determinant in fund allocation, but equity appears to be a much more significant consideration. Fund allocation in these countries is often related to objective measures of system extent and usage, notably mileage and vehicular travel. In these countries, allocation and distribution is designed to ensure that all areas receive a share of available funds, regardless of need.

A combination of allocation strategies appears to be desirable to ensure both system efficiency and equity. Such a combined system could allocate funds through road programmes based on functional or administrative classifications keyed to national or regional mobility and economic development parameters. Objective economic measures of rates of return could be used to focus investment on the most economically efficient projects while an equity based measure could be used to address local projects, usually lower volume facilities, that would not be addressed using purely economic criteria.

The variation in distribution methods also appears to depend on the overall degree of centralisation or decentralisation of governmental authority and the political framework used to govern the country.

For smaller countries, or countries with few political jurisdictions and subjurisdictions, fund suballocation is used sparingly. In these cases, local governments are required to petition the central government for funding on the basis of technical analysis. The central governmental authority then establishes grant criteria and seeks to achieve equity and political balance through grantsmanship.

In larger, more decentralised countries, virtually all of the road rehabilitation funds are apportioned to subjurisdictions, along with the responsibility for road repair and maintenance. Among the participating countries, road funds are allocated for at least two major road categories, nationally most important road network (the 'Interstate System', 'E-Roads', 'Main Roads',etc. depending on the country, as reviewed in Chapter II) and other roads. The procedures used for this road category distribution are usually established in law and national policy, and based on objective measures of system extent and usage characteristics.

III.3.3. Methods of distribution by type of road improvement

In all participating countries, distribution by type of road improvement is a rigorous engineering and/or economic analysis, requiring the use of sophisticated computer programmes that relate investment to system performance impacts. In most cases, distribution analysis is sufficiently sophisticated to relate investment to changes in measurable engineering parameters such as pavement and bridge condition, safety, or levels of service.

In fewer cases, analysis is more refined, and is sufficient to relate investment to changes in highway user costs, including vehicle operating costs, travel time, fuel consumption, emissions, and safety. Several countries have efforts underway to relate investment to broader economic or other measures, such as national productivity, capital consumption, and/or social welfare. But these efforts are not widespread.

The quality, consistency, and application of complex road and bridge data banks and analytical systems to support the development of rehabilitation and maintenance budgets vary widely among participating countries. For instance, all participating countries consider bearing capacity in calculating pavement backlog requirements and in determining budget requirements and allocation. Further, site-specific pavement information is generally available among this study's participants, but often for surface conditions only. This information may include measures of roughness, deflection, rideability, and/or surface cracking. This information can be used to establish bearing capacities to support the development of pavement management programmes.

On the other hand, drainage adequacy and subbase condition is seldom available, and these are major factors that help determine the particular type of pavement rehabilitation strategy required for accurate life-cycle pavement cost estimation. In addition, future travel forecasts, particularly by vehicle category and subcategory, appear to be absent for many countries.

Safety information, including system related information on curves and grades, geometrics, and sight distance, and vehicle based information on accident rates, are data items typically not available or not used for resource allocation purposes. In some cases, reductions in fatalities and injury due to accidents are advanced as objectives for resource allocation. But there appears to be little support for determining the relationship of investment allocations to achieving these goals.

Capacity deficiencies do not appear to be a major consideration in either determining budgetary goals or in allocating funds in general, or to rehabilitation and maintenance, or in particular. This may reflect a sense among participating countries that adequate capacity exists to accommodate the foreseeable growth in highway demand, or it may be a reflection of the budget allocation practices whereby capacity additions, and rehabilitation and maintenance are decided on different grounds. This latter interpretation seems to be borne out from the data. At least in some countries, new capacity is considered separately and subjected to different evaluation criteria. But, in others, all rehabilitation and maintenance requirements are subjected to similar analysis requirements, typically based on rate of return or some other form of economic analysis, as new investments. It is not clear whether sufficient data are available to compare alternative investment strategies, which include both new investment and rehabilitation, with the same degree of accuracy or adequacy. The desirability of "level playing field" was spelled out in Chapter I, and diagrammatically expressed in Figure I.3.

III.4. CONCLUSIONS

It is advantageous for resource allocation and distribution decisions to be made using a consistent, reproducible, and standardised evaluation methodology. This methodology may be thought of as a "nested" technique, where allocation and distributions are made using common, but increasingly more detailed, data systems and analytical procedures that are linked in conceptual design.

The Road and Bridge Management System, described in Chapter I, referred to in Chapter II, and conceptually elaborated in the next Chapters, presents an attractive model to begin this standardisation and search consistency.

Any analytical design should focus on rigorous analytical forms in order to minimise the variability inherent in the use of equity to achieve regional balance in fund allocation/distribution. Although equity will continue to be used as a means of achieving regional and political balance, the use of systematic methods for allocating resources to transport will increasingly enable countries to evaluate transport alternatives on their own merits.

This move toward consistency requires the development of standard techniques and data systems, within the context of a fully integrated road and bridge management system. The system should be capable of accommodating the types of allocation and fund distribution currently required, including:

(1) Development of budgetary totals based on relating expenditures to changes in overall system performance;

(2) Development of regional distributions through the use of economic analysis that equitably compares the overall value of investment by jurisdiction; and

(3) Development of functional distribution tools to calculate and compare changes in road user costs associated with various investment strategies.

In addition, integrated system performance should be undertaken to support related economic analysis, including computations to relate capital and maintenance investment strategies to macroeconomic performance, input-output by major industry groups (see Box V.2), and economic development impact analysis.

CHAPTER IV

ANALYTICAL APPROACH TO OPTIMISATION

IV.1. THE THEORETICAL FRAMEWORK

The engineering-economic approach for optimising road management systems should be flexible enough to be applied in the diverse institutional settings found in OECD countries and discussed in previous chapters. This Chapter presents such a conceptual framework as well as guidelines for the development of an analytical procedure that will begin to address this question. The process of generating these guidelines necessarily involves a variety of micro-economic concepts and options for their application.

When the situation is viewed as a whole it is apparent that road maintenance managers are caught between two conflicting objectives:

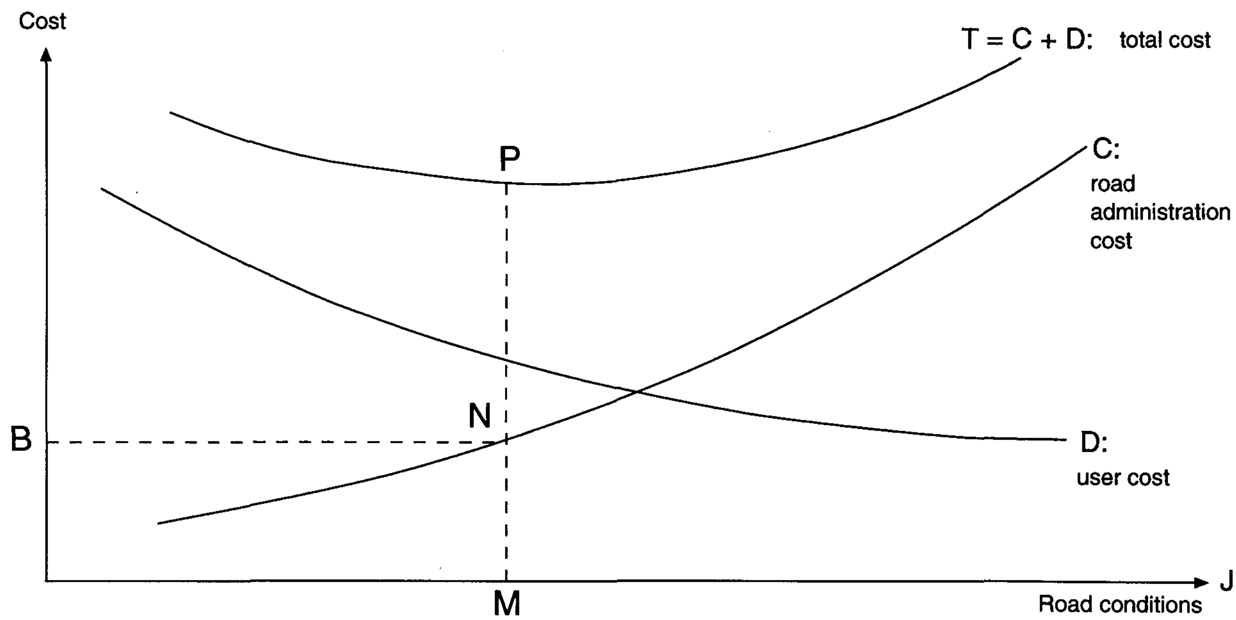
-- improving road user service, and
-- reducing the cost of providing that service.

The aim is to find the minimum possible total cost to road users and to the society as a whole (see Figure IV.1). If a graph is plotted with a road condition quality indicator on the X-axis, the curve which shows road user costs decrease and that which shows road administration costs rise. The total cost curve, the sum of these two types of costs has a minimum value i.e. the theoretical economic optimum which however does not necessarily reflect the optimum road conditions determined on the basis of the required road standards.

In Figure IV.1 the optimal road condition would be at M and the associated total cost for bringing or keeping the road in this standard would be at P; the agency costs being MN and the user costs NP. Alternatively, Figure IV.1 can refer to a subnetwork and indicate the network wide optimal road standard and the budget associated with the standard. It is important to appreciate this result which at the same time determines the best road condition standard and the associated agency cost (Or, the agency budget for an area or subnetwork and its aggregate optimal condition).

The idea presented in the graph masks a fairly common reality for road professionals. Decision-makers are often faced with financial constraints; and engineers are often faced with both a budget constraint and road standard constraints to achieve an optimum road condition. To address this reality, it is important that an analytical procedure enable the appropriate decision-makers to find the "second best optimum" in the light of these constraints. The graph illustrates this concept and the effect of standards and budget constraints on allocation and distribution of funds (See Box IV.1).

Figure IV.1. **Engineering-economic approach to optimising road rehabilitation and maintenance**



J : road condition indicator
D: user cost
C: road administration cost
T: total cost (T = C + D)

M : Optimal road condition
MN: Budget to sustain optimal road condition
MP: Total cost minimum for the optimal road condition

The proposed analytical procedure must also be able to account for present and future costs because the object of analysis is a set of actions whose lifetime is longer than one year. Furthermore rational road management calls for the development of multi-year road programmes, consisting of different actions to which the road condition is closely linked[1]. These actions range from yearly routine maintenance to reconstruction of the road. For instance, the costs of routine maintenance of a given road will be less than that of reconstruction but, if that road is deteriorated, the road cannot be brought to desired standard by routine maintenance alone. Also, the user costs will be much higher on a deteriorated road than on a road requiring only routine maintenance. These costs normally occur in different years and need to be related to a common comparative reference basis.

Later sections in this chapter will show how the theoretical framework is applied in practice and which simplifications may be necessary. Concrete aspects of decision processes will be tackled when dealing with the successive stages of the decision-making process and when dealing, conceptually, with the benefits of road rehabilitation and the associated external costs.

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1 Road condition is described by a set of parameters: roughness, rutting, distress, structural strength, etc. These parameters affect user costs and depend upon agency actions: reconstruction, overlay, etc., and their costs to attain a specific state of road condition.

Box IV.1. **Effects of budget and road constraints to optimising road rehabilitation and maintenance**

An often-used constraint in determining road budgets is a road condition standard. This standard may be expressed as the maximum allowable rut depth in asphalt concrete pavements, as the maximum pavement roughness value, or other quantifiable road condition states. Standards are often used to provide a uniform level of service on a given route, rather than on a single road segment. Thus, the standards may have meaningful operational value. As will be discussed later in this Box, the management must be very cautious in applying both standards and a budget constraint at the same time.

Let us assume that the standard is set at J_2. It is seen from Figure IV.2 that the total costs would be J_2P_2 of which the agency cost share, the agency budget, is J_2B_2. It is also seen that the standard is not "optimal"; the user costs are lowered because of a higher quality road, but the road agency costs are higher. The user cost decrease is less than the increase in the road agency costs, which presumably must also be paid by the users. In short, the standard J_2 is too high.

If, on the other hand, the agency has a budget constraint, say B_1, then the best the agency can do is to deliver a road condition at J_1. The consequence of this constraint is that for the society the costs are going to be J_1P_1 which is more than the minimum social cost MP. In this case the users pay more out of their pockets than what is saved in the agency budget. In short, the agency budget is too small.

There is a third idea which can be illustrated by means of Figure IV.2: as a rule it is not possible to have road condition standards and a budget constraint at the same time. For example, to set the road condition standard at J_2 and budget constraint at B_1 is simply not feasible, because B_1 monies are not enough to attain road condition at J_2; the latter requires a budget of B_2.

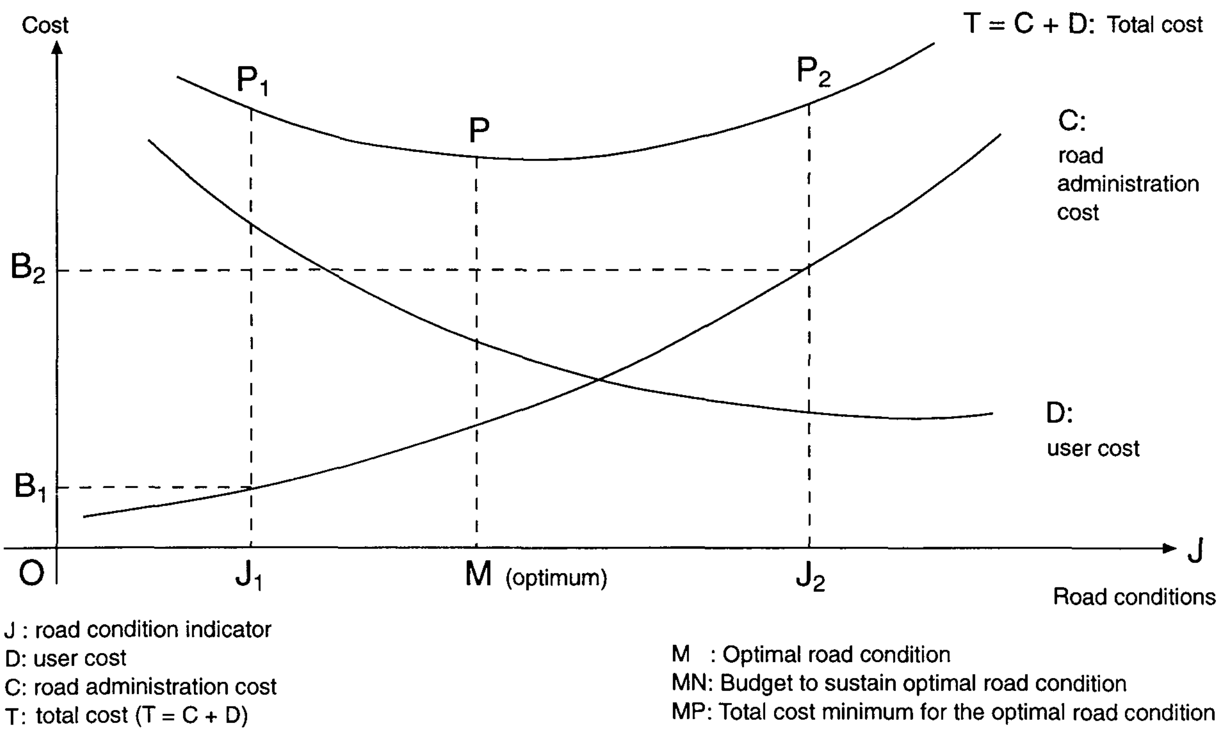
There are two cases when maintenance standards and budget constraints are both possible. These cases will have unintended consequences either on the agency or the road. In the first case the agency may have a budget of B_2 but be required to deliver a road condition of J_1. Clearly this leads to inefficiency, as B_1B_2 monies are wasted. An important by-product of the proposed framework is immediately evident: a managerial check can be exercised over the efficiency of the highway agency.

The other case is more subtle but extremely important; it is difficult -- but not impossible -- to explain it by means of Figure IV.1. It was mentioned earlier that the 'road condition' is multidimensional: the condition for roads with an asphalt pavement is characterised by distress (cracking, potholes, etc.), rut depths, roughness, and structural strength; etc. Thus, "road condition" does not mean 'rut depth' alone or 'roughness' alone, it means all the road condition parameters together. For example, the agency budget in fact is B_1 and the road standard is set at J_2; clearly an inconsistent combination as far as the graph goes. However, if "road condition" means only 'rut depth' and the standard J_2 refers to 'rut depth' only, that standard can be perhaps achieved but the other dimensions of road condition, roughness, structural strength, or distress, will deteriorate. It can also be that more than one of the road standards can be met for a few years with inexpensive 'stop gap' measures, but after a few years the road system will require extensive and expensive restoration works.

The practice described above is called **deferred maintenance**. Its harmful consequences are widely known and in order to avoid the damaging consequences it is imperative that **life cycle costs** of maintenance actions are utilised. If constraint must be used, as may be required by shortage of monies or by law, then **either** a budget **or** road standard constraints are used, but not both. The interaction of road standard and budget constraint should always be considered.

There is a yet a fourth idea which can be illustrated by means of the graph. In Figure IV.2, the costs are expressed in nominal values; an ECU saved in agency costs is equally valuable as an ECU saved in user costs. However, scarceness of funding always poses a dilemma, as discussed in section IV.6. In addition, there may be elements in user costs that have major uncertainties associated with them because they are not valued in the market. These non-market values include accidents, travelling time, and pollution to name the most important ones. It is therefore possible to weigh the user cost curve by a factor of 1/k (or the agency costs by a factor of k).

Figure IV.2. **Effects of budget and road condition constraints to optimising road rehabilitation and maintenance**



The importance and validity of road standard and budget constraints -- justified by non-monetary criteria and the disadvantage of taxes -- will then be demonstrated; and a solution outlined. The concept of uniform level of service will be addressed as well as the relationships between investment and maintenance policies prior to summarising the methodological rules based on the theoretical framework proposed in the Chapter.

IV.2. THE INFLUENCE OF THE FUTURE ON CURRENT DECISIONS

Figure IV.1 refers implicitly to a single year. In fact, the actions carried out in a particular year have an effect on all later years and current decisions should take this into account. For example, inadequate periodic maintenance would permit roads to deteriorate and, thus, require repairs and increase agency costs during subsequent years. In this respect it can be said that one of the objectives of periodic maintenance is the preservation of the road stock. This is quite true, but even if periodic maintenance is not neglected to the extent that it endangers the integrity of the road, any expenditure which is "saved" in this manner this year is in fact postponed until later, when the life time of the road is exhausted and it needs reconstruction at substantial cost.

It is, therefore, not possible to consider the optimisation of maintenance costs only on the basis of the current year's expenditure. The totality of current and future expenditure must be considered ("schedule of expenditure"). The "road stock preservation" objective then enters into calculations as an optimisation of "schedule of expenditure" for maintenance and that which relates to road user expenditures. The total transport cost T to be minimised is the discounted sum of expenditure C and road user expenditure D, or simply: **Minimise $T = C + D$.**[1]

However, expenditure which is to be made in ten years time cannot have the same weight in decision making as the same expenditure which is made next year. A valid comparison can only be made by applying an interest rate to discount expenditures on the basis of their date. Mathematical presentation of the optimisation problem is given in Box IV.2 and is necessary to its full comprehension.

IV.3. CALCULATION OF DIFFERENCES

The above calculation might appear simultaneously simple and cumbersome. However, it provides necessary theoretical support to the thought processes and calculations which will be required. It would be unrealistic to imagine the total amount of expenditure thirty years into the future. A simplification can indeed be made. The thought processes and calculations which are to be carried out will always consist of comparing two possible policies, or, less ambitiously, two possible actions for a particular year.

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1 It will be later shown that the right expression for minimisation is **$T' = kC + D$.**

Box IV.2. **Mathematical presentation of the concept to minimise agency and user costs subject to constraints**

Influence of the Future (cf. IV.2)

The totality of current and future expenditure must be considered ("schedule of expenditure" or "time sequence") when optimising the "road stock preservation" objective.

This is formally expressed as follows: let successive maintenance expenditure be called c_1 c_2 c_3.. c_n.. and road user expenditure be called d_1 d_2 d_3.. d_n. It is the schedule of total costs (t_i = $c_i + d_i$) which contains the wanted data, i.e.: t_1 t_2 t_3.. t_n..

However, expenditure which is to be made in ten years time or so cannot have the same weight in decision making as the same expenditure to be made immediately. Valid comparison can only be done by applying a discount rate to each item of expenditure on the basis of its date (see Box V.1. for a discussion about appropriate discount rates). If the discount rate is assumed to have been selected and is known as i, the discounting coefficient for the year n is $\mathbf{1/(1+i)^n}$ and the total expenditure to be minimised is: $\mathbf{T = \sum t_n / \{1/(1+i)^n\}}$.

It can also be assumed that the discounted sum of maintenance expenditure C and road user expenditure D can be calculated as follows:

$$\mathbf{C = \sum \{c_n/(1+i)^n\}}$$

$$\mathbf{D = \sum \{d_n/(1+i)^n\}}$$

Or, in short hand, **MinimiseT = C + D**. This expression will be modified later with the introduction of factor **k**.

Calculation of Differences (cf. IV.3)

Decisions always consist of choosing between two possible solutions. Thus, only differences need to be calculated. On the other hand, the differences in user expenditure are generally subjected to a change of sign and transformed into user "benefits". The objective will therefore no longer be made to minimise total expenditure, but rather to maximise the difference between benefits and costs, this difference being referred to as "net benefit". In the context of investment the discounted benefit of an operation is referred to. In the context of rehabilitation and maintenance one could talk of the net benefit of a programme, or even the net benefit of a change in the programme.

The pertinent mathematical expressions are then:

Change or difference in cost: $\mathbf{\Delta C = \sum \{\Delta c_n/(1+i)^n\}}$ ($\mathbf{\Delta C_n = C^1_n - C^2_n}$, for two projects 1 and 2)

Additional user benefit: $\Delta \mathbf{A} = \Sigma \{\Delta \mathbf{a}_n/(1+\mathbf{i})^n\}$, ($\Delta a_n = d^1_n - d^2_n$, for two projects 1 and 2)

Discounted net benefit[1]: $\Delta \mathbf{B} = \Delta \mathbf{A} - \Delta \mathbf{C}$

Marginally, each minor variation in committed funding dC leads to an additional benefit of dA. A correct choice would be to increase C as long as dA is greater than dC, or alternatively as long as dB is positive (**dB/dC > 0** or **dA/dC > 1**).

If the choice has been genuinely optimal, the value of **dB/dC = 0** at the selected point or alternatively dA will be equal to dC. Each monetary unit spent will produce a marginal benefit of the same amount. Any divergence from this absolute optimum will involve the coefficient **k** which will be discussed below.

<u>The budget constraint (the k-factor) (cf. IV.6)</u>

Whenever there is a budget constraint the maximisation problem becomes a classic operational research problem. In optimisation calculations it is necessary to apply a factor known as the dual constraint value to the constrained variable.

In economic terms this is, very simply, the constrained opportunity cost of funds.

The optimal programme without a budget constraint is one in which **dA/dC = 1**, i.e. that, marginally, an increase in funding of one monetary unit produces one monetary unit (ECU) in benefits. But if there is a budget constraint and the funding which has been fixed is judged inadequate by the decision maker it is because at the point at which the programme must be halted, **dA/dC** is greater than 1; let us say **dA/dC = k**. A new project will be of interest only if at a cost of ΔC it bears a return of **ΔA = kΔC**.

In order to determine whether one programme is more beneficial than another the objective function should not be the discounted net benefit **ΔB = ΔA - ΔC** but a proper modification of it: **ΔB' = ΔA - ΔC**. This could be called a "consolidated net benefit". This is the additional benefit which the modification itself brings to the programme.

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[1] Subject to what will be said below regarding the k factor.

Real decisions always consist of choosing between two or more possible solutions. Everything which is common to the choices disappears in the comparison process, which is only concerned with differences. One of the first results of this is that the distant future frequently disappears from calculations, as it is assumed to be the same in whichever case. Another consequence is that differences in expenditure become more easily a subject for discussion, particularly the road user expenditures which are much easier to establish than the expenditure itself.

The differences in user expenditure are generally called "user benefits", that is savings in user costs. The attempt to minimise the total expenditure is thus equivalent to maximising the difference between benefits and costs, this difference being referred to as "net benefit". In the context of rehabilitation and maintenance one could talk of the discounted net benefit of a programme, or even the discounted net benefit of a change in the programme.

Within the limits of a given maintenance policy it is generally possible to modify the total amount of funding to some extent. Marginally, each minor variation in committed funding leads to an additional minor benefit. A correct policy choice would be to increase the costs, the size of the rehabilitation and maintenance programme, until the increase in benefit is equal to the increase in cost, or alternatively as long as "net benefit" is positive (See Box IV.2).

If the choice is optimal each monetary unit spent will produce a marginal benefit of the same amount. Any divergence from this absolute optimum will involve the coefficient k which will be discussed below.

IV.4. SUCCESSIVE LEVELS OF DECISIONS - ALLOCATION AND DISTRIBUTION OF FUNDING

The above framework is presented at a sufficiently general level for it to be assumed that only one decision maker and one level of decision are involved. In reality, there are several successive levels of decision, each of which takes decisions at its respective level and assigns a total amount of funding to the level below together with objectives and instructions to implement these objectives as well as possible and in greater detail.

To simplify, decisions can be described as being of two types: allocation and distribution of funding. In this representation, one level of decision making decides the amount of funding to be devoted to network rehabilitation and maintenance. The next level, to which funds are entrusted, finds the best utilisation for them: where, when, how. The thought processes are completely different: the decision maker at the "higher" level, who is generally a politician or a high level manager, must weigh on one hand the value of public monies and on the other the services provided to citizens. He or she must then balance them in order to establish the volume of funds which will be allocated to a given sector of expenditure. The "lower" level, which is a purely technical level, has raw materials in the form of allocated funds, means of production in the form of the rehabilitation and maintenance programmes which can be considered, and has as its purpose the goal of obtaining maximum user benefits.

The basic difference is that in one case (resource allocation), establishing the amount of funding is the main purpose of decision making, whereas in the other case (resource distribution) utilising the funding -- the amount of which is a constraint -- is the main purpose. An example of how the proposed theoretical framework may be utilised in resource allocation and distribution is presented in Box IV.3.

Reality is still more complex because the person who allocates resources does not do so without having an idea of the use which will be made of them. The "distributor" too can delegate certain distribution tasks by allocating funds to subordinates.

An attempt has been made in this Chapter to make a distinction between whether the decision maker is able to modify the amount of funding which is available to him or if he should consider this as a constraint. Evidently there is a wide divergence in actual practice among OECD countries in this regard. Nonetheless, in their pure form these two decision problems are of a different nature.

Box IV.3. **Successive levels of decisions: distribution of funds between regions and road classes: an example**

The principles outlined in Section IV.1 can, and for consistency should, be followed in allocating monies to investment, rehabilitation, periodic maintenance and routine maintenance. Regarding rehabilitation and periodic maintenance a further distribution question arises which must be dealt with at the network level. Let us assume that the question concerns the apportionment of monies to different road or traffic volume classes (VC) - High, Medium, Low - and regions (R) - North and south - of the country[1]. In the most optimistic case when no budget constraint exists, it suffices to compute the minimum total cost for each region and road class separately to determine the associated budget and road maintenance objectives (dA/dC=1). This would then constitute the management's budget allocation and the objectives for technical staff as to the quality of road service they are expected to deliver to the users. Because the road condition is linked into specific actions, the management's guidelines to the technical staff also imply a specific distribution of actions to be taken but would not specify the road segments on which the remedial actions must be taken.

The complications arise when there is a budget constraint or standards to be achieved. A proposed allocation criterion, equalization of the shadow price, is illustrated in Figure IV.3. Again, the principles of Section IV.2 (and Box IV.2) apply. In the upper left hand corner (the change) in user costs (dA) is plotted against (the change) in agency costs (dC); the slope of the quotient dA/dC is called the shadow price as it tells how much additional benefit can be obtained for an extra ECU spent. When the shadow prices for different road classes and regions are equalized it is not economically efficient to transfer monies from any road class or region to any other. Figure IV.3 shows a concrete example and an algorithm, starting from highest budget levels and proceeding increment by increment toward lowest budget levels, how this might be accomplished. The solution in which the shadow prices for each Region-Road Volume Class are equal (and nearest to -1) would constitute the management's budget constrained allocation and road quality objectives to the technical staffs in their respective regions. It is noteworthy that these objectives are measurable and provide a basis for evaluating agency performance.

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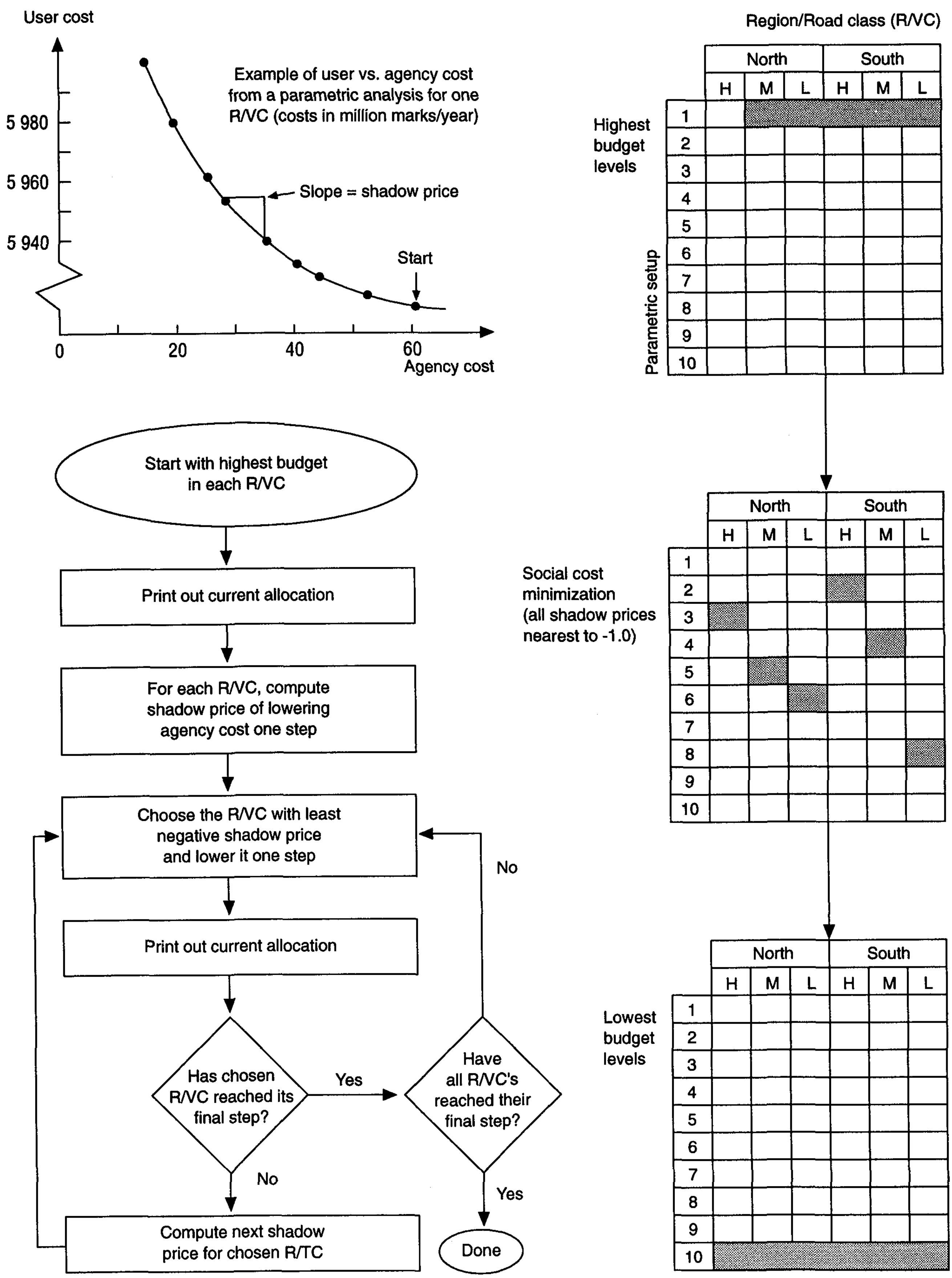
[1] The specific distribution question depends on the organisation and managerial principles followed in the country. The example is given here for concreteness' sake, and must be adapted to the particular circumstances of any given country.

IV.5. EXTERNAL BENEFITS AND EXTERNAL COSTS

In the above it was considered that the benefits to be weighed against agency costs consisted solely of benefits to road users and corresponded to their "expenditure". However, other parties in addition to the managing agency and road users are affected by the level or the nature of road maintenance.

Figure IV.3. **Budget distribution between regions and road classes**



These include[1]:

- -- Residents who may be affected by noise or varying degrees of local traffic difficulties;
- -- Local firms whose activities may be helped or hindered beyond the mere operating costs of vehicles and, through this, regional economic development may be affected;
- -- Civil engineering contractors involved in performing the works and, as a result, the employment market;
- -- The larger community which incurs costs of an emotional and material nature generated by road traffic accidents;
- -- The economy, and social psychology at large, which experiences the indirect effect of levying taxation.

The benefits obtained by road users are also more complex than it appears at a first glance. The most obvious gains by road users are vehicle operating costs. But economies of time are an important benefit, fairly obvious in the case of employees and commercial vehicles, but no less real for other road users. The value to be assigned to this time is therefore a problem in itself which requires the agency or decision-makers to adopt a clear position.

Let us simply bear in mind that the benefits of good maintenance include the following:

- -- Monetary benefits to road users (a reduction in vehicle operating, see Figure I.2);
- -- Non monetary benefits to these road users (gain in time, gain in safety);
- -- Benefits to other members of society;
- -- Benefits to the nearby community.

Quantifying these benefits is not a solely objective problem, and not everything can be quantified. These issues will require the decision maker to adopt positions which although reasoned, will inevitably include a subjective commitment on his part, and that in itself will constitute a decision.

The benefits which are thus taken into account and the value which is assigned to them will not necessarily be the same at all levels of decision-making. The highest levels will take into account macroeconomic or political benefits (or disbenefits) which escape the lower levels' attention and decisions.

IV.6. SCARCENESS OF FUNDING -- THE k-FACTOR

It follows from the foregoing considerations that the funds allocated to a certain level of road administration hierarchy often appear to be unrealistically low. This (often technical) level has only a partial view of the reasons which have led to the total amount given to it and is thus burdened by this day-to-day reality in optimising his work under seemingly unrealistic budget constraint.

What should the decision-maker, whose available funding is fixed as a constraint, do with a low and inadequate budget? His aim is still to achieve the largest possible quantity of benefits with the funds at his disposal. This is accomplished by applying a budget constraint (and perhaps other constraints on standards; see section IV.9) when choosing the actions and projects. In economic terms

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1 These non-quantifiable and/or external costs will be considered in Chapters V and VII in greater detail.

this is the (constrained) opportunity cost of funds. The optimal rehabilitation (maintenance) programme is one in which monetary unit increase in funding produces one monetary unit increase in benefits. If the budget, which is fixed, is judged inadequate by the (technical) decision-maker it is because at the point at which he runs out of money the benefits from a road project are still greater than its costs, by a factor **k**., which means that with one ECU more in funding it is possible to obtain **k** ECU more in benefits. This is the definition of opportunity cost: marginally, the decision maker has several possible ways of transforming one unit of road budget money into **k** units of benefits. A new opportunity, a new project, will therefore only be of interest if its (discounted) benefit is **k** times its (discounted) cost.

In order to determine whether one programme is more beneficial than another one should therefore consider not the discounted net benefit, but the modified net benefit in which the agency costs have been multiplied by a factor of **k**. One could call it "consolidated benefit" in the meaning it has in reference to private company "consolidated benefit"' statements (see Box IV.2). Experience shows that it is absolutely universal for funding to be inadequate to enable all cost effective works to be carried out. The practical consequence is that in order to seek budget constrained optimal programmes, it is necessary to apply the **k** factor to costs. What value should be given to this factor? The value of the k-factor will vary from country to country and possibly between time periods. What is important is that in each programme the value should emanate from awareness of the marginal cost-effectiveness of available funds (See also Box IV.4 for another perspective on the 'k-factor').

IV.7. MULTICRITERIA ANALYSIS

All the benefits (and costs) which may result from decisions do not necessarily appear in the figures which are used to calculate the user benefit. Numerical values cannot be assigned to some benefits, and in some cases, such as the value of time, there may be substantial uncertainty as to its value. However, it is justifiable to take such difficult-to-quantify values into account when deciding which alternative to select. In this case the numerical elements are one of the criteria for decision making, but other criteria must also play a part and the decision making process is thus of the multicriteria type. These non-quantifiable other criteria often concern the environment or economic development, or safety. The weight of such non-numerical criteria is greatest in the most important decisions, which are political in nature and involve macroeconomics, the larger environmental issues and other important factors. These criteria may express regional or psychological preferences or macroeconomic concerns.

The lower, more technical, levels of decision do not need to take account of this type of criteria -- because they are embodied in the plan or design itself -- and can normally make do with the numerical criterion which consists of the discounted sum of net benefits or, more accurately, as proposed, with the modified net benefit in which the agency costs, consisting only of monetary elements weighed by a factor of k, and then subtracted from the user benefits.

Thus, the applicability of the theoretical framework requires a clarification, which is given in a simplified form as follows (there are, of course, intermediate cases and gradations in reality):

- "Major" decisions > political decision makers > multiple criteria > establishment of total funding and general guidelines
- "Minor" decisions > technical decision makers > single criterion > total funding already fixed > seek to find the best use of money

Box IV.4. **The k-factor viewed as the disutility of taxation**

The **k** factor appeared in section IV.6 as a way of finding the best programme for a decision maker upon whom a budgetary constraint is imposed and who has no possibility of modifying the amount of funding that is available.

A decision maker who is free to establish the total amount of funding has a different problem. It could be anticipated that someone in this position would increase funding until the marginal benefit obtained was equal to the additional funding allocated. The subordinate decision maker, whose total funding has been fixed, would then find that **k** = 1. Why is this not the case, why does the high level decision maker not increase funding for k to equal one?

In general, the higher level decision maker does not do so because, and as will be pointed out in section IV.7, he or she must take account of criteria which have no numerical value, in particular -- at the highest political levels -- of the **disutility of additional taxation**. This term covers the following phenomena:

- -- Additional taxation has negative economic consequences;
- -- Additional taxation is badly received by the electorate and has negative psychological effects;
- -- Additional taxation alters the overall sphere of State action, which is in itself an objective.

It is clear from experience that the State is not willing to collect additional taxes to the value of 1 ECU if citizens do not receive a considerably higher return (say, for example, 1.5 ECU for 1 ECU of taxes).

It is therefore justified for a particular value of the coefficient k to be used when establishing the sum of total funding for highway rehabilitation and maintenance. This factor has, therefore, two aspects:

- -- The decision makers who decide the amount of funding allocation also implicitly establish a value for the **k** factor which may quite legitimately be greater than 1 (1.5 is probably a reasonable minimum),

- -- The lower level technical decision-maker for whom the total amount of funding is fixed finds, ipso facto, a coefficient **k** which for him is merely a computational tool (a value of 2 is often encountered in reality, but different countries have different values).

The k-factor then lumps together, or sums up, criteria and factors which cannot be quantified. However, the analytical procedure proposed in Chapter IV for allocating and distributing resources for road rehabilitation and maintenance is flexible, and can accommodate different kinds of values and priorities -- as appears to be the case in the OECD countries -- and use these differences to arrive at consistent and rational recommendations.

Road rehabilitation and maintenance often fall into the second class of "minor" decisions and would benefit from the application of the proposed methodology.

IV.8. LEVEL OF SERVICE - UNIFORMITY OF ROUTES

The basis of the benefit calculations described above is to discover what road users can gain as a result of road works. These benefits increase with the number of road users affected and are approximately proportional to this number. However, other considerations which are not connected with the number of road users may play a part in decisions.

It can, for example, be a requirement for all roads of a particular administrative or functional class to comply with certain minimum specifications. For example, it may be required that all Main Roads be protected from thawing conditions; or that roads of such and such a class must be paved whatever their levels of traffic.

Similarly, it may be justified to require a route to be treated in the same way throughout its length even if some sections carry less traffic than others. It can also be decided to provide a general level of service to a particular set of roads which, although possessing a variety of traffic levels, share a common feature as regards function, type or appearance to road users.

Choices of this type, which are marked by a degree of generality, invite two types of comment about the decisions which are to be made:

-- The network level decisions by the management should be informed by comprehensive studies in which the microeconomic calculations by a management system, such as that recommended in this Report, are an important factor, but in which the desire for uniformity of service level in road network's functional classes also plays a part,

-- Lower level decisions, (yearly or multi-year programmes, distribution of funding to specific uses on specific links), should restrict themselves to minimising total user and agency costs while complying with the network level decisions which are considered as constraints or objectives.

IV.9. MAINTENANCE AND INVESTMENT

The relationship between decisions which relate to road maintenance and those which relate to investments (new construction) invites comments of a practical as well as theoretical nature.

Investment expenditure is often considered to be a noble expenditure which increases the wealth of the country. Maintenance expenditure, on the other hand, is regarded as an unavoidable but, on the whole, non-productive expenditure. Politicians are therefore often trying to increase investment expenditure as much as they can by reducing maintenance expenditure as much as possible.

The fundamental error in this cannot be over-stressed. One of the functions of maintenance is to preserve assets which have been created by a prior investment expenditure. Therefore, the benefits which good maintenance aims to bring to road users now are the same which investments aim to provide them in the future. This is ensured by the benefit-cost calculations which are used to direct maintenance programmes and based on the same principles which are used for investment programmes.

It is essential to eradicate the idea that one aspect of expenditure is noble (investments) and the other is not (maintenance and operation). It should, furthermore, be common practice for investment decisions to be accompanied with the decisions to finance maintenance and operation over its life time in a manner consistent with their use. This is necessary to ensure that the decision to invest is taken with full knowledge of its true life time cost.

In this connection, it is worth knowing that a road is one of the investments which, in percentage terms, generates the least annual expenditure. Each 100 ECU spent requires an annual expenditure of only 1 to 1.5 ECU for satisfactory maintenance. The operating costs associated with road furniture (lighting, traffic management) are higher, about eight per cent.

Awareness of these standard percentages, and those relating the GNP to total road expenditures, merit refinement and should not be taken literally to apply in every member country. They could, nonetheless, provide rough guidance which can be produced with the analytical procedures and data collection methods proposed in this report. For this reason it is essential that the Highway Agency has sophisticated management tools to help in investment, rehabilitation, periodic and routine maintenance decisions.

IV.10. CONCLUSIONS

The following ideas can be distilled from the above discussion:

-- The user benefits (reductions in user costs) constitute an important objective in road rehabilitation and maintenance programmes;

-- The decisions which relate to road maintenance and rehabilitation are taken at many hierarchical levels;

-- Each level passes down to the level below its instructions (objectives, constraints) and resources for action;

-- A distinction must be made between situations in which the budget has been fixed and those in which this depends on the decision in question;

-- The search for the best decisions must always involve comparison between different possibilities (variants and alternatives) and systematic consideration of the differences between them;

-- Whether or not there is a financial constraint, an ECU of funds for public use may not be directly compared to an ECU of user benefits. Comparison involves a coefficient **k** (scarceness of funds at the engineering level, disutility of taxation at the political level);

- User benefits include monetary elements, but also important elements of other types (time, safety, physical and psychical comfort, environment, etc.)

- Benefits to other citizens, or to the community, must also be considered and this may lead to the introduction of several criteria in the decision making process;

- Choices such as "minimum service", and "uniformity of level of service" may prove justified in some cases;

- Lastly, maintenance must cease to be the poor relation of investment as its purpose is to assure the value of investment over time.

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