Strategies for Managing Public Expenditures for Road Maintenance

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Public disbursements for highways include investments in network and capacity expansion and expenditures on current operations and maintenance. A number of factors contribute toward complicating the process of managing public expenditures: (*a*) a multiplicity of budget-making bodies, (*b*) the propensity to favor new construction, (*c*) disparate treatment of activities relating to new construction and maintenance, and (*d*) divergence in analytical approaches for cost estimation. The result is a profusion of budgeting techniques, including line-item, lump-sum, and program or performance budgets. Alternative approaches to predicting life-cycle expenditures for highways are examined to derive a unifying methodology for sound management of public expenditures. Aggregate techniques, such as indices of absolute or relative expenditures, are contrasted with disaggregate procedures using detailed predictions of maintenance work volumes and activity costs. The advantages and disadvantages of each method vis-à-vis a budgeting process are also presented. Of special concern is the treatment by each technique of the following: (*a*) variation in unit costs, (*b*) modalities of highway failure and their maintenance consequences (catastrophic, monotonic degradation, nonmonotonic drift), (*c*) configuration of highway network characteristics (age and use levels), and (*d*) trigger mechanisms for maintenance (user costs, capacity and structural constraints, asset depreciation, employment generation, economic productivity). The methodology is applied to the evaluation of a typical country's budget for road maintenance.

Public expenditures on highways include investments in network and capacity expansion, reconstruction, rehabilitation, and upgrading of existing highways, as well as expenditures for current operations and maintenance. A number of factors complicate the process of managing public expenditures.

First, there are many budget-making bodies: (*a*) central units within ministries of transport that may be in charge of programming the expenditures for the trunk or primary network; (*b*) state and local government agencies that may have operational responsibility for state and local roads (secondary and tertiary network); (*c*) ministries of planning, economy, and finance with an overall responsibility for planning and prioritizing public investments; and (*d*) ministries of agriculture or tourism with responsibilities for maintaining part of the network such as rural and special (historic or scenic) roads. The budget-making process involves intensive interagency interaction and coordination. The complexity of these interactions is mainly due to an unclear alignment of functions and responsibilities, as well as nonintegrated policies.

Second, the various bodies involved in planning and budgeting for highways may treat similar investments disparately. For example, a budget-making unit within a ministry of economy and finance may assume a different planning horizon, unit costs, and standards of construction from that used by a programming unit within a ministry of transport for the same type of construction. Such practices may lead to different estimated allocations within a budgeting year.

Third, planning units that are politically appointed may tend to favor new construction, since such investments are more clearly linked to voting outcomes than are maintenance or small-scale improvements. Such biases may lead to unbalanced investment profiles, with larger allocations to new construction as opposed to maintenance, encouraging a cycle of new construction–deferred maintenance reconstruction.

Finally, each budget-making body may use different analytical approaches for cost estimation, leading to large variations in estimated budgets. Budgeting for new construction involves projecting lumpy, discrete, and quantifiable expenditures at specific locations. Deviations in budget estimates for this type of project derive mainly from unit cost variation as a consequence of assumptions for standards and methods of construction. Maintenance and operation expenditures, on the other hand, are recurrent, incremental, and difficult to quantify. Differences in budget estimates for these projects are mainly due to the spatially diverse nature of maintenance activities, the wide span of management control, and disparities in delegation of authority for maintenance between centralized and decentralized units, as well as contract and force account (in-house) work.

As a result, a profusion of budgeting techniques exists for public infrastructure expenditure, including line-item, lump-sum, and program or performance budgets.

This paper examines alternative approaches for predicting life-cycle expenditures for highways and suggests a unifying methodology for sound management of public expenditures. Aggregate techniques such as indices of absolute or relative expenditures are contrasted to disaggregate procedures using detailed predictions of maintenance work volumes and activity costs. The advantages and disadvantages of each method vis-à-vis the budgeting process are also presented. Of special concern is the treatment by each technique of the following: (*a*) variations in unit costs, (*b*) modalities of highway failure and their maintenance consequences (catastrophic, monotonic degradation, nonmonotonic drift), (*c*) configuration of highway network characteristics (age and use levels); and (*d*) trigger mechanisms for maintenance (user costs, capacity and structural constraints, asset depreciation, employment generation, economic productivity). The methodology is applied to the evaluation of a typical country budget for road investments.

Types of Highway Budgets

The main purpose of a budget is to provide a meaningful and operational framework for accountability, while allowing for sufficient flexibility in the application of allocated funds.The budget serves as a contract between the road agency and the government, with the road agency committed to producing a quota of work outputs for the financial resources it receives from the government. The government is responsible for making the necessary financial allocations in a timely fashion. A good budget clearly spells out the obligations and responsibilities of each party, so that a clear basis exists for auditing and assessing budget performance and for evaluating the effectiveness of public expenditures against desired economic and social outcomes. There are three types of highway budgets in common use: line-item, lump-sum, and performance-based (see Table 1 for examples). In addition, zero-based budgeting (ZBB) has been used as a tool for budget justification. For a detailed discussion of alternative budgeting practices for highways see Faiz (*1*), Kelley (*2*), and Premchand (*3*).

Line-Item Budgets

A line-item budget determines expenditure allocations in money terms rather than on the work to be accomplished. The budget lists amounts under proposed expenditure categories such as personnel services, contractual services, commodities, and other charges (see Table 1). In a line-item budget, funds are used on the basis of individual judgment rather than work objectives or comparative levels of service. This type of budget offers some advantages, such as the ease of preparation and simple projection from historic expenditure patterns. It is also easy to administer since the budget items are the same as the expense items incurred during budget execution. However, a line-item budget is highly restrictive and offers little flexibility in changing allocations across itemized categories. For example, transferring funds from materials to personnel is not allowed, even if there is an excess of funds for materials and a shortage for personnel.

Line-item budgets are suitable for relatively stable situations with no changes in personnel, technology, or materials needs, and where historical patterns are relatively representative of expected patterns of expenditure. As a result, they may be suitable for new construction projects in areas with little topographical or geological variation, where work is carried out by force account. They are not suitable for most maintenance and emergency projects, due to their spatial and temporal variability and associated expenditures.

Lump-Sum Budgets

In lump-sum budgeting procedures, a single-line item represents all the expected expenditures for a particular agency (see Table 1). Such a budget offers the greatest flexibility for allocating across highway construction, reconstruction, rehabilitation, and maintenance activities; across particular road links; and across expenditure categories such as personnel and materials. However, the budget preparation must be based on a sound physical program, and performance must be closely scrutinized to ensure accountability. Such budgeting procedures are most suitably used where there is an advanced maintenance programming and evaluating capability and good capability for estimating costs and work requirements.

TABLE 1 Types of Road Budgets

PERFORMANCE BUDGET

Fiscal Year: 1982 | Department: HIGHWAYS | Activity: ROAD MAINTENANCE

ACTIVITY No.	Description		WORK AND COST In-House	Contract	Total
1101	Spot Premix Patching	Work	8,050.00	0	8,050.00
	Units: Sq. Feet	Cost	33,407.50	0	33,407.50
1103	Recycle Asphalt Pitch	Work	2,010.00	500.00	2,510.00
	Units: Sq. Feet	Cost	10,271.10	2,485.00	12,756.10
1100	**Roadway Maintenance**	**Cost**	**43,678.60**	**2,485.00**	**46,163.60**
3201	Roadway Mowing	Work	873.00	315.00	1,188.00
	Units: Swath Mi	Cost	3,622.95	1,332.45	4,955.40
3204	Litter Pickup	Work	375.00	0	375.00
	Units: Man Hrs.	Cost	5,632.50	0	5,632.50
3200	**Roadside Services**	**Cost**	**9,255.45**	**1,332.45**	**10,587.90**
Activities (1100 + 3200)			52,934.05	3,817.45	56,751.50
Other Activities + Administrative Overhead			35,683.32	2,573.09	38,256.41
Total			88,617.37	6,390.54	95,007.91

LINE-ITEM BUDGET

Fund: GENERAL | Department: HIGHWAYS | Activity: ROAD MAINTENANCE

CLASSIFICATION	ACTUAL 1982	BUDGET 1983	BUDGET 1984
Personal Services	65,429.18	83,198.00	87,927.00
Contractual Services	6,312.18	7,000.00	7,500.00
Commodities	4,450.02	3,540.00	4,450.00
Other Charges	19,946.15	22,000.00	26,500.00
Gross Expenditures	96,137.53	115,738.00	126,377.00
Reduction of Costs	1,129.62	2,500.00	2,500.00
Net Expenditures	95,007.91	113,238.00	123,877.00

LUMP-SUM BUDGET

Fiscal Year: 1982 | Department: HIGHWAYS | Activity: ROAD MAINTENANCE

CLASSIFICATION	ACTUAL 1982	BUDGET 1983	BUDGET 1984
Net Expenditures	83,113.23	102,240.00	112,843.00

Program or Performance Budgets

Program or performance budgets are relatively recent, appearing after the development of maintenance management systems and cost accounting procedures around 20 years ago. Such budgets are based on detailed activity, work, and cost estimates (see Table 1). Achievement targets are specified for levels of service, and the method of execution—whether by force account or contract—is indicated. This type of budget indicates both what is to be accomplished (in units of work such as man-hours of litter pickup or square feet of roadway patched) and what it will cost. Whereas the expenditures may not exceed the allocations for specific activities, the performance or program budget allows for considerable flexibility in the use of component resources (labor, equipment, material), which are not appropriated by each object of expenditure as in the line-item budget. The performance-based budget offers the best balance between accountability and flexibility principles underlying highway expenditure budgeting.

PREDICTING LIFE-CYCLE EXPENDITURES

Aggregate Approaches

Aggregate approaches for predicting life-cycle costs are used in conjunction with lump-sum budgeting procedures. They have the advantage of flexibility of use and are usually based on an index or ratio at the beginning of the analysis period, which is updated at each period. Such an index may be derived from a function relating the average cost of an activity like maintenance to indicators of the need for maintenance, such as the time since the last major rehabilitation and the level of deterioration. Alternatively, projecting a ratio of the relative expenditure categories (ratio of maintenance to capital expenditures) over time may be useful as an aggregate measure of need if the techniques for projecting one type of expenditure (e.g., new construction) are well specified. The major disadvantage of such budget estimation techniques is the inability to incorporate different types of activities, varying effectiveness of activities, and other factors affecting the efficacy of planned activities.

Absolute Expenditures

Absolute indices for predicting future expenditures are generally log-linear functions of the following form:

$$\ln(C_m) = aX + b\ln(U) \qquad (1)$$

where

- C_m = average cost of an activity such as maintenance (dollars/km),
- X = indicator of the need for the activity such as the time since the last major rehabilitation (years),
- U = indicator of the scale of an activity such as the level of deterioration on a highway due to accumulated use, and
- a, b = estimated coefficients.

An example of an aggregate road maintenance cost prediction model is given by Sharaf and Sinha (*4*), where the total routine maintenance cost per year per lane mile is predicted as a function of the age of the pavement since the last rehabilitation and the accumulated traffic is measured in equivalent axle loads.

Relative Expenditures

Relative expenditure prediction methodologies are useful when there is a good basis to relate a particular category of costs, such as capital and maintenance expenditures. Generally, coefficients of the expected balance between categories of investments are calculated and used to project the necessary allocations between categories. Heller (*5*) suggested such a measure for detecting the degree of underfinancing of recurrent development costs for a variety of road investments. The functional form used for relative expenditure models is

$$E[C_m/C_c] = \text{coeff} \qquad (2)$$

where

- C_m = annual maintenance expenditure (dollars/km),
- C_c = total capital expenditure (rehabilitation, reconstruction, new construction) (dollars/km), and
- coeff = expected value of the relative balance between investment categories.

The table that follows (*5*) gives an example of estimated coefficients for feeder roads and paved roads. This table demonstrates the high variability in such coefficients, especially for feeder roads, where the design and maintenance standards are disparate:

Road Standard	*r Coefficient*
Feeder roads	0.06–0.14
Paved roads	0.03–0.07

Limitations of Aggregate Approaches

Aggregate approaches are useful for managing highway expenditures at the network level. These approaches implicitly assume that estimated coefficients are stable over time. This assumption is difficult to justify for most highway systems, for a number of reasons. First, they are insensitive to variations in unit costs and the rhythm of highway system failure. In addition, they are not easy to adjust to multiple criteria for undertaking activities, and are useful when there is a stable set of well-established policies for maintenance and rehabilitation. These factors will be discussed in more detail later.

Disaggregate Approaches

Disaggregate approaches require detailed models for predicting work volumes and costs of activities. These are of two general types: (*a*) models predicting the volumes of work to be done, measured in production units (lane miles of joints sealed, linear feet of cracks sealed, number of potholes patched), total manhours required, and types and quantities of materials (tons of patching mix); and (*b*) cost prediction models that estimate the cost of a particular activity such as crack-sealing by the kilometer or mile. The two approaches differ significantly in the type of data required for projecting highway expenditures.

Work Volume Predictions

Several models have been used extensively to project the work volumes required to carry out life-cycle expenditure analysis for highways: (*a*) a study by the Federal Highway Administration to predict damage and performance of pavement systems that have received a wide variety of alternative maintenance and rehabilitation actions (*6*); (*b*) a simulation model called EAROMAR-2 for predicting highway performance, maintenance, and rehabilitation costs (*7*); (*c*) a pavement management system developed by the U.S. Army Corps of Engineers (*8*); (*d*) a highway design and maintenance model developed by the World Bank (*9*); and (*e*) the Transportation Research Laboratory (TRL) Overseas Unit Model RTIM (*10*).

Such models require a variety of data types:

1. Route characteristics such as geometry, capacity, and administrative sections;
2. Pavement characteristics such as strength, layer thickness, age, traffic loadings, quality of construction, and type of materials for the pavement layers;
3. Pavement history including the time since the last rehabilitation and pavement age since construction;
4. Pavement condition including the extent and severity of cracking, rutting, potholes, and roughness, as well as factors retarding distress, such as preventive maintenance actions;
5. Maintenance policies, including local work scheduling practices, and unit costs of maintenance labor, equipment, and materials;
6. Planned activities such as routine maintenance, preventive treatments, rehabilitation measures such as resealing and overlay, and reconstruction;
7. Environmental and climatic variables such as landslide frequencies, precipitation levels, and freeze and thaw cycles;
8. User consequences such as vehicle operating costs, travel time, accident costs, and pollution emissions; and
9. Economic data such as discount rates, differential inflation, and costs of safety.

Such models can be represented by the following system of equations:

$$S(t+1) = S(t)\, f(C_r, C_m, U)$$

$$\Psi(t) = g[S(t), C_r\,(j, t), C_m\,(i, t)]$$

$$C_r\,(j, t) = a + bS(t)$$

$$\log[C_m(i, t)] = \alpha + \beta \log[S(t)]$$

$$\$(t) = \gamma_j\, C_r(j, t) + \mu_i\, C_m(i, t) \quad (3)$$

where

S = condition of a predefined pavement segment;
f = deterioration function relating the condition of the pavement to the utilization, maintenance, and rehabilitation activities performed;
t = analysis year;
U = measure of utilization of the pavement such as accumulated vehicle loads or age;
$\Psi(t)$ = a selected set of maintenance and rehabilitation activities to address the pavement condition problems observed at the time period t;
g = function mapping the observed condition to a set of maintenance and rehabilitation activities (usually based on the maintenance policies followed);
$C_m(i, t)$ = annual maintenance cost (dollars per lane-km) for a package of maintenance actions i at time t;
$C_r\,(j, t)$ = rehabilitation cost (dollars per lane-km) for activity j at time t;
a, b, α, β = estimated coefficients;
$\$(t)$ = estimated highway expenditure for the year t; and
γ_j, μ_i = unit costs of the selected rehabilitation and maintenance activities, respectively.

The first equation is a condition-prediction model as a function of the utilization and efficacy of maintenance and rehabilitation activities. Condition is defined either in index form, such as the pavement serviceability index (PSI) or the pavement condition index (PCI), or is a physical measure of deterioration such as percentage cracking or pavement roughness level.

The second equation represents a mapping process whereby activities are selected to address the current condition $S(t)$ in order to obtain the desired condition $S(t + 1)$. Maintenance and rehabilitation activities are classified according to frequency (annual, periodic, or infrequent) and expected impact (no change in surface condition, change in surface condition, change in life of pavement, change in pavement strength, change in all parameters).

The effect of such activities on the condition of pavements is generally captured as (*a*) a discrete correction of a fixed amount of damage (square meters of cracks patched per km) represented by the coefficients in the third and fourth equations a and α; and (*b*) a continuous measure of retardation of future deterioration or improvement in condition as measured by the coefficients in the third and fourth equation b and β. The log transformation for the maintenance cost function is used here because it has been demonstrated by past studies to be the best available model specification. Humplick (*11*) summarizes best practices in highway maintenance expenditure cost modeling, and Sharaf and Sinha (*4*) apply such a model for road maintenance expenditures in Indiana.

The last equation is the major input into budgeting processes because it represents the estimated expenditures for a selected set of maintenance and rehabilitation activities.

Cost Per Activity

Other models in use are based on predicting the cost of a given set of activities. Examples include the Ontario Pavements Analysis of Costs (OPAC) and the Program and Financial Planning in Pavement Rehabilitation (PARS), both developed for Ontario. The OPAC model (*12*) uses the concept of repeatability of expenditures and performance cycles to estimate future expenditures as a function of rehabilitation activities such as overlay. This model estimates the expected life of a rehabilitation investment in years, where the rehabilitation activity is measured by the thickness of overlay. The expected cost of the investment is consequently estimated from a preestimated function (the second function in Equation 4). The approach is summarized as follows:

$$T = \alpha q_r^{\beta}$$

$$\$ = C_m + C_r * q_r \quad (4)$$

where

T = life-cycle length (the life of the proposed rehabilitation) (years);
q_r = the unit quantity of the rehabilitation work, such as the thickness of overlay (cm or in.);
α, β = estimated coefficients;
C_m = constant cost of maintenance per km;
C_r = variable cost of rehabilitation per km and unit work volume; and
\$ = estimated expenditure.

The PARS model (*13*) is similar to the OPAC model. This model predicts pavement performance as a function of utilization variables (age, traffic) and quantities of rehabilitation work planned (thickness of overlay). This is represented by the first of the following equations. The expected cost of the works is estimated from the second of the following equations.

$$S = S_{\max} - \kappa U^a q_r$$

$$\$ = C_m + C_r * q_r^{-b} \quad (5)$$

where

S = the performance condition (PCR or PCI),
$S_{\max}$ = maximum pavement performance level that can be achieved (e.g., 100),
κ = estimated coefficient,
U = measure of utilization (age and traffic),
q_r = thickness of overlay, and
a, b = estimated constants.

The advantages of these types of models is the ability to predict the total cost of an activity such as rehabilitation, its impact on the pavement, and its expected life. It can therefore be used as an input to the performance budget mentioned previously.

Factors Affecting Maintenance Costs

The predictions that can be made by the various methodologies are subject to a number of factors that render them uncertain. Among these are (*a*) variations in unit costs, (*b*) modalities of highway failure, (*c*) configuration of highway network characteristics, and (*d*) trigger mechanisms for maintenance.

Variations in Unit Costs

Highway expenditures as described so far comprise construction, reconstruction, rehabilitation, and maintenance costs, over the planning and budgeting horizon. These expenditures are included in the budgeting process as unit

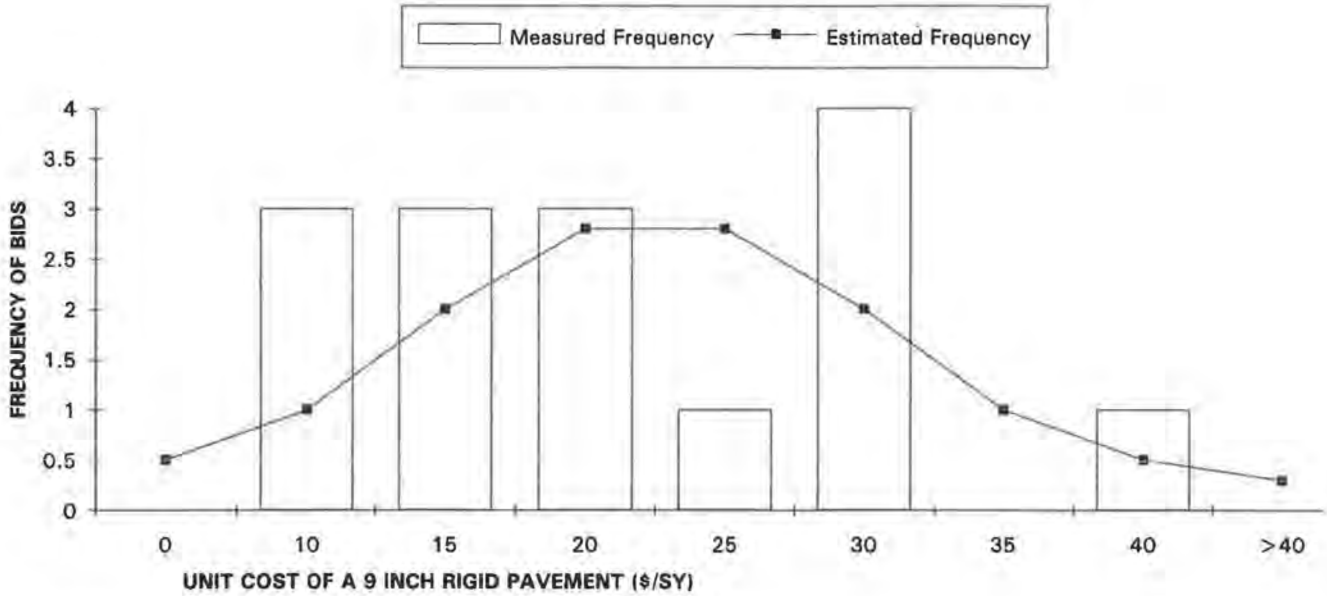

FIGURE 1 Variation in unit costs for a single pavement design (*11*).

costs per unit of work done or as annual expenditures. The common practice in budget preparation is to derive a single estimate of unit cost for a particular activity, as described earlier, which is then used as a parameter in the cost estimation. Estimates of unit costs are extracted from engineers' previous estimates, highway bids, or publications of current unit prices. A number of factors introduce uncertainty in the cost estimates, such as design and construction practices, traffic levels, weather and geography, maintenance policies and technologies, and bidding procedures. An analysis of the variation of unit costs for rehabilitation of rigid and flexible pavements (see Figures 1 and 2 respectively) indicates the wide differences that can be expected in highway expenditures. Figure 1 shows the variation in the unit cost for a single pavement design (a 9-in. rigid pavement), and Figure 2 shows the variation as a function of different designs (thickness).

For example, there is a high variability in the types of work required at a given time, ranging from spot maintenance to minor rehabilitation, making the maintenance budget difficult to estimate. The ratio of maintenance to capital expenditures would be affected by such variation, reducing the utility of the aggregate budget projection procedures previously described.

Modalities of Highway Failure

Many of the models described in this paper require a mechanism for triggering an activity such as maintenance or rehabilitation. Highway infrastructure may suffer three different types of failure: (*a*) catastrophic failure, such as when a bridge collapses; (*b*) monotonic deterioration, such as when pavement surfaces crack; and (*c*) nonmonotonic failure, such as when a highway is periodically congested. Figure 3 gives a summary of these types of failures along with analogies to failures in other infrastructure systems. The corresponding expenditure responses to the failure modalities in Figure 3 are shown in Figure 4. Catastrophic failures are addressed by lump-sum and discrete expenditure to address the particular condition once and for all. Monotonic failures require continuous outlays of expenditures on a period-by-period basis, such as an annual budget for carrying out routine and preventive work. Nonmonotonic failures fluctuate with levels of demand (such as the congestion example) or with climate (such as flooding, rock slides, and icy roads, which are cyclically dependent on the weather). All these factors affect the accuracy of budgeting procedures and must be accommodated.

Configuration of Highway Network Characteristics

Highway networks are typically made up of a collection of roads with varying age profiles, design and construction methodology, and use patterns. As a result, there are numerous combinations of systematic and random patterns of failure for a given network. Systematic failures are due to the rhythm of building whereby a typical highway will last around 20 to 40 years with the proper design and maintenance. Random failures result from variations in construction quality, spatial variations in roadway strength, climatic and other factors, as well as actual main-

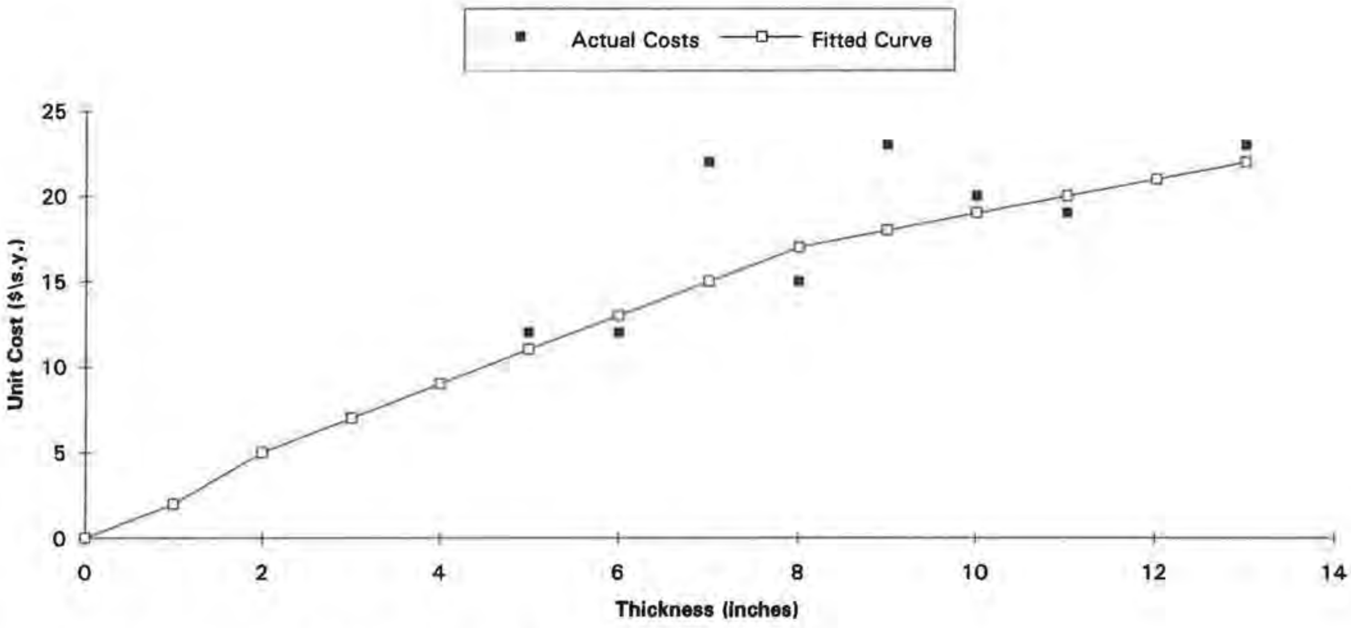

FIGURE 2 Variation in unit costs as a function of different designs (*11*).

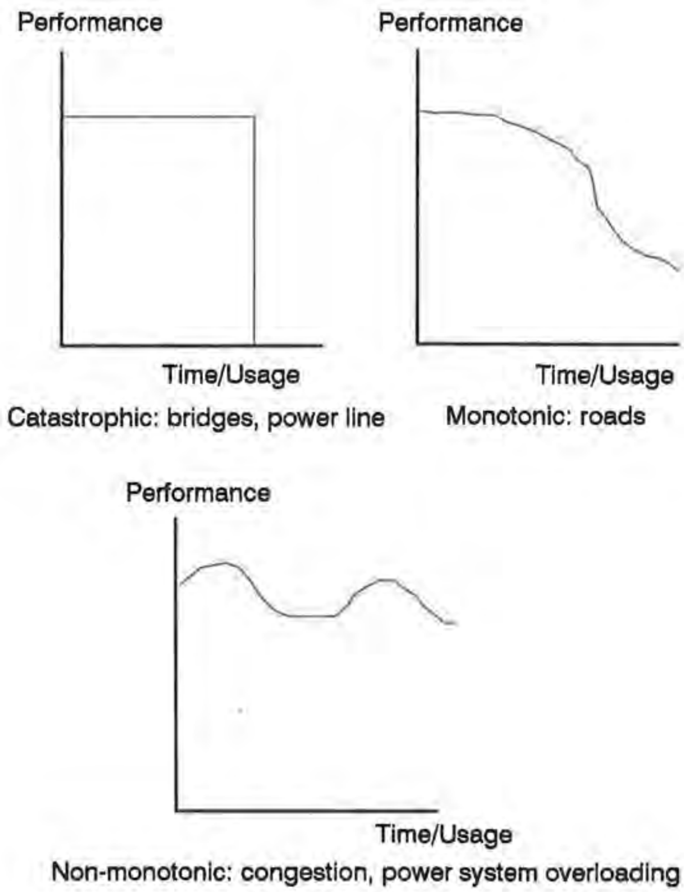

FIGURE 3 Characteristics of infrastructure failures.

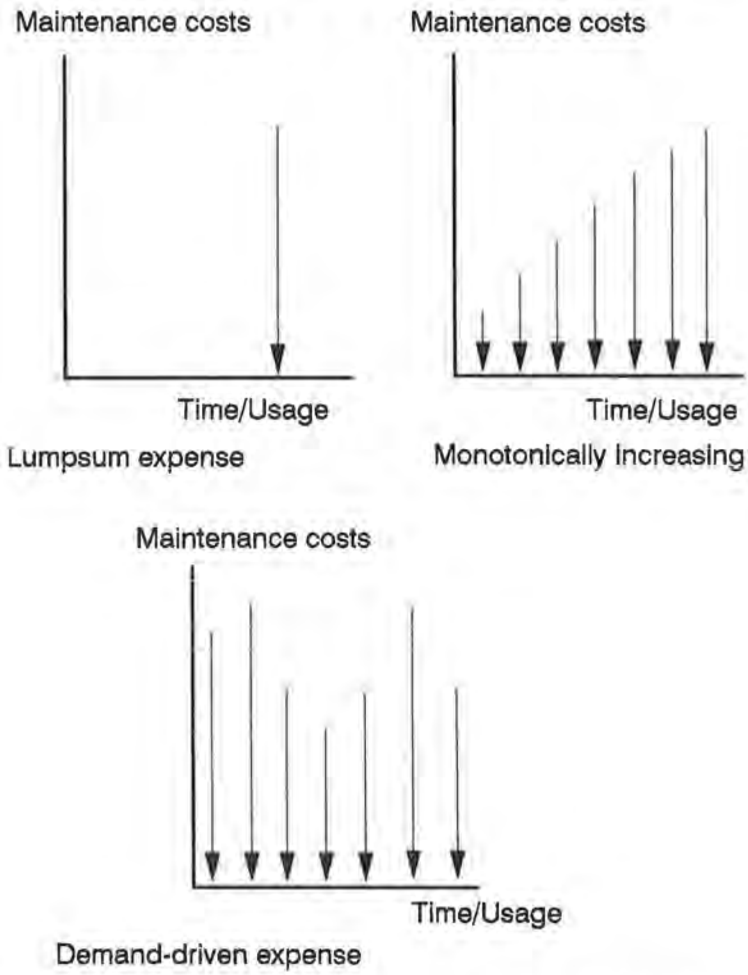

FIGURE 4 Maintenance responses to the three types of infrastructure failure.

tenance history. These factors make it difficult to assess the relative size of the maintenance allocations without more detailed modeling of failure and deterioration patterns. The aggregate prediction approaches are more affected by these factors than the disaggregate modeling techniques presented previously.

Trigger Mechanisms for Maintenance

There are different reasons for doing maintenance or capital works, ranging from responding to user complaints to generating employment. Figure 5 summarizes the perspectives, perceptions, and preferences for doing maintenance work. As an illustration, maintenance may be undertaken to satisfy a user or a manager of a highway system. Users are more concerned with the quality of service and whether there has been a cessation in service. Highway managers care about capacity and structural concerns. The users' preference would therefore be for reparative and restorative work, whereas the managers' preference would be for capacity expansion and rehabilitative actions. Many budgeting procedures do not relate the type of activity and its related expenditure to the reasons for undertaking these activities. As a result, it is difficult to project future expenditures.

Diagnosing a Typical Country Budget

We will now use a case study to illustrate some of the points made in this paper. The case study involves the analysis of highway expenditures in Peru from 1985 to 1993, for the purpose of suggesting adjustments to its budgeting procedures. Figure 6 shows the actual ratio of maintenance to capital expenditures in Peru from 1985 to 1993. As can be seen from this figure, there is a high variability of this coefficient over time. It was highest in 1991 and lowest in 1989. An average ratio from these data is around 0.5, a figure well above those suggested

PERSPECTIVE	PERCEPTION	PREFERENCE
Micro		
User	quality and cessation of service	reparative and restorative actions
Manager/operator	capacity and structural deficiencies	capacity expansion and rehabilitative actions
Owner	value of assets	preventive actions to slow depreciation
Macro		
growth	unreliability of service and productivity	all of the above
employment	infrastructure investments and employment	labor-intensive actions

FIGURE 5 Trigger mechanisms for maintenance actions.

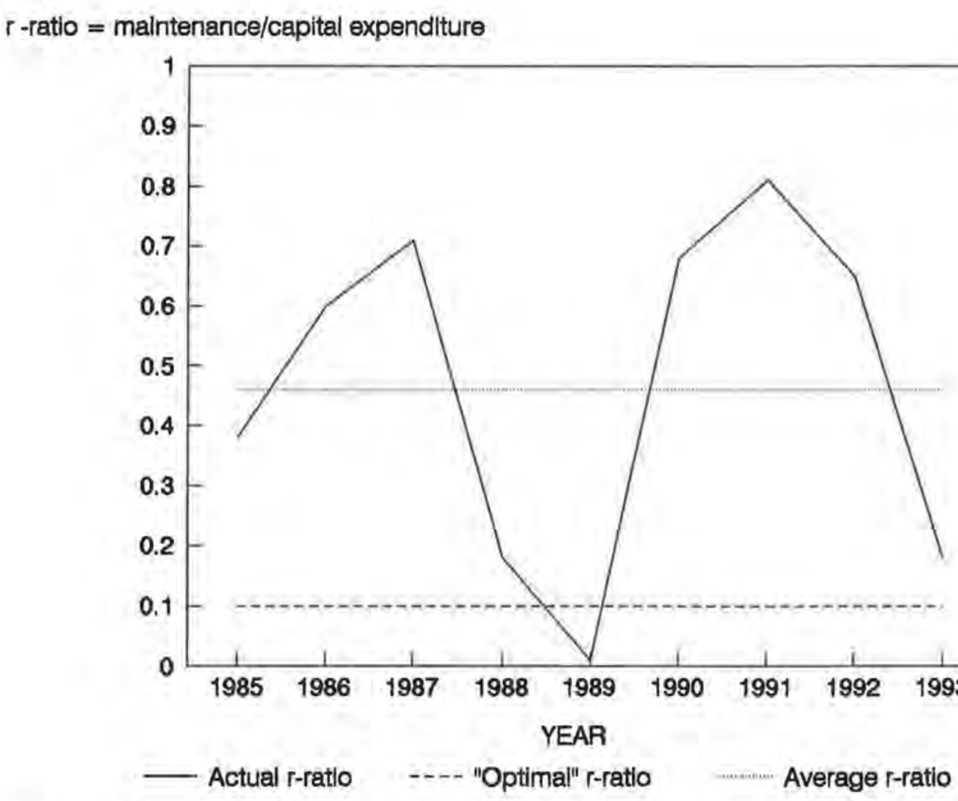

FIGURE 6 Impact of deferred maintenance (*14*).

TABLE 2 Conditions of Peru's Road Network (*14*)

JULY 1990			DECEMBER 1992		
Rating	km	%	Rating	km	%
Good	1,936	12	Good	2,668	17
Fair	6,815	44	Fair	8,474	54
Bad	6,942	44	Bad	4,551	29
	15,693			15,693	

by Heller (*5*), which were around 0.03 and 0.07. Using the HDM model and past data, an optimal ratio was calculated. The optimal ratio is an average ratio based on the assumptions that maintenance is triggered to minimize user and highway agency costs. As can be seen from Figure 6, the optimal ratio is well below the average ratio, indicating that Peru was seriously deferring maintenance and resorting to a cycle of reconstruction–deferred maintenance–reconstruction.

To check whether the diagnosis was correct, the condition of the highway network before and after the maximum point of the ratio in Figure 6 was compared in Table 2. This table shows that in 1990 the proportion of the network that was in good condition was 12 percent, compared with 17 percent in 1992. Similar improvements were found in the highway network rated in fair condition, which was 44 percent in 1990 and 54 percent in 1992. Therefore, the relative ratio method was picking up the right overall pattern. However, if we were to use this ratio to project future allocations between maintenance and capital expenditures (reconstruction and rehabilitation), we would have arrived at the wrong result, because the average ratio we calculated from actual data was far higher than the optimal ratio, if the correct reasons for maintenance were considered.

Summary and Further Work

We have presented alternative methodologies for preparing highway budgets, citing their advantages and limitations, as well as the factors affecting their robustness. These methodologies can be used as a tool kit for diagnosing past expenditures and recommending strategies for highway expenditure budgeting. These methodologies should be tested further using a variety of policy scenarios, to provide measures of robustness and general recommendations suitable for particular country situations. Field data, such as global condition surveys using randomly selected samples, would provide a basis for calibrating and testing the models developed in this paper.

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