Financial Mechanisms for Road Maintenance in Developing Nations

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In most developing countries, the funds allocated to maintain the principal roads have traditionally come from the governments' fiscal budgets. However, the economic restrictions of these countries, many of which are just coming out of lengthy economic crises, have compelled the governments to allocate most of their fiscal funds to other activities that are considered of higher priority (social welfare, education, etc.). Because insufficient funds are allocated to maintenance, principal roads in these countries are experiencing today an accumulated and consistent deterioration. The roads discussed in this paper are the national roads under federal government jurisdiction that carry the larger portion of national and international passenger and cargo flows. This part of the road system is commonly known in most countries as the "basic road network." Several mechanisms that could be implemented in developing nations to generate additional funds needed to adequately maintain and rehabilitate principal roads are discussed. A specific proposal for Mexico is presented. Though specifically aimed at developing nations, the criteria presented can be valid for any country.

The lack of adequate maintenance in road systems leads to inefficient operation and inappropriate use of the different modes of transportation and their interaction. It results in different kinds of energy being wasted without benefiting society at all. It seems adequate to propose a concept of social entropy with a similar meaning to that of physical systems: the energy that a society loses without any foreseeable or foreseen benefit can be assumed as added to universal chaos; that is, as an increment of social entropy. It is obvious that all social movements increase social entropy, but it is also obvious that the goal of all societies should be to minimize that increment. In fact, all excesses above the minimum, that consume resources without generating wealth for society, are undesirable and increase real social costs. Seen in this way, the fact that maintenance reduces the real costs of the countries becomes a sort of natural law. It is necessary to give punctual and concrete meaning to this law by fostering actions that generate resources for maintaining the road networks. In other words, developing nations need to find mechanisms that permit them to obtain required resources. This way, when resources are properly allocated, nations minimize social waste, which, from many standpoints, is represented by inefficient transportation.

Several mechanisms that could be implemented in developing nations to obtain the funds needed to appropriately maintain principal roads are discussed. The roads discussed in this paper are the national roads under federal government jurisdiction that carry the larger portion of the national and international passenger and cargo flows. This part of the road system is commonly known in most countries as the "basic road network." In Mexico, the total length of the roads in the basic road network is about 30,000 km.

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In most developing countries, it has been intended for the whole of these funds to come from the government fiscal budget. However, the economic restrictions of these countries, many of which are just coming out of lengthy economic crises, have compelled the governments to allocate most of their fiscal funds to other activities that are considered of higher priority (social welfare, education, etc.). Because insufficient funds are allocated to maintenance, principal roads in these countries are experiencing today an accumulated and consistent deterioration. In Mexico, for example, 60 percent of these roads, which carry more than 80 percent of the national passenger and cargo flows, are in poor condition (*1*).

This paper specifically deals with mechanisms for generating additional funds needed to adequately maintain and rehabilitate principal roads. A specific proposal for Mexico is presented. The recommendations are directed mainly toward authorities in the different countries responsible for managing public funds; it is their duty to select the most convenient alternative according to their particular conditions.

GENERAL IDEAS

The aforementioned mechanisms should meet the following four conditions (*2*):

- Be systematic. The temptation to take advantage of circumstances that allow allocation of funds within a given year but whose allocation may not be repeatable should be resisted.
- Be clearly related to national road transportation. Mechanisms that use funds from other areas are questionable because there will always be additional needs.
- Enable nations to collect funds from those that benefit from the use of roads.
- Permit nations to generate funds as positive results are attained from providing better maintenance on main roads. The funds collected should be directly proportional to the economic benefits produced by improved conditions.

It seems an obligatory matter that society as a whole should contribute to the solution of this serious problem. From this viewpoint, road maintenance should receive a similar treatment to that given to many other public services supported, in great measure, by the social group of users.

When making suggestions to the authorities responsible for allocating funds to road maintenance, several basic concepts should be addressed:

- Roads represent a public service, and should be treated similarly to other services, such as water supply, electric energy, and telecommunications (to a certain extent). It is universally accepted

that the users of these services should contribute in some way to the cost to maintain them.

- It is also true that there is another group of essential services that are generally accepted all over the world as justified to receive, at least in part, government subsidy. Such policy is considered reasonable for these services as they are of fundamental importance for the nation and for the population. In general, these services have to be offered directly by the government or they have to be provided at such a low fare (so that they can be afforded by most of the population) that they lack, in themselves, the necessary capacity for generating the funds (and profits) commonly required by private investors to run them satisfactorily. Education, basic health, national defense and public administration are examples of these services. Road maintenance does not fall within these services, as apparently road users are, in general, a socioeconomic group that does not require subsidies.
- In part, road maintenance should be paid directly by the vehicle drivers that use the roads. This policy may not only allow the collection of sufficient funds for road maintenance but may also help road users to be aware of the important link that exists between the fare they pay and the higher benefits they receive in exchange. This policy would also arouse a very healthy interest of the users in road maintenance and would also generate a convenient pressure in favor of efficiency in the fulfillment of maintenance works.

REVIEW OF SOME POSSIBLE MECHANISMS

A basic idea that should be emphasized is that any mechanism suggested to a national government to obtain resources for road maintenance should be preceded by a clear and simple strategy to adequately spend these resources. Such a strategy should contain technical elements that help define the present condition of the road system, the actions that need to be accomplished to bring each particular road up to a specific level, the costs and benefits derived from such actions, and criteria that allow hierarchization and selection of the most convenient actions to be carried out within a given time period, considering the relative importance of the roads, available resources, and the development of policies toward the future. All these elements are usually assembled in what is commonly known as a pavement management system (PMS). A national strategy or PMS for managing the maintenance activities of the Mexican road network has been developed by the Mexican Institute of Transportation (*3–11*).

In the past, the idea that road maintenance could be financed through special (labeled) taxes created for that particular aim was popular. Through this mechanism, it was sought, to a certain extent, that such taxes were collected from users of the service to which the same funds would be allocated. However, this system gave rise to a lot of criticism as such taxes were frequently allocated to other different purposes. The urgent socioeconomic needs of many developing nations, particularly those experiencing fast population increase, forced the governments to integrate all resources collected into a single fund. This practice provided more flexibility to attend urgent needs that arose as a result of the daily life of society. It should be recognized that the disappointment produced by this method of "labeled" taxes for a particular service is very widespread today, and its critics seem to have very solid arguments against it.

Toll collection is another mechanism that is sometimes used to obtain funds for road maintenance. To be justified economically, this mechanism requires a certain minimum traffic level. Frequently, this minimum level is set to about 800 vehicles per day (*2,12*). For traffic levels lower than this, administrative (fixed) costs make this system less attractive. Indeed, low traffic is a factor usually argued against this mechanism in many developing countries. This system could be considered suitable for, probably, not more than 10 percent of the road networks of Latin American and Caribbean countries. Evidently, toll collection cannot be implemented throughout the basic road network. The use of this mechanism seems to be limited to freeways. In the case of Mexico, toll collection in freeways generate sufficient resources for freeway maintenance, but these funds are insufficient for providing significant maintenance for the whole network.

Studies conducted at the Mexican Institute of Transportation (MIOT) in 1994 (*2,3*) have concluded, for the moment (even recognizing that these studies could be enhanced and extended), that it would be highly convenient to analyze a mechanism based on a very slight increase in the price of fuels (gasoline and diesel). This analysis should be complemented with a general study on impacts produced by that increase in the different sectors of the economy. These impacts should then be compared with the savings obtained by national transport and its effects in those same sectors. If the final balance from this comparison results in favor of such savings, then the country as a whole would benefit from applying this alternative.

Based on the former ideas, a specific mechanism was proposed for Mexico. This proposal is directed toward maintenance of the basic road network—the national roads that are most important for the commercial and industrial life of the country (in general, for the mechanisms that support the income generation).

The proposal presented assumes that the government will continue to contribute the annual amount that has been allocated for the past several years (around $180 million) to road maintenance. This amount is considered to be sufficient for routine maintenance of the 30,000-km Mexican basic road network (crack sealing, patching, resurfacing, cleaning and repair of side slopes, signs and markings, ditches, culverts, dikes, berms, drainage channels, etc.). In addition, the proposal takes into account the need for more substantial resources to rehabilitate and structurally strengthen the basic network. By investing in these additional resources, the road network would acquire a timely and durable strength so that eventually it would not need to be strengthened as frequently nor as significantly, even under the increments in traffic and truck weight. These additional funds are needed because presently most Mexican basic roads are older than 30 years and were built for much lower traffic intensities and much lighter trucks than the ones they carry today (in 1955, the heaviest vehicle weight allowed in Mexico was 10 ton; today, present regulations allow vehicle weights of up to 65 ton). Due to this situation, the maintenance actions required in the road network for the next 10 to 20 years include substantial surface reinforcements, drainage improvements, and, frequently, important reconstruction actions.

Specifically, the proposal plans to bring the road network up to such a good condition of alignment, safety, and structural strength within an initial period of time, that after that period it can keep its satisfactory condition with regular investments like those required for routine maintenance (which are substantially lower than the ones required for strengthening or reconstruction). After this initial period, the fund-generating mechanism already implemented could be used to support the construction of new roads, which will always be required.

The studies accomplished do not consider that every road should be improved with the same target condition in mind. The strategy developed at the MIOT contains elements that permit definition of

the most suitable level of quality (ideal) for each highway corridor, depending on the economic value of freight flows traveling on them (*2*). This criterion for defining such quality levels was selected because the economic value of freight moving on basic roads is directly related to their contribution to national transport and, in general, to the generation of national wealth. (The corridors were determined by integrating adjacent links with similar freight economic value.) The optimum set of projects to carry out in the road links yearly was defined by applying the PMS developed by the MIOT (*1–3*).

SPECIFIC PROPOSAL FOR MEXICO

Analyses carried out at the MIOT (*2,3*) showed that the value of the Mexican basic road network is about $30 billion (replacement value). The cost of transportation operations that will take place on this network during 1994 amounts to nearly $15 billion. This value will increase to $17 billion and $20 billion by the years 2000 and 2006, respectively, presuming the present annual traffic growth rate remains the same within the next few years (around 3.5 percent). The former vehicle operating costs include "avoidable overcosts" of about $1.2, $1.85, and $2.7 billion for years 1994, 2000, and 2006, respectively, taking into account the network's present condition and that an amount of about $180 million will continue to be allocated annually to routine road maintenance. (The term "avoidable overcosts" refers to the difference between vehicle operating costs for the network's present condition and the vehicle operating costs for the most suitable level of quality, or the ideal, defined for each corridor.) In the case of the Mexican network, the actions to attain the most suitable condition in each particular road would lead to an increase in the present network mean present serviceability index (PSI) of 2.5 [international roughness index (IRI) of 6] to about 3.5 in 10 years (IRI of 4) and to a value of 4 in 20 years (IRI of 2.5). Evidently, if road maintenance improved, the network condition would also improve and the vehicle operating overcosts would be reduced.

It should be emphasized that the above-mentioned overcosts were not determined for a global network ideal target condition but for an adequate condition of each road corridor based on its direct contribution to the generation of national income. Moreover, such a condition is compatible with the technical capabilities of Mexican engineering. The possibilities of reaching the target condition for each corridor will be higher if a PMS, like the national strategy developed at the MIOT, is applied.

On these bases, it was determined that the increase of the network's mean PSI to the annual values shown in Table 1, could produce an accumulated income in 20 years of up to $42 billion (for the highest alternative investment considered in the table) with regard to the amount that would be obtained during that same period for the present annual investment of $180 million. The data in Table 1 consider five different investment levels, allocating $180 million to routine maintenance (which would not lead to increments of the roads' structural capacity) and the rest to structural reinforcement of the network, drainage improvement, etc. The investment levels considered in the table were selected to cover the range of economic possibilities of the Mexican government (they correspond to rounded amounts in Mexican currency but become rather odd amounts when converted to U.S. dollars). The first allocation level analyzed corresponds to an initial investment of $180 million (made during Year 0), which grows in subsequent years at the same yearly rate as traffic (3.5 percent on average for the 30,000-km network considered). For this alternative, it can be observed that the present mean PSI of 2.79 becomes 2.54 after 20 years and that avoidable overcosts increase more than 100 percent within that same period.

If, on the other hand, $610 million are invested during year 0 to principal roads maintenance, with the same annual growth rate as traffic, overcosts will decrease about 60 percent in 20 years, and the road network mean PSI will improve within that same period from

TABLE 1 Investment Alternatives for Road Maintenance (Amounts in Millions of Dollars)

	Allocation Levels									
	180[a]		305				455			
Year	Mean PSI	Avoidable Overcost	Mean PSI	Avoidable Overcost	Cumulative Expenditure	Cumulative Income	Mean PSI	Avoidable Overcost	Cumulative Expenditure	Cumulative Income
0	2.79	1 699[a]	2.79	1 699	120	0	2.79	1 699	267	0
1	2.61	1 847	2.67	1 804	245	43	2.72	1 548	552	299
2	2.45	2 138	2.58	2 016	376	164	2.69	1 650	849	786
5	2.23	2 535	2.54	2 180	798	988	2.72	1 703	1 800	3 006
10	2.16	3 000	2.63	2 293	1 619	3 910	2.93	1 398	3 638	9 661
15	2.34	3 375	2.74	2 193	2 600	8 899	3.23	1 082	5 863	19 757
20	2.54	3 385	2.95	1 848	3 515	16 509	3.66	787	7 995	32 633
	Internal Rate of Return (%)				50.9				77.0	

	610[a]				760			
Year	Mean PSI	Avoidable Overcost	Cumulative Expenditure	Cumulative Income	Mean PSI	Avoidable Overcost	Cumulative Expenditure	Cumulative Income
0	2.79	1 699	415	0	2.79	1 699	570	0
1	2.76	1 443	862	405	2.80	1 350	1 106	497
2	2.76	1 462	1 321	1 079	2.80	1 341	1 773	1 294
5	2.85	1 357	2 768	4 192	3.00	1 104	3 802	5 098
10	3.25	904	5 655	13 000	3.57	632	7 622	15 402
15	3.73	639	9 077	25 443	3.86	593	9 773	28 448
20	3.90	648	10 145	39 461	3.91	641	10 637	42 505
Internal Rate of Return (%)			65.0				55.7	

2.79 to 3.9. Similar information is also presented in Table 1 for allocation levels of $305, $455, and $760 million.

In all the alternatives analyzed, the data in the "Expenditure" columns correspond to the additional funds that would be allocated yearly to road maintenance, above the present investment of $180 million. The data in the "Income" columns, however, concern the difference between the annual overcosts of a given alternative and the yearly overcosts corresponding to the initial investment of $180 million (the first alternative). For example, in Year 10 of the initial investment of $610 million, an accumulated savings in avoidable overcosts (accumulated income of the country) of around $13 billion would be obtained with respect to what will be acquired in that same year from the initial investment of $180 million.

The bottom row in each alternative shows the internal rate of return (IRR) for each additional annual amount allocated. From these values, it is evident that the most feasible alternatives correspond to initial investments of $455 and $610 million (additional allocations of $270 and $430 million, respectively, above the present investment of $180 million). The selection between these two alternatives is not easy.

Going back to Table 1, it can be observed that if the initial allocation is $455 million instead of $180 million, the cost of improving the network mean PSI up to 3.66 in 20 years will be around $8 billion (cumulative expenditure) in addition to the amount needed for routine maintenance (1994 values). If, on the other hand, the initial investment is $610 million US dollars, that same cost for improvement will be about $10 billion, but in this case, better and faster results will be obtained. It should be noted that the PSI values shown in Table 1 are not generalized values for the whole network but are a weighted average of the PSI values provisionally attained by the process of reaching the most suitable value for each corridor.

It should also be noted that there is a surprising and enormous difference between the benefits derived from appropriate maintenance over a 20-year analysis period and its corresponding costs. Such a difference practically justifies any additional funds allocated to road maintenance.

In most developing countries, it is difficult to generate additional resources to maintain principal roads. Most of these countries assign barely enough funding for routine maintenance, and often even less. Consequently, practically nothing is done to repair roads showing the effects of natural deterioration or to adapt them to conditions other than those for which they were built. Traffic demand continuously grows in all developing countries, which means maintenance resources should grow too.

Assuming that the alternative corresponding to an initial investment of $610 million is selected and that this amount is assigned by simple allocation of fiscal resources, during the first year, as shown in Table 1, the country will receive an income of $405 million—almost the additional amount initially assigned above $180 million (the expenditure in Year 0). In subsequent years, that income will become increasingly higher than the amount allocated. This way, only the initial additional investment of $430 million will be previously unrecovered investment that could be financed, for example, through a foreign loan.

Figure 1 depicts a series of economic flows for the alternative recommended in this paper (the initial investment of $610 million). The first consideration that can be made in relation to Figure 1 is that the savings (income) are distributed in some way among society, but they are not ready monies that could be used for road maintenance. In fact, the monies needed should be provided by the government. In Figure 1 a curve is shown to represent the additional amount necessary allocated above $180 million, which is considered the obligatory minimum initial investment. As stated earlier, that additional allocation increases at the same annual rate as the rate of traffic. The initial additional allocation is around $430 million.

In the same figure, a "collections" curve is represented. This curve was developed with the consideration that the government would provide fiscal resources for road maintenance, but it would also receive the amounts represented by this curve, resorting to increments in the price of fuels. To minimize possible inflationary impacts, these increments should be such that, during the first 9 years, they generate annual collections that do not exceed one-third of the savings (income) obtained from the previous year. A possible mechanism to implement this requirement would be to increment the growth, starting from Year 1, of the price of fuels in equal amounts for 7 consecutive years, until reaching a total growth of $0.015 per liter of gasoline or diesel. These tolerable increments would produce the flow of resources needed.

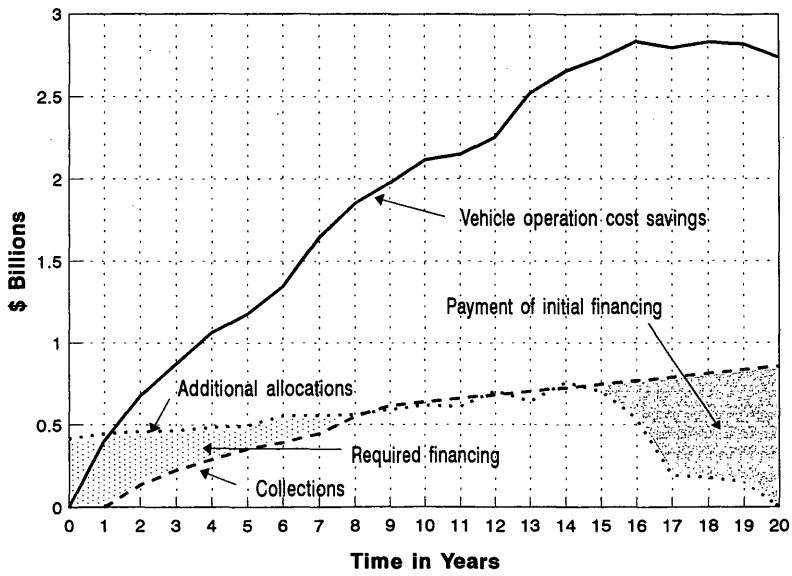

FIGURE 1 Economic flows for the $610 million alternative.

It can be observed in Figure 1 that by Year 9 the annual amount collected would already be about what is required. Figure 1 also shows a curve of yearly savings obtained due to vehicle operating cost reductions (income for the nation).

The shaded area on the left side of the figure, between the curves of annual allocations and collections, deserves particular attention. In this area, which corresponds to a time period of 8 years, maintenance receives more funds than what is collected. These annual differences could be covered through financing. Between Years 8 and 14, the funds collected are practically those that are required. After Year 14, the improved condition of the road system allows for significant reductions in the allocations needed for road maintenance. Within this period, the surplus, or the difference between what is collected and what is required, can be used for paying the initial financing. Likewise, within this period, the annual amount needed tends to become what is required for routine or preventive maintenance.

Figure 1 includes several considerations for minimizing inflationary effects derived from implementing the mechanism proposed herein. First, collection starts after the first year, when savings for road transport have already occurred. Second, as mentioned earlier, collection in a given year never exceeds one-third of the savings obtained the year before. Finally, the recommended alternative requires a maximum annual collection of $610 million. The fact that after Year 9 the collected amount exceeds this maximum collection level is just due to normal traffic growth derived from the growth of the gross national product.

The proposal described herein has been formulated in greater detail than presented above. For example, impacts produced by fuel increases in different sectors of the economy were assessed. Essentially, it was shown that except for the fishing sector, savings transferred to different areas of the economy will always be higher than the cost increase produced by the fuel increments. Therefore, the collections proposed are not inflationary and help make road transport and the national economy more efficient.

The expenditure of funds collected will not produce inflation either, as these resources will go to the sectors of construction and professional services, both of which have available labor.

Annual amounts of financing during the first years, as well as financing conditions, will not generate serious negative effects because there is a clear mechanism for recovering investments.

The proposal suggested has other additional significant benefits:

- Part of the savings attained in different sectors of the economy will turn into profits for private firms, thus increasing the collection of taxes.
- In a competitive system, an additional part of the savings will lead to reductions of transportation prices charged by the truckers, with corresponding benefits for different sectors of the economy.
- Improved road maintenance leads to lower fuel consumption. It was determined that by improving the condition of the road network to the level corresponding to the suggested alternative, the daily refining of nearly 100,000 barrels of oil will be eliminated (or the importation of fuels around the annual cost of $1 billion).
- Reductions in vehicle deterioration will also eliminate the importation of equipment and parts by an additional $800 million annually.
- In addition, the alternative suggested will lead to the creation of 100,000 new direct jobs and 200,000 indirect jobs.
- Finally, improving the road network will help improve the Public Administration image.

CONCLUSIONS AND RECOMMENDATIONS

Road maintenance is of special interest to the authorities and individuals involved in this activity. It is also an element of great importance for the economy of any nation. The concern for generating funds for road maintenance is, indeed, a consequence of that interest.

This paper proposes a mechanism for Mexico to acquire funds for maintaining principal roads appropriately. The most outstanding aspect of this mechanism is that it reduces road transport costs, which benefits most sectors of the economy. In addition, the mechanism is not inflationary. For all these reasons, these suggestions deserve serious consideration.

Though developed for developing nations, the criteria given may be valid for any country. The financial system proposed can also be extended to include maintenance of other kinds of road networks (urban, secondary, etc.) after carrying out the specific studies.

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